27th ITS World Congress
Hamburg 2021

HAMBURG
ITS World Congress
11 - 15 Oct 2021
Experience Future Mobility Now

Experience future mobility now

Post-Congress Report

Organised by:

ERTICO

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ITS AMERICA

ITS ASIA-PACIFIC

Supported by:

Federal Ministry of Transport and Digital Infrastructure

Hosted by:

Hamburg

27th ITS World Congress

Post-Congress Report

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KEY SUCCESSES

15,000 REGISTRATIONS

1,336 DELEGATES

705 NUMBER OF SPEAKERS

13,200 PARTICIPANTS

66 COUNTRIES

EXHIBITION VISITORS **4,090**

3,675 PUBLIC DAY

EXHIBITION PERSONNEL **2,844**

105 STUDENTS

244 PRESS REGISTERED

STAFF AND VOLUNTEERS **121**

TAKING PART IN **32** ASSOCIATED MEETINGS

1,660 OPENING CEREMONY

210 SESIONS

34 DEMONSTRATION

15 TECHNICAL VISITS

335 TECHNICAL VISITS BOOKED VIA APP

NETWORKING **11,844** MESSAGES EXCHANGED

2,612 DEMONSTRATIONS SLOT BOOKED VIA APP

JOINED BY **24** COMMERCIAL PARTNERS

8,104 BADGE SCANS

198 INDIVIDUAL EXHIBITORS

24 MEDIA PARTNERS

MEETINGS BOOKED **409**

25,560 Sqm EXHIBITION AREA

30 ITS NATIONAL ASSOCIATIONS

12,618 CONTACTS MADE

APP DOWNLOADS **7,523**

INTRODUCTION

The Congress's principal theme "Experience future mobility now" was chosen to illustrate the radical role Intelligent Transport Systems, digitalisation, and cooperative, connected and automated mobility can play in addressing the key challenges in the mobility and transport sectors. Deployment of ITS can take us further down the road to a mobility world that is accessible, equitable, affordable, has zero fatalities, has zero emissions, is resilient when stressed, and is seamless across Continents. How to achieve these benefits was presented in policy discussions, technical and research paper sessions, demonstrations, technical tours and the Congress Exhibition.

The European Programme Committee, chaired by Lisa Boch-Andersen, appointed rapporteurs for each topic tasked with capturing the key messages and outcomes from the Congress, the exhibition and the demonstrations. The headline theme was addressed by a wide range of different types of sessions, over 250 in total – Plenary, Executive, Special Interest, Technical, Scientific and a range of Forums.

Part 1 of this Report summarises the Congress proceedings. The second part paints a picture of proceedings at the Plenary and Executive Sessions. The third part focuses mostly on the Technical & Scientific papers and the Special Interest Sessions. The final part summarises the proceedings at the ITS Summit.

Profound thanks to the marvellous team of rapporteurs who contributed so much to making this report happen – with a special mention and good wishes for Richard Easley who had to retire because of ill-health and thanks for Janneke van der Zee who took over his role at short notice:

Lavinia Burski	**Topic 4**	**Risto Kulmala**	**Topic 1**
Richard Easley	**Topic 3**	**Renee Ray**	**Topic 6**
Louise Guidi	**PLs & ESs**	**Carol Schweiger**	**Topic 2**
Jill Hayden	**Topic 4**	**Janneke van der Zee**	**Topic 3**
Sharon Kindleyside	**Topic 5**	**Marieke van der Tuin**	**Topic 1**
Carol Kuester	**Topic 6**	**Maggie Wieteska**	**Topic 1**

Thanks also to the moderators and note-takers for the ITS Summit: Steve Dellenback, Louise Guidi, Wolfgang Höfs, Jane Lappin, and Marieke Martens. My colleagues from ITS America, ITS Asia Pacific, ERTICO, the Hamburg Host team and MCI all deserve thanks for their quick and cheerful handling of all my enquiries and questions.

PROFESSOR ERIC SAMPSON

CHIEF RAPPORTEUR

BRUSSELS December 2021

PART 1 | SUMMARY

The Congress had as its main theme "Experience future mobility now" chosen to illustrate the radical role Intelligent Transport Systems, digitalisation, and cooperative, connected and automated mobility can play in addressing the key challenges in the mobility and transport sectors. The event was organised around six key topics:

- **Automated, cooperative & connected mobility Vehicles**
- **Mobility on Demand, Mobility as a Service**
- **Goods journey from ports to customers**
- **Intelligent infrastructure**
- **New services from new technologies**
- **Cities and citizens solutions**

The ITS Summit was a key element of the Congress with over 80 Ministers, industry leaders and senior representatives of national and local governments coming together to talk about common transport challenges and possible solutions. The overall aim was to encourage cross-sector discussion on transport concerns and priorities. This year's Summit discussions were focused on reaching conclusions on five prevalent challenges that included modal shift, public acceptance, avoiding regional stand-alone solutions, market dynamics and regulations, as well as coping with increasing city-logistics. The participants enjoyed this first opportunity since the Singapore Congress in 2019 to meet their global counterparts face-to-face

Around 400 papers were presented in about 200 Congress sessions roughly divided as follows – Topic 1: 145 papers; Topic 2: 50 papers; Topic 3: 30 papers; Topic 4 75 papers, Topic 5: 35 papers; Topic 6 65 papers. In the three Plenary Sessions and six Executive Sessions senior industry executives, public officials and international experts shared their perspectives and extensive experience of ITS topics encompassing policy, strategic, economic, technical, organisational and societal aspects.

There was a large (more than 25,000 sq m), eye-catching and very busy Exhibition involving over 400 organisations. It included a large area dedicated to over 40 start-ups to give them a space to showcase their ideas and have discussions with future sponsors and customers. In addition to these indoor activities there were 30 managed demonstrations and 19 technical tours to local control and service centres.

The Automation and connectivity topic had the largest presence in the Congress, with more use cases, and more emphasis on actual deployment and take-up of services. Automation received much attention, mainly the higher levels of automated driving (L3 and L4) but level 1 or 2 support systems were also addressed such as dynamic distance assist or infrastructure supported Adaptive Cruise Control. Safety and security services were prominent such as risk estimation, cybersecurity, safety assurance, and pedestrian safety. Several papers explored the differences in legal approaches to CAV technology within different countries and examined the future role of laws.

Cooperative ITS had definitely moved forward and discussions addressed its integration into day-to-day business, the stakeholders, lessons learned in deployment, and the impacts on a smart transport system. Digital twins and roadside & cloud architectures were recognised as important building blocks of smart transport. Cooperative was currently seen as moving from large-scale testing to widespread use, so the importance to road authorities and operators for improved safety and efficiency was also increasing.

By contrast highly automated public transport seemed stuck. Successful pilots of automated shuttle buses, mostly on dedicated infrastructure, have not been adopted. Municipalities and transport companies seemed loath to operate regular services. This prompted the question "Why is establishing an operational system so much more than running a pilot"? Clearly the road to commercial automated vehicles is not just technology, and it will gain lots of attention in the coming years.

Mobility on Demand, Mobility as a Service was Topic 2 and this popular subject has been discussed at World Congresses since 2014 and the publication of the seminal MSc thesis. Popular topics in Hamburg included:

- Impact on travel behaviour
- Equity and inclusivity
- Standardisation
- Business models
- Impacts on the environment

We heard about a number of new ideas including:

- A framework for MaaS scheme indicators,
- User Centred Trusts – a novel data governance framework
- An improved algorithm to solve the dial-a-ride problem of integrating autonomous vehicles into conventional public transport

Sessions and papers, and a vigorous discussion at the ITS National Associations meeting, showed that progress overall had been steady but had been inhibited by many non-technology challenges:

- the complexity of bringing together many different stakeholders in many organisations
- a lack of trust and willingness to share data between and among the sector actors
- managing public subsidies/revenues is not easy when the value chain includes both public and commercial actors.
- public bodies taking too long to update – or perhaps remove – regulations to respond to technology developments
- And let's be honest – some incumbent transport service suppliers have been trying to block the launch of new ventures

Looking ahead there were signs that public authorities and industry partners accepted the need to develop the overall organisation, adapt the product development to include greater collaboration on regulations, and encourage a more agile leadership.

Topic 3 was Goods journey from ports to customers. This has often been the smallest topic at Congresses partly as the subject matter is so broad and partly as the supply side has a great many small organisations. However with COVID affecting daily lives across the planet this topic has taken centre stage. Transporting the masks we wear today, or supplies of vaccines, or the food delivered to grocery stores or your local take-away – all illustrate the key fact that freight & logistics and ITS cannot work without each other.

Hamburg saw the best ever response to the Call for Proposals. We had some lively sessions including our first ever Global Forum. Discussions revealed how the sector was steadily becoming digitalised and connected but it remained a fragile system overall: the component parts – loading from origin to ship, ship management, port internal management, port hinterland, delivery fleet management, 'last mile' delivery – did not always connect well. Repairing this and speeding up the development of open platforms would continue to be a focus for collaborative work.

Intelligent infrastructure is a relatively recent concept reflecting major advances in all the ITS technologies. There was much interest in AI, machine learning, new types of sensors and algorithms to generate the intelligence to support network operation. Connected vehicles and communications were big again with connection not just to road vehicles but also to water traffic, rail, and unmanned aerial systems. Vulnerable road users were recognised as becoming a topic of much interest especially the potential for C-ITS use cases for pedestrians and cyclists:

There were relatively few papers and sessions on Electric vehicle charging infrastructure, digital twins, cyber security and overall more papers on trials compared to technical innovations. There were some interesting innovations for example:

- Green light optimal speed advice for buses to incorporate waiting at bus stops
- Directional speakers to provide voice alerts to drivers
- Simulation of routing strategies at an industrial park using A M devices

Overall, different countries were regarded as being at different stages using intelligent infrastructure. Some countries were cautiously trialling use cases which they thought would benefit them. Other countries were past trials and were showcasing the impacts on the wider world such as improved user interaction.

But there was still a chicken-egg situation – operators were not investing in smart systems as too few vehicles are ready to use them; and drivers were not being made

aware of the benefits so were not buying them and so few vehicles were ready to use them.

There had been an intriguing shift in Topic 5 New services from new technologies. This was almost the smallest topic perhaps reflecting current trends of using technology to improve existing services and applications rather than the creation of new services. There were numerous Business Presentations with the most popular theme (also for papers and sessions), developments in Urban Air Mobility. In general the emphasis was concepts and business models for mobility in the third dimension and integrating ground and air traffic management. We had new approaches to traffic management & tolling using AI and Deep Learning to manage signals adaptively. Modelling, simulation, monitoring and incident detection were all presented with innovative solutions.

Data use was seen as an enabler rather than a new technology or service with several discussions on approaches to sharing and managing data and the need for a collaborative business environment for sharing sector data.
The newest presentations stressed the need to link to behavioural and social impacts, and explore how to incorporate future mobility needs and MaaS thinking into town and city planning perhaps using new planning approaches and tools.

Cities and citizens solutions saw some new thinking on designing policies. Most research and technical papers focused on hardware and software solutions to reduce vehicular congestion but, in general, not by diverting motorists to other travel modes. A number also addressed technology innovation to gather and analyse air quality and vehicle emissions data in order to support decisions on air quality-related goals. Road user charging has been a familiar topic for years but discussion featured real-time distance pricing; and time-based charging, once laughed at, is being seriously studied in Hong Kong to address their circulation and parking problems.

We heard about innovative methods of traffic distribution such as real time information dissemination, dynamic modelling, and incentives to nudge drivers into using roads or time periods they might not otherwise consider. Dynamic incentivised trip making was an emerging thought; the challenge lies in how such a system convinces drivers it's worth their while to change their time or route.

Papers and sessions discussed the components of a "smart city" solution which suggested that implementing a true Smart City vision was not yet being realised. The tools that were identified as potentially contributing to smarter cities included making data-informed decisions that drive measurable outcomes; using "dashboard" tools to highlight problem areas are so help target solutions; and the need for planners, especially in cities, to do more to understand what is happening 'on the ground'. An ideal Smart City would presumably rely on multimodal solutions with travellers using technologies to suit particular trips. It was interesting that most papers focused on how to manage cars, traffic, and congestion with not much emphasis on mode shift.

So overall – a very successful week with thousands of delegates enjoying a face-to-face event after months of screen watching. The ERTICO, Hamburg and MCI team delivered a major event despite Covid constraints.
A speaker in one session put it rather well "I did experience future mobility now: in sessions, in the Exhibition and at demonstration sites".
Looking back it was clear that despite COVID disruptions we were further down the road than we were 2 years ago in Singapore. The road to a mobility world that is Accessible, Equitable, Affordable, Has zero fatalities, Has zero emissions, Is resilient and is seamless across Continents.

We're not there yet. Around the globe there are some difficult problems still to be solved. And some of them are all about our behaviour. if we want a better eco-system, we need to cut back all our personal ego-systems. Smaller projects with exciting new ideas are being developed and implemented rapidly everywhere. However the bigger, more ambitious projects with potentially larger impacts are slower moving. They are often constrained by excessive concerns on regulation, integration, competition, and collaboration – none of these is a technology barrier.


Halle Hall
B4
Celebrating 30 years
of innovation.
ERTICO

PLENARY 01 | Ensuring sustainable mobility

Moderator:

Sarah Sharples	**Department for Transport; UK**

Panellists:

Matthew Baldwin	**DG MOVE, European Commission; Belgium**
Markus Schlitt	**Yunex Traffic; Germany**
Carolin Reichert	**Bosch; Germany**
Daniela Gerd tom Markotten	**Deutsche Bahn**
Tetsuro Fukunaga	**Ministry of Economy, Trade and Industry; Japan**
Roger Millar	**Washington State Department of Transportation; USA**

The Moderator opened the session and explained that technology developments in the mobility of people and transport of goods had hugely benefited society with accessible, equitable, inclusive, safer and more efficient services available to all. However we also needed to consider longer-term impacts such as climate change and biodiversity, at a time when adding more infrastructure or vehicles was also being challenged. The Plenary would look at past achievements, review the expected benefits from solutions and look at some of the global challenges:

- How do we define sustainable mobility and measure it?
- How can we deploy ITS to decarbonise mobility while addressing climate change and maintaining quality services for citizens?
- If we still want next day delivery of goods what needs to change to ensure that freight mobility is sustainable?
- How could travellers benefit from multimodal and sustainable services when the pandemic had caused them to question using public transport?
- How could we ensure that effective ITS technologies and services were affordable for the many and not a luxury for the few?
- How can we best leverage ITS solutions to deploy new sources of revenues (eg road user charging) to fund infrastructure investment and incentivise the use of multimodal solutions.

Matthew Baldwin's Keynote address outlined the crucial role digitalisation has played and will play in the existential battle against climate change and the policies and commitments made so far by the EU as part of the European Green Deal and the 'Fit for 55' package. He stressed the major contribution made by transport when it comes to emissions and explained how a carbon reduction in transport can have much wider impacts, for example from air quality to road deaths. To enable this the EU was developing a new strategy for smart and sustainable mobility which would mark a big rethink for Europe. ITS would have a fundamental place in this activity given its ability to enable multimodality, optimise existing capacity, among other benefits. He highlighted how the EU intended to increase the application of ITS, including the deployment of CAVs, digital ticketing, and enhanced information such as carbon footprint of journeys or the number of passengers in public transport – to inform the micro decisions made by numerous passengers. Siloed thinking had held back advances in

sustainable mobility to date and we needed to bring it together with ITS to tackle some of our key challenges.

Markus Schlitt described how Yunex had been launched as a separate business in the middle of the coronavirus pandemic. Despite its young age the company had a long history and knowledge; it was derived from Siemens ITS which had over 100 years' experience – while retaining the agility of a start-up. Its focus was to promote collaboration and data sharing, supporting local authorities in their design of road networks to enable efficiency.

Carolin Reichert emphasised the scale of growth needed to make transport truly sustainable, from the EVs and logistics fleets to e-bikes. To fully enable this transition a real focus on charging infrastructure was required to meet the increased demand and it should be based on using renewable energy. Ms Reichert made a strong case to stress the need to place the user at the heart of this process – convenience would be key.

Daniela Gerd tom Markotten reminded the audience that the reality of ITS is a question of perspective and perception – autonomous driving was already a reality for rail travel. Compared to other modes rail had the best offer in terms of sustainability. However a key issue was how to drive modal shift to increase rail usage by both passengers and freight. The key challenge in this was how to best integrate three key different areas: sustainability, intelligence and digitalisation. We needed a strong focus on bringing advances in these areas together and combining it with user-centred thinking to 'wow' people and encourage more sustainable choices.

Tetsuro Fukunaga highlighted Japan's commitment to carbon neutrality by 2050 and the critical role innovation would play in achieving this – as was the case for other nations. The approach taken by the Japanese government to support this goal focused on bringing innovation to adapt existing systems, with several different types of actions to achieve this. Projects ranged from the development of high-definition 3D transport maps and dedicated communication systems to the four autonomous driving services currently live across regions in Japan. He also highlighted the successful demonstration of truck platooning earlier in the year and new ambitious projects in logistics. He issued a challenge to Congress participants to adopt a global mindset to develop constructive actions that could support the transition to sustainable mobility.

Roger Millar emphasised that whilst technology was important we must remember that transport was a means to an end and not the end. As such, we must focus on the "why?" and three 'P's in particular: People, Planet and Prosperity. When thinking about transport technology we had to think about how we could harness technology for our own benefit, rather than let technology harness us. He made the case that developing new technology was the easier part of the battle towards sustainable mobility and that the real challenges were data sharing between private and public organisations, the integration of land use and transport, ensuring equity of access and inclusion, and the impact new technologies would have on existing professions. Given the potential for leaving behind large swathes of the existing labour market he emphasised the need to have a much broader discussion about sustainability – it must include those promoting data privacy, equity and inclusion and workers' rights.

During a wide-ranging discussion the panel looked at the importance of safety and equity when considering sustainable mobility, how to ensure effective ITS technology and solutions were affordable for many and not a luxury for the few, and how to make them viable for businesses. They agreed that creating platforms that were scalable and open was an integral part of the answer. We should continue to focus on creating partnerships for the sake of customers, that could overcome the well-known challenges of trust and legal barriers that come with data sharing.

The panel also discussed how the pandemic led to the increased demand for the fast delivery of goods and their associated environmental impacts. Whilst many technologies already existed to minimise this potential impact such as electrification, the trend also prompted many questions over the use of existing space such as kerbsides or parking areas and we should recognise that we may need to rethink urban areas or develop entirely new solutions.

PLENARY 02 | Delivering safe, efficient and integrated solutions

Moderator:

Joost Vantomme	**ACEA; Belgium**

Panellists:

Tobias Miethaner	**Federal Ministry of Transport & Digital Infrastructure; Germany**
Kristian Hedberg	**DG MOVE, European Commission; Belgium**
Gilles Mabire	**Continental Automotive; Germany**
Michael Bueltmann	**HERE Technologies; Germany**
Daniel Deparis	**Mercedes-Benz AG; Germany**
Young-Jun Moon	**KOTI; Korea**
Ramin Massoumi	**Iteris Inc; USA**
Roger Millar	**Washington State Department of Transportation; USA**

The moderator welcomed everyone and explained that the aim of the Plenary was to look at what was being done globally to integrate mobility services to bring about efficiency and effectiveness gains and ask some questions about the ways forward – for example

- How do we develop the regulatory framework and operational standards needed for the wide-spread deployment of multimodal services, mobility on demand and MaaS?
- What are the best ways to integrate automation in our mobility services and systems?
- How can we ensure that time-sensitive bottlenecks such as pick-up timeslots of cargo, last mile delivery services or port traffic delays are under the full control of informed and cooperating logistics operators?
- How do we balance competing demands for road space, the movement of goods and passengers, micro-mobility services, and parking?
- Are we ready for extensive use of air space – air taxis, verticopters etc.

Tobias Miethaner's Keynote speech summarised the actions taken by the German government to support transport innovation. Germany had made serious investments in CAVs, including the HEAT project in Hamburg which saw automated public transport travel during the Congress. This was only possible by legislative changes put in place to enable CAVs in dedicated road space and last-mile logistics. Modernising regulatory frameworks had been an important part of enabling new solutions to be realised and must be supported by harmonisation across regions and countries – the EU's initiatives in this area had been strongly welcomed. Mr Miethaner highlighted the importance of encouraging transport innovation outside cities to promote sustainable mobility in all areas, with MaaS as a key route for this. To this end the German government had amended legislation to enable the licensing of new platforms and transport modes with a view to increasing the integration of services and promoting new options. The government was also putting its data strategy into practice by creating a data space for the secure trading of mobility data. This had not only already created several exciting use cases, but it had also being taken as the focal point for a new data strategy by the EU.

Kristian Hedberg outlined the EU's renewed blueprint for safe, efficient and integrated mobility which placed digital twins at the centre of its approach. As well as investment in new propulsion systems the new programme also challenged the sector to make better use of the infrastructure already available. As part of this policy the EU was updating the 2011 ITS Directive to include provisions for MaaS and ways to improve interop-

erability and service provision across borders. He also highlighted the upcoming revision of the framework for real-time traffic information data and the mapping of existing European data catalogues. His key message was that there was a great deal already available; we needed to bring it fully to life and make better use of it. Ramin Massoumi focused on the development of integrated solutions and how data was at the heart of this. There was a vast wealth of data already available in the modern world (for example, our mobile phones turn us all into sensors) and cities, municipalities and organisations were seeking reliable information to make better decisions. There was a clear move from reactive to more proactive use of data. But we could only capitalise on this if the raw material was good quality and this required us to invest in standardising datasets so we can make best use of what we already have.

Daniel Deparis outlined how Mercedes-Benz was driving forward the development of new transport solutions through partnerships with local government, academia, charities, and businesses. Its approach was centred on co-creation which he suggested could be seen as a bit like cooking – if we combined what I have in my fridge and what you have in yours, what could we make together? This included reusing existing assets (hardware, software, data), applying existing solutions to new contexts (eg using traffic data to make streets safer) and ensuring all partners were operating at the same speed – and he gave the warning that cities work much faster than people think.

Michael Bueltmann highlighted that the importance of data sharing had been one of the major lessons from the development of CAVs ie no organisation can do it alone and we must work in partnership. He drew comparisons with the development of the coronavirus vaccines where confidence in trial results came from comparing data across competitors. Good use of data also had a massive role in achieving our climate targets, including trying to reduce journey length by minimising the search for parking, for example. Mr Bueltmann welcomed initiatives for data regulation but warned that focusing too much on regulation can often make innovation fall by the wayside. Since data is about playing, if we make the scope too narrow we risk not being able to play anymore.

Giles Mabire made the case for trying to look at smart mobility not from the perspective of one category but across the system. This involved an end-to-end approach to solutions so that new and efficient technologies were developed in line with regulation, and highlighted the importance of flexibility so that industry can connect to different ecosystems across cities, regions and places. Whilst industry could produce new solutions, clear standards and interoperability were needed for them to be scalable.

Young-Jun Moon reminded that a debate at 2010 ITS World Congress in Busan, Korea, had discussed this same topic and questioned whether progress had been made since then. He suggested that while we probably have not made things better, our community had probably prevented it from getting worse. As an example of the challenges faced by our community he cited a case from Korea where the early setup of public transport systems had led to well-known traffic problems despite strong commitments to make the site a smart city from ITS deployment. Efforts were now focused on deploying CAVs to improve mobility.

The panel discussed how to promote partnerships with a real appetite to drive issues forward. An important part of this rested in establishing partnerships which set the research agenda from the outset so that it was co-created by both industry and markets. The harmonisation of data platforms and operating environments were also seen as cornerstones – these can create new or wider markets and spur innovation. This was important so that we could harness the terabytes of data which already exist and which demand huge efforts to understand them, instead of producing actionable information. Standardisation of data would enable better quality data and insights by moving us from ‘raw data’ to ‘enriched data’. Progress on this front required hard work and close collaboration. Through this, it would also be possible to reduce existing ‘data lakes’ whereby large corporations have most or all the data in a particular area or theme.

PLENARY 03 | Navigating data marketplaces in Smart Cities

Moderator:

Steve Dellenback	**Southwest Research Institute; USA**

Panellists:

Max Lemke	**DG CONNECT European Commission; Belgium**
Monali Shah	**Google; USA**
Christian Kaiser	**Volkswagen Group Info Services AG; Germany**
Philip Tseng	**Far EasTone Telecommunications Co., Ltd; Taiwan**
Shailen Bhatt	**AECOM; USA**
Shah	**Washington State Department of Transportation; USA**

Dr Dellenback opened by saying that digital transformation, underpinned by the Internet of Things, Artificial Intelligence, Machine Learning, Big Data and Advanced Analytics, had sponsored innovations and services that had reshaped transport systems and changed the way we live. Digitalisation was helping the development of automated mobility and new services and the much anticipated "ubiquitous future connectivity". Connected Mobility was expected to take us towards more intelligent, more sustainable and safer traffic systems. Copious data were collected daily by a multiplicity of stakeholders for diverse ends. However the true value of the data generated and collected would only be realised if the different actors collaborated in an organised way in standardised and regulated data marketplaces. The Plenary would discuss the role of such data marketplaces for mobility ecosystems and the challenges in meeting different stakeholders demands. It would also consider some key issues such as:

- How could we ensure that data marketplaces offered digital openness and viable business models while simultaneously safeguarding privacy and security of users' data?
- Who truly benefits in a data marketplace? How can we ensure ethical behaviour and equity?
- How is connectivity technology, as part of a broader and continuously evolving Internet of Things, being integrated into the latest traffic and public transport products?
- How will the next generations of mobile networks help to meet demands for secure, robust, uninterruptible communications coupled with ubiquitous connectivity?
- What technologies might we use to better connect infrastructure and mobility services that also ensure rural and suburban areas share in all the expected benefits?

In his Keynote Max Lemke outlined that transport has an important role in key EU priority areas, such as reducing carbon emissions as part of its "green deal" or making mobility smarter to become fit for the digital age. Data sharing was sitting at the centre of all these areas but it was riddled with challenges: reluctance to share data, dominance of large platforms, and fragmentation of the data landscape. Mr Lemke reviewed some of the key actions by the EC to address this. There was a focus on designing an EU-wide data strategy and the creation of horizontal legal frameworks to enable the creation of digital markets, strong data governance and high-value datasets. The EC was also taking a sector-based approach to its legal framework for data – recognising the need to update the 2011 ITS Directive. It was investing in the establishment of European data spaces, including mobility data, that would ensure good data governance whilst promoting better data usage and interoperability across technology areas such as 5G or AI.

Monali Shah emphasised the importance of having a clear focus on the questions and problems we were trying to solve in mobility. Only when we have established what these are can we then turn to data and converting it into insight. She made the case that, to truly promote change and progress, we must empower an open ecosystem. Her organisation aimed to do this by making data openly available on its platforms and make all of its tools available so that anyone could use them. Making them accessible was seen as a critical part of democratising technology.

Christian Kaiser highlighted the fundamental role played by industry in data marketplaces and how data-sharing initiatives must involve industry. This enabled companies to explore potentially new business models and improve the services they already offered to customers. He described how Volkswagen was planning to launch over 20 new data-based services over the next two years and invited the audience to come forward to collaborate and develop new services.

Philip Tseng described how open APIs can help others overcome challenges in collecting data by making it accessible for anyone to use and apply in any area. As a topical example, mobility data could be used to notify individuals when they had come into close contact with someone due a follow-up Covid-19 test. Alternatively, 5G connectivity could enable customers to use mobile apps to find parking spaces and reduce journey duration and length. He argued that examples such as these highlighted the importance of system integration to connect services and data together to enable innovation.

Shailen Bhatt made the case for a stronger focus on the outcomes we seek for our communities and also challenged the audience to think about the broader implications of our efforts in ITS, such as equity or climate. For example, one study in the US had investigated the relationship between access to prenatal care and public transport, showing that health outcomes for children were much better when mothers had access to public transport. He argued that this type of lateral thinking must drive our ITS work.

As part of the discussion the audience voted on who should have responsibility to protect individual data – around 70% of participants voting for government and 30% for industry. The panel discussed the need for collective action from all players, although governments should set the ground rules and establish frameworks. This would also enable us as a community to be clear to customers about what data we hold and how we are collecting it. With respect to whether more effort was needed in data standardisation, 70% of the audience agreed that this was the case. The panel agreed that we must think about equitable access as part of this process: when we talked about data standardisation, we needed to ask which communities had been left behind? For example, communities of colour and in lower income areas had poorer access to mobility (and in turn less economic opportunity). Our work must include data that enables organisations to tackle such questions so that we can move towards more equitable access.

The panel also discussed approaches for data standardisation between different parts of the globe and the need to build trust in organisations that hold our data. On cybersecurity, three different approaches were discussed: a technically-focused model where trust and security were achieved through strong data architectures, a more open approach based on trust but which could be easily lost, or a more context-dependent one that was sensitive to different geographical and culture regions or types of data (eg healthcare, mobility).

EXECUTIVE SESSION 01 | **Where are all the CAVs?**

Moderator:

Beth Kigel	**HNTB Corporation; USA**

Panellists:

Randell Iwasaki	**Amazon Web Services; USA**
Aria Etemad	**Volkswagen Group Innovation; Germany**
Steve Kuciemba	**WSP; USA**
Bernard Schmidt	**Jacksonville Transportation Authority; USA**
Jong-Oh Kim	**Ministry of Land, Infrastructure and Transport; Korea**

Ms Kigel welcomed delegates and speakers. To launch the session she reminded that for a number of years several high-profile carmakers and tech companies had made bravado announcements about how rapidly fully self-driving cars would be available for the public.

It had been an exciting time, full of the promise of future AVs that would improve driving safety and provide independent mobility for people who could not otherwise drive themselves. In the years since these announcements, the blame for the lack of progress had targeted lack of national legislation, conflicting regional regulations, insufficient sensor capability, unpredictable pedestrian or bicycle behaviour, and the need for measures that could establish how safe was "safe enough". At the core of the AV promise were innovative operating systems promising business models that would drive investment and development, and sufficiently proven safety systems to assure technologists and society.

The session would bring together international public and private sector experts to provide an update on the current status and anticipated progress of innovation, testing, and public acceptance of highly automated vehicles. Key questions were where do we stand with reference to the key systems? What can we expect from the different modes and models of automated vehicles, such as last mile delivery vehicles, shared passenger vehicles, long-haul trucks, low-speed shuttles?
In a Keynote address Randell Iwasaki reviewed the history of Connected and Automated Vehicle (CAV) development, beginning with a discussion at the 1996 World Congress in Orlando on 'automated highways systems' and the first worldwide CAVs trial consortium which had sparked his passion for ITS. But it had been challenging to identify the impact of CAV projects since then.

Regulatory frameworks had changed significantly since those early days when the US Federal Government would initiate consortia and bring regulation closer through sponsoring innovation. For example, legal amendments had been required in California to remove the requirement for steering wheels and enable further development of CAVs. He also illustrated how the community had used testbeds to push developments to their limits and the now numerous deployment projects taking place around the world.

Aria Etemad described how the first pan European field test covered 35 million km of data with around 1,000 vehicles across several countries. He emphasised that in absolute terms the complexity of automated driving was not particularly high, the challenges lay in relation to the overall operating environment and at the start the community had underestimated its complexity. The evolution of the CAV project showed us clearly that this was not a sprint but a marathon.

Steve Kuciemba highlighted the need to see vehicles and infrastructure as a holistic system – they must work

together. Although recent years had been marred by negative stories about CAVs in the press he emphasised that there had been several positive developments during this period which the community must bear in mind such as the use of automation in delivery and logistics. Mr Kuciemba argued that we must push hard for the connectivity element of CAVs as it is an important layer on top of automation – we needed the connectivity element to retain a systems view.

Bernard Schimdt gave an overview of programmes led by the Jacksonville Transportation Authority which had brought CAV to reality such as the Ultimate Urban Circulator and the Test and Learn Program. A key focus of these projects had been to build on the use of existing infrastructure by introducing CAVs to better connect communities. As part of this they had received a grant to develop a pioneering autonomous public transport system in a partnership involving local and federal governments. He also described how they had brought CAVs to real-world applications during the pandemic by using low-speed shuttles to transfer Covid-19 tests samples between sites.

Jong-Oh Kim described the current status of CAVs in Korea and the progress of Korean ITS since the 1990s. Much effort had been devoted to institutional and technical preparation through the development of standards, certification and security systems, including current implementation projects and expected nationwide rollout in 2024. He demonstrated the evolution of CAV investment over the years and projections for a rapid growth ahead of 2025 – an almost doubling of current investment was forecast. Mr Kim outlined the key priorities for the Korean government in ITS and CAV development which included investment in smart infrastructure, raising public awareness and understanding, close collaboration with the private sector and initiatives to support technology development (eg sharing big data, creating testbed facilities, etc). Finally, he gave the example of Gangneung where to tackle problems derived from high tourist influx there had been serious efforts to make it a CAV-based smart city through the largest ITS budget for small and medium cities in Korea.

In an extensive discussion the panel considered some of the reasons behind the apparent slow down of CAV evolution in recent years. Reasons included the sheer complexity of the task at hand and the need for a large ecosystem with many different players which required strong coordination. It was also relevant that the various companies' product cycles across the infrastructure, vehicle and technology sectors were significantly different and there were also challenges derived from their different working cultures.

There were many lessons to be learned from existing efforts which should help us accelerate development and deployment. The panel highlighted the need for more, and more inspiring, leaders able to make bold decisions and push local agencies to turn prospect into reality, as had been done well in Jacksonville. This example also highlighted the importance of incorporating real understanding and trust by the public – but even so there was still some way to go.

The discussion also looked at the measures needed to ensure vulnerable road users were protected and the challenges placed by the urban environment. To enable progress with these difficult issues we needed to look beyond the vehicle itself and incorporate physical infrastructure and planning – particularly important points given how challenging and costly it was to change infrastructure. Strong evaluation methods must be incorporated in the answers, although the panel recognised that the rapid pace of technology development made this an additional challenge.

EXECUTIVE SESSION 02 | **Future Mobility; Future City**

Moderator:

Gino Franco	**Swarco Mizar; Italy**

Panellists:

Michael Hofmann	**Audi China R&D; China**
Maree Bridger	**Department of Infrastructure, Transport, Regional Development & Communications; Australia**
Anna Fedeles	**Australia Trade & Investment Commissioner for Germany, Switzerland, Poland & Austria; Australia**
Season Chan	**Transport Department, Hong Kong Government**
Paul Xia	**Zhongguang International Hong Kong Co. Ltd**
Jarrett Wendt	**Spoke Safety; USA**
Julien Toulouse	**Toulouse Metropole; France**

Gino Franco opened the session by reflecting that the thriving and continued development of information technology had fundamentally changed our concept of mobility and was leading us into a new era. Mobility transformed by the development of new cutting-edge digital technologies would reshape both people's daily lives and the environment around us. On the one hand the impacts of future mobility would reshape the city and take it towards to a new age based on seamless connectivity and numerous new services. On the other hand the innovative technologies deployed in the future city would bring a wider ranger of mobility opportunities.

The session was an opportunity to pause, take stock and consider:

- What opportunities and challenges do we have when facing the future mobility and future city?
- What policies and strategies can we choose?
- What technologies and solution can we apply and deploy towards the future?

Michael Hofmann explained in his Keynote address that one of the societal lessons from the Covid-19 pandemic was that private transport is considered a right. Given the growth of EVs, the public expected that charging infrastructure would be as easily available as fuel stations, with a similar charging experience. This demand for growing EV infrastructure created both an opportunity and a need to make our cities smarter, alongside our cars. Much of this could be achieved by exploiting the advantages offered by 5G, including real-time vehicle data, which, in turn could accelerate the development of data security standards. He argued that policymakers and legislators had to move fast to put in place the necessary instruments and legal conditions to support much needed development in this area.

Maree Bridger made the case for the importance of national approaches for the development of future mobility approaches within cities, as well as wider connectivity with other services. She argued that one critical aspect of this was how governments collaborate with private companies who could support the development of solutions in areas where innovation was most needed. These partnerships must also bring the user and communities to the heart of ideas – to unlock the real benefits of smart cities, they must serve the interests of communities, so they must be part of the co-creation process.

Season Chan speaking through a recorded message outlined the approach taken in Hong Kong around smart mobility. He explained how every type of 'mover' was

being considered in their work, from motorists and passengers to pedestrians. The experience in Hong Kong had shown what a number of cities had learned: that some of the challenges they faced could not be tackled by building more or better connected infrastructure – it required placing user convenience first. For example, the development of a free-flowing tolling system was being rolled out in phases so that users could opt to pay either manually or automatically to accommodate for different needs.

Julien Toulouse outlined the mobility objectives set by Toulouse to decarbonise transport and reduce congestion in the city – a particular challenge given half a million more journeys were expected for 2025 compared to 2015. The city aimed to continue its approach to being an urban innovation lab. This included approaches to reduce the overall need for mobility by creating the conditions for people to remain in their neighbourhoods.
Paul Xia described how cities of the future could function in a more sustainable way in the face of our current challenges, particularly climate change. He argued that opportunities were always presented at the same time as challenges emerged and made the case for the transformative potential of the key technologies available in our sector for example MaaS, automated and autonomous vehicles, and digital smart infrastructure. To harness this trend his company was developing a 'digital brain' which combined cloud computing, intelligent storage and connectivity, bringing them together to provide smart solutions.

Jarrett Wendt explained Spoke's mission to protect the most vulnerable road users such as cyclists. To support this they had developed a small device to enable the connection of vulnerable road users to the wider environment through sensors and cameras attached to a backpack or to an e-scooter. It used three levels of connectivity within the traffic ecosystem integrating vulnerable road users, vehicles and cloud computing, with plans to expand it to visual representation within cars quite soon following a partnership with Audi.
The session discussion started with a debate on the extent to which city-level interventions required national-level coordination. The panel agreed that there was a huge opportunity for policymakers to develop policies that were fit for purpose and enabled city innovations to be implemented. In Australia the national government was providing leadership and establishing frameworks and standards, providing testbeds and attracting manufacturers, although the domestic market was not huge. In France efforts had been focused on setting up public-private collaborations including testing and R&D facilities. The panel noted also the importance of investing in skills and training and working with partners outside the mobility sector as innovation often flourished at the edge and in the overlaps between sectors.

The panel also discussed ambitions for the future for different cities and regions, particularly given that mobility is such a big part of the quality of life. There were huge opportunities for cities to become hubs of innovation and lead the way in mobility technology, inspire national policy and support their citizens in flourishing. Placing communities and users at the centre was a fundamental part of this. But consideration also had to be given to how we could better connect less populated and rural areas, and how to create solutions that did not depend on location so they could be transferred more easily.
Equity and privacy were also important topics of discussion since not everyone had access to mobile technology or might be willing to use sensors. How might we also develop safety enhancing innovations that could be used universally similar to the seat belt? It was noted that safety was not always driven by the end user and must come from above, including the manufacturer. But above all the user wanted convenience.

The panel also agreed that smart mobility trials were essential for city-level innovation, including those examining behaviour change – we must understand not just what has worked but also why it worked.

EXECUTIVE SESSION 03 | Digital evolution or digital revolution?

Moderator:	
Joachim Klink	**T-Systems International GmbH; Germany**
Panellists:	
Markus Schlitt	**Yunex Traffic**
Suzanna Kraak	**DG RTD European Commission; Belgium**
Christa Koenen	**Schenker AG (DB Group); Germany**
Monali Shah	**Google; USA**
Anna Fedeles	**Australia Trade & Investment Commissioner for Germany, Switzerland, Poland & Austria**
Chris Bennetts	**Transport for NSW Australia**
Julien Toulouse	**Toulouse Metropole; France**

Joachim Klink welcomed delegates and speakers and opened proceedings by noting that we have already experienced massive change in our daily life brought about by the arrival of affordable and effective technology innovations. And we should take note – there was more change on the way. But were we perhaps overloading the end users? Were we providing complex products that were not accessible to all? This session aimed to review some of the challenges for deploying future digital services, and consider whether we were accidentally dividing younger and older; city dwellers and suburban/rural livers; users of motorised vehicles and cyclists and walkers? How could we make sure that we did not exclude some users or some categories of the population from access to information that was adapted to their individual needs and circumstances?
The session would look at the best ways to balance digital openness with privacy and security and try to answer the question "Where does the burden lie in ensuring ethical behaviour and equality of opportunity in connected and automated mobility"?

Markus Schlitt delivered the Keynote address and argued that the scale of the challenges we faced in relation to carbon emissions in transport meant that we simply did not have the time for digital evolution in how we delivered mobility – we needed the revolution. But to enable this we must face barriers within our own sector. There was already a vast amount of data in the world, with some estimated 44 Zettabytes (or 44 Billion Terabytes) and lots of good quality, useful data. However, much of this data was not shared and remain unused. To enable this much needed revolution we must better connect the dots and move from our current 'egosystem' approach to focus on the 'ecosystem'. Only with such a shift in mentality might we find the solutions and answers to our problems. He put the case for working much more closely with industry and in turn pushing industry to work more openly with their data – and they should also trust using our own because we have no time to lose.

Monali Shah explained that on its own data has no value. It only becomes useful and has meaning when we use it to generate insights and address our questions. Whilst we spend a lot of time talking about the need for data to be shared, of good quality, standardised etc we do not focus enough on discussing the questions that really matter or sharing the tools we use when working with data. Google sought to do this by adopting a '10X thinking' approach, whereby it focuses on the world's biggest questions and then works to democratise technology by making data and tools available for anyone to use them.

Suzanna Kraak argued that regardless of whether it was a revolution or evolution, what mattered was that we pushed to bring change to our mobility systems – transport was a key battleground in our climate and green agenda, and an area where innovation and new ideas were really needed. She made the case that this must come with a focus on regulation and governance through creating a shared understanding of our common goals and considering the wider ecosystem and impact of our activities. She suggested that talking about evolution or revolution in the digital world implied that they are out of our control. Whilst that was not the case we certainly needed to agree a shared pragmatic, inclusive and holistic vision for transport, focused not on individual needs but on the collective needs of our societies and communities.

The panel discussed whether shared objectives and goals should be enforced for R&D projects. This was potentially important to ensure that the benefits of smart and sustainable mobility reached all areas and communities, or we risk letting companies focus exclusively on more profitable opportunities – which will typically be in central or urban areas, less so in rural ones. But whilst there is value in stipulating such requirements, care must be taken not to over-specify them so we do not risk stifling innovation or choosing a particular technology which may not be the best suited in the long run. One example given of such challenge-driven and user-centric approach was within the EU's Horizon 2020 where CAV projects were opened up to include the wider needs of citizens, beyond a sole focus on customers.

Consideration was also given to how governments enable the development of new approaches to mobility. The panel noted that governments must lead the way but ultimately the technology itself has to be invisible to the user or consumer – it is hidden 'underneath' and all that matters is the benefit and its impact. That was why user-centric design was so critical. One example of government action in such a way came from Chris Bennett who explained how the local government in Sydney, Australia, had opened up its mobility data by making it all fully available in real-time and anonymously, including ticketing and carriage weight data. Despite much initial criticism the local government focused on 'partnering really hard' with industry via its transport digital accelerator. The idea was to focus on setting the problem in neutral terms, thereby letting businesses develop solutions, and making sure that government would be the first customers for the products developed. This clearly demonstrated how governments could set the key problems and questions for businesses to innovate towards and help solve them.

Anna Fedeles emphasised the need to connect wider society with innovation, empower communities to be involved from the bottom up and tackle the digital divide within our society. Many communities were currently left out from opportunities offered by digital technologies as well as being under represented in existing data sets. To tackle this the panel suggested we should aim to bring a fresh perspective and challenge existing assumptions, approaches and any big players in the field. The first step towards this lay in articulating our shared goals and needs – this would enable us to create focused partnership to solve them together.
Some large corporations were also trying to play their part in reducing the digital divide. Monali Shah explained that for example Google was helping to tackle the world's biggest problems by organising the information available globally and then making it accessible by putting its tools available for anyone to use it online. In this way we can make massive information accessible not only to tech experts but also to policymakers, academics and wider businesses.

Christa Koenen gave an overview of the challenges faced in the logistics and cargo sector, where the logic when it comes to moving from A to B was markedly different when compared to passengers. Last mile delivery in urban areas had become a major challenge for the sector, including the shift during the pandemic to 'give the street back' to pedestrians. To decide how to give a fair share of streets to all players (from pedestrians and cyclists to cars and logistics), we must first agree on our priorities. She argued that we must bring a stronger voice of freight into our communities and discussions since the sector represented 'half of the problem'.

EXECUTIVE SESSION 04 | Smart traffic management: removing the roadblocks

Moderator:	
Jeroen Brouwer	**TomTom; The Netherlands**
Panellists:	
Martin Huber	**Ministry of Transport and Mobility Transition; Hamburg, Germany**
Rodrigo Castiñeira González	**Indra; Spain**
Marcus Anders	**SWARCO Traffic Systems; Germany**
Sameer Sharma	**Intel; USA**
Wen-Yuh Leu	**Freeway Bureau, MOTC; Taiwan**

Jeroen Brouwer started the Session by suggesting that in recent years the growth of vehicle-infrastructure connectivity, increasing numbers of on-vehicle sensors, advances in connectivity technologies and massive expansion of computing power had combined to open a world of improved traffic management solutions for city and municipal authorities. Real-time, integrated and data driven traffic management was a key benefit from connected vehicles and led to predictive as well reactive solutions. Traffic management that was data driven, interactive, and based on the cooperation of all actors in the sector delivers represented gains for everyone. City authorities were better placed to balance the individual needs of citizens with the system-wide city requirements for efficient mobility throughout the network. Traffic management centres were better able to optimise flows and ensure safety while fleet managers had a much sharper focus on the efficient and effective operation of their vehicles.

The aim of the session was a review of the ways in which smart traffic management could help to address the needs of all classes of all stakeholder, and explore what types of incentive needed to be in place for all the actors in the network to work together rather than individually.

Martin Huber's Keynote presentation argued that the focus of a Ministry's policies should go well beyond simply removing roadblocks: they should be about improving the wider transport network and mobility. This was important in order to promote better quality of life, tackle climate change, create more liveable places and so on. This was why Hamburg had plans in action in several areas such as improving the public transport offer by expanding bus services and bike lanes, and converting current analogue prioritisation systems into C-ITS platforms. As services evolved and expanded it was essential to consider the interests of local communities very seriously and take into account the public's view on what success meant in order to win their trust and support. The formula for success had many components and it involved having reliable real-time data, power interfaces between stakeholders across all levels, harmonised frameworks for standardisation and translation of services across borders, and environmentally friendly forms of mobility. He hoped he had made a strong case for why good traffic management must not be underestimated and must be taken seriously if we are to truly bring benefit to our communities.

Marcus Anders gave an overview of SWARCO's work which aimed to tackle the mobility problems of today as well as the expected future ones. As an international company their activities and traffic management solutions were in use across the globe, ranging from traffic light controllers at small or very large junctions to more central integrated systems. Other areas included parking, traffic signs and CCAM, as well as inter-city mobility services such as motorways. Mr Anders stressed the im-

portance of having systems integrators whose business interests were a broad portfolio that enabled them to take a wide systems view.

Sameer Sharma described the importance of adopting a 'global team' approach to our investments in technology developments for ITS. Many powerful tools were available ranging, from AI and 5G to cloud computing, but the difficult question was how do we create a truly vibrant ecosystem? It was only when we worked together that we could think of overcoming our biggest barriers. He reminded that the high level global view had to be balanced with the need to take a 'hyper-customised' approach, so that we could continue to be sensitive to the priorities of local places, from mobility and public safety to sustainability. He challenged the audience to first focus on the types of solutions and technologies we should invest in, so that we could then create partnerships between the right players.

Wen-Yuh Leu gave an overview of Taiwan's activities to tackle congestion problems using ITS. She highlighted the benefits that had followed from making its big data platforms open and publicly available and how this had enabled new solutions to be developed and applied to traffic management systems. This included the application of weigh in motion systems to electronic toll systems and to traffic management more generally. Looking to the future, Dr Leu highlighted smart parking and fleet management as some of the priority areas for Taiwan going forward, and made the case for a stronger involvement of citizens as part of partnerships between private and public sectors.

Rodrigo Castiñeira González described how his company's activities spanned a number of sectors, in particular transport, defence and security. By using a cross-modal approach they were able to bring together data from different modes (eg highways, trains, buses) to develop traffic management solutions applicable across the full transport network. He highlighted the importance of looking beyond typical transport-focused parameters and instead looking at wider impacts, from potential improvements in quality of life to more sustainable transport networks.

In a vigorous discussion the panel shared their perspectives over what were the biggest roadblocks expected for the coming years when developing better traffic management. Creating space for walking and cycling was seen as a particularly important bottleneck – how do we share our already spaces that are already limited and under pressure? Given the challenges in creating infrastructure (time, cost, space etc) this was a major constraint. One way suggested to tackle this was improving current data sharing approaches so that we could start to break down silos between transport modes and better integrate them across our networks. It was also emphasised that the main challenges were all outside the technology space and in the remit of policy, regulation and funding – if it was just technology we could easily solve our problems. These challenges were made more prominent by the changes resulting from the coronavirus pandemic and the trend for increased urbanisation across the globe. Panellists also stressed that that much of the community's technology still remained in the research space and this and the fragmentation across regions and countries were particular barriers that had to be overcome.

The panel then considered how to tackle the return of congestion to pre-pandemic levels. Whilst the impact of this problem was big the discussion emphasised that congestion was mostly restricted to quite limited time periods and therefore did not justify massive changes to infrastructure. Instead, we must make better use of data and technology to create truly dynamic and adaptive networks. Although this had been an area of significant efforts over the years it was suggested that initiatives such as the low emission areas becoming very visible in the EU would force new solutions to appear. Covid-19 had accelerated these discussions and the development of potential solutions, and this should be welcomed.
Another key area of discussion was whether governments were well-equipped to enable traffic digitisation to become reality. The panel agreed that there was a lot of heterogeneity across different places and progress was too heavily dependent on individuals and personalities. One way shown to work well across the world was government taking leadership in setting the challenge and problems to be solved, alongside creating strong partnerships with businesses who could then develop and test solutions that were scalable.

The challenges of data was also a key theme of discussion. More than one speaker stressed that the data rev-

olution was not “coming soon” – it was already here, and to capitalise on it we needed to create public-private partnerships to turn existing data into insights. This did not need new data just the ability to harvest and use what we already have. One way to achieve this was bringing different datasets together – it was at the intersection of different areas that knowledge emerged and innovation really happened.

In terms of data standards, the panel agreed that there was no single solution which would enable the community to make progress. It required collaboration on each use case plus ensuring the various existing interfaces could come together to speak to each other. Developing such a ‘aggregation layer’ would truly enable innovation but it had to be done with safety and security as top priorities.

EXECUTIVE SESSION 05 | Implementation of Green Intelligent Transport Systems (G-ITS)

Moderator:

Young-Jun Moon	**KOTI; Korea**

Panellists:

Young-Jun Moon	**KOTI; Korea**
Jung-Ming Chen	**Department of Transportation, Taipei City Government; Taiwan**
Seok-je Lee	**Gangneung City; Korea**
Steve Dellenback	**Southwest Research Institute; USA**
Victoria Sheehan	**New Hampshire Department of Transportation; USA**
Pierre Lion	**AKKA Research; Belgium**

Opening the Session, and also delivering the Keynote address, Young-Jun Moon explained that the session aim was a wide-ranging discussion on the concept of green intelligent transport systems. This term aimed to describe an environmentally aware approach to interlinked current and future issues – how to implement a management of transport networks that was able to improve both mobility and sustainability, would increase operational efficiencies, and would also unlock enhanced safety and user-facing applications based on. Such a mobility ecosystem could build on the explosion of the shared economy for transport including partnerships between public transport and shared mobility services, as well as through green and/or eco-mobility and demand management application. The new wave of providers ought to offer multi-modal trip planning and targeted traveller information, deploying connected automated vehicles technology for fuel economy, reduction of GHG emissions and increasingly payment for services.

Dr Moon questioned whether our transport systems were yet good enough for the next generations and highlighted the imperative of making them more sustainable and environmentally friendly. He described the vision of Green-ITS (G-ITS) to add a layer of sustainability on top of ITS programmes to improve the environmental impact of our driving and modal choices, traffic management and freight. To enable this we needed to develop new measures of effectiveness in ITS which build on the typical parameters (time, cost, length) and enable us to evaluate the environmental impacts. It also required different policy instruments such as green mileage points for public transport users or taxation regimes based on travel miles rather than fuel.

Steve Dellenback described how a significant proportion of transport R&D was still focused on how to optimise combustion engines, fuel usage and reduce emissions. But there was an opportunity to bring together such programmes with CAV research to leverage connected information streams (V2V, V2I and V2X) and automation to improve energy efficiency and performance. To explore this a US project funded by ARPA-E applied ITS technology to the powertrain of a regular vehicle and demonstrated a 20% reduction in energy consumption without any changes to hardware or compromises in safety, emissions or driveability – a major return just by combining existing technologies. The benefits did not step there as the project showed further potential benefits in other areas such as optimising vehicle speed to avoid stopping in traffic, achieving an optimal balance between battery and energy operation to meet power demand or calculating routes which minimise energy consumption.

In a similar vein, Pierre Lion made the case for how much could be achieved simply by making something

new from what already existed around the world. He explained that although a lot of effort in making transport more sustainable had focused on the car there was huge untapped potential in exploring existing infrastructure. One example of this was technology developed by AKKA which enabled electric vehicles to drive on the road like normal cars but also travel in unused railways via a dedicated road-rail system – thus, using technology to reduce waste. He reiterated that our efforts in G-ITS must include making use of what already existed and which could be translated into new solutions.

Jung-Ming Chen described efforts in Taiwan to reduce emissions from its transport sector. Vehicle and ride sharing had been at the centre of their approach and their activities spanned different transport modes – for example, car-sharing usage amounted to 10,000 a day and e-bikes up to 100,000. Looking ahead MaaS was a key priority so user journeys could be simplified, alongside developing technology-driven approaches to improve community safety in the streets.

Victoria Sheehan outlined how clean transport was also an equity issue. If only those with access to cars today were able to access EVs then we would have failed as a transport community. In order not to leave people behind it was critical that we align funding investment with the needs of people and communities in a way that is inclusive and equitable. Creating truly strong and cross-cutting partnerships was at the heart of this so we could turn the great technologies of ITS into reality for all.

Seok-je Lee described the case of Gangneung, a city with 200,000 residents but one which received around 30 million tourists a year. Such a huge influx generated consequentially large transport problems for the city. Every holiday or weekend the city was flooded with tourists – but its infrastructure had been based on a budget calculated on the number of residents. What were the options available for a city like Gangneung to tackle the challenges that came with fast and unexpected growth in traffic demand and drive towards sustainable development? He described the two main options the city was pursuing. First a heavy investment in CAVs to make intra-city public transport autonomous within ten years, accompanied by promoting a shift from car usage to rail or bus for arriving tourists. In parallel it was tackling pollution and energy inefficiency by building hydrogen plants in two different areas of the city with potential technology for reducing refuelling time and energy consumption.

In the discussion the panel emphasised the need for the ITS community to become part of infrastructure planning – current infrastructure for CAVs was limited especially in urban areas. For this to succeed it was important to bring all stakeholder groups together so we could design more inclusive systems and bring the public along with us – citizens needed to hold governments to account. It was also highlighted that we cannot just push for new green technologies in isolation as we need to keep an eye on costs – a 'super green' approach might well be too expensive and so would never take off. What was the right balance?

The panel also considered further options around the challenges faced in Gangneung. Particular emphasis was given to interventions that can drive behavioural change such as increasing the cost of driving into the city as well as providing greener options that are significantly faster – if you make it more convenient, people will follow.

The role of financial incentives and penalties and how they affect equity was also discussed. The panel noted that subsidising EV sales further emphasised the existing divides. For example some people live in suburban areas because they cannot afford more central housing and increased taxes on fuel meant that they end up paying even more. At the same time it could be argued that it was reasonable to subsidise EVs given we are in a climate emergency. However it was noted that this approach would become suboptimal at some point in the transition into EVs and alternative measures, such as paying for miles travelled, must be considered despite the current low public acceptance.

EXECUTIVE SESSION 06 |

Achieving traffic safety: Herd immunity with vaccinated AVs

Moderator:

Jane Lappin	**Consultant; USA**

Panellists:

Bart van Arem	**TU Delft; The Netherlands**
Carlos Braceras	**Utah Department of Transportation; USA**
Paul Ajegba	**Michigan Department of Transportation; USA**
Satoshi Taniguchi	**TOYOTA; Japan**
Angelos Amditis	**ICCS; Greece**

Jane Lappin opened the session by suggesting that prompted by Covid we had all now learned about herd immunity – when a sufficient proportion of people in a community had been vaccinated against or were otherwise immune to an infectious disease then the disease could not spread and so the entire community was protected. Could this public health formula be applied to traffic safety and if so the key question was what level of AVs was needed to achieve the pandemic equivalent of herd immunity? And as a supplementary question were there follow-on benefits linked to reduced to greenhouse gas emissions, improved journey time reliability or energy consumption etc? The Session would discuss the safety opportunities and operational and policy challenges that emerged when modelling and simulating a safe traffic based on a future with "vaccinated" AVs providing improved public safety for all

In a joint Keynote presentation Ms Lappin and Prof Bart van Arem described research into answering the question of what would be needed to have the public safety equivalent of herd immunity for AVs. Under this view if every AV in the system behaved as a fully vaccinated agent in the medical analogue then they would offer protection against crashes from human-driven vehicles in circumstances where a collision was avoidable or foreseen. If we assumed AVs would not cause crashes, and that they could detect imminent crashes and 'absorb' human errors, they could 'spread' safety within the system.

The risk model they had developed and presented showed that in round terms the answer was that the more connected and autonomous vehicles (CAVs) you inserted into the network, the higher the number of accidents prevented once you passed a certain threshold. With a 50% CAV to human vehicle rate, the impact of CAVs was around nil but the reduction in accident rate progressed linearly from that point onwards – the more CAVs, the higher the share of accident-free runs.
Why did this matter? Lappin and van Arem argued that the introduction of Level 4 and Level 5 was a question of 'when?' rather than ''whether?' and so it was important to understand the associated impact on safety in order to manage highway networks, decide what regulations were needed, and harmonise vehicle behaviour across different manufacturers.

Carlos Braceras noted that safety was the key goal of any transport organisation and it was vital to take measures that led to improvements. There were various arguments regarding CAVs about how safe they might be and it was also necessary to take into account that people were less tolerant of mistakes apparently made by a machine rather than by a person. The 'herd immunity' analogy was a good one and would help to explain policies to the public. He reminded that in the USA the typical average age of vehicles was 12 years and this prompted some simple maths. Going to the medical case immunity for measles required about 95% vaccination and the work just described strongly suggested that safety benefits would come from a significantly lower CAV percentage. Utah was considering whether to allocate dedicated lanes for CAVs to accelerate the achievement of safety gains but this was near-impossible in inner city areas because of

space shortage. Some fairly rough arithmetic suggested that taking the expected growth of Level 3 and 4 vehicles by 2030 the Utah fatal accidents could reduce by around 50% – clearly a worthwhile gain. The message for a transport Department was to seek to accelerate the deployment of CAVs.

Paul Ajegba said that when listening to a technical argument based on numbers we must not forget that the numbers were people. The pandemic had forced a reduction in vehicle traffic for 2020 but also a change in the types of incident – with the emptier roads leading to increases in speeding. A key benefit from the deployment of CAVs that had not been mentioned so far was the ability to record near-misses so contributing valuable data to the knowledge of what was actually happening on the highways. The OEMs had delivered a number of safety processes (advanced sensors, lane departure warnings, speed advice, active safety engineering for enhanced driver protection in collisions etc) but their future focus was converting fleets to EVs. There was surely a case for pressing for timetables to convert vehicles to CAVs to secure the safety benefits.

Angelos Amditis also welcomed the "herd immunity" concept which was important for wider understanding – in many ways the Congress was one way to present ITS to a non-technical public. He wondered out loud whether it would be possible to use the same approach for system efficiency? Returning to the presentation of the research he wanted to explore what was the key element of the vaccine: was it the automation (in which case which level) or was it the connectivity? In his view the key scenario was substantial connectivity as the 'first dose' of protection with automation as the second dose. Seeking to achieve herd immunity using solely AVs would push up the required penetration level whereas the mixed scenario of connected and automated would bring it down.

There were some other points to consider – again with the pandemic example of contrary behaviour such as multi-vaccinated people becoming infected. Would cybersecurity weaknesses affect the overall rate of progress? What impact could very good or very poor investment in intelligent infrastructure have? Did we need to take account of driver training? The key point was not to consider automation as a single contributing element but as one of many technical services forming a holistic system. ERTICO was trying to move away from the connected and automated terminology and instead refer to an Internet of Mobility.

Responding to an audience question Carlos Braceras suggested that the first wave of CAV investment would be by fleet operators who were best placed to deal with the technical and legal liability issues and this would impact the deployment rates.

An audience question asked whether it was right for automation to be driven by the high end OEMs; given the safety benefits it surely ought to be government policy. What should the public sector do? Paul Ajegba felt that a clear strategy was needed by governments to explain capabilities to drivers to convince them that they should relinquish their direct control of a vehicle – which we should remember was responsible for the majority of accidents. Carlos Braceras agreed that action was needed. The usual argument was that government intervention deterred innovation so industry should be left to deliver but it was frequently necessary to pose the 'equity' question of what was the best solution for society as a whole? Jane Lappin suggested that Europe seemed to find it easier than the US to build public-private working with multiple different manufacturers and a range of different national level bodies.

Another audience question asked about the impact on equality – were we looking at a safety world that was not affordable by many? Carlos Braceras agreed that this was a worrying issue – similar in some ways to criticism of electrification where the early vehicles were significantly more expensive than the combustion equivalents. This was an area where assessing costs and benefits was tricky – for example an increase in the numbers of electric vehicles brought cleaner air for everyone. Paul Ajegba stressed that transport agencies must consider equity and the wider case of accessibility. Angelos Amditis agreed but pointed out that the history of mobility is one of trade-offs between different processes and competing investments. Services such as ABS and even seat belts were once added-cost extras but were now standard fit.

Jane Lappin thanked the speakers and closed the session with a recorded presentation by Satoshi Taniguchi who had been unable to travel to the Congress.

TOPIC 1 |

Automated, cooperative & connected mobility

The overall situation

As has been the case for the last decade, the topic of automation and connectivity had the highest number of presentations and sessions in the Congress. The topic is moving forward quickly with increasing use cases, and more emphasis on actual deployments and take-up of services. For this Hamburg Congress the topic of automation received even more attention than the connected and cooperative.

Automated

Development of automated driving use cases addressed motorway driving, automated public transport, shuttles, robot taxis, truck platooning, tele-operated vehicles, remote operation, and also indoor robots. For the elements of these systems the Congress addressed, among others, automated vehicle management, AI-related decision support systems, positioning, lane-level navigation, obstacle and object detection, perception systems, communication alternatives, OTA upgrading, and the utilisation of external information and dynamic maps.

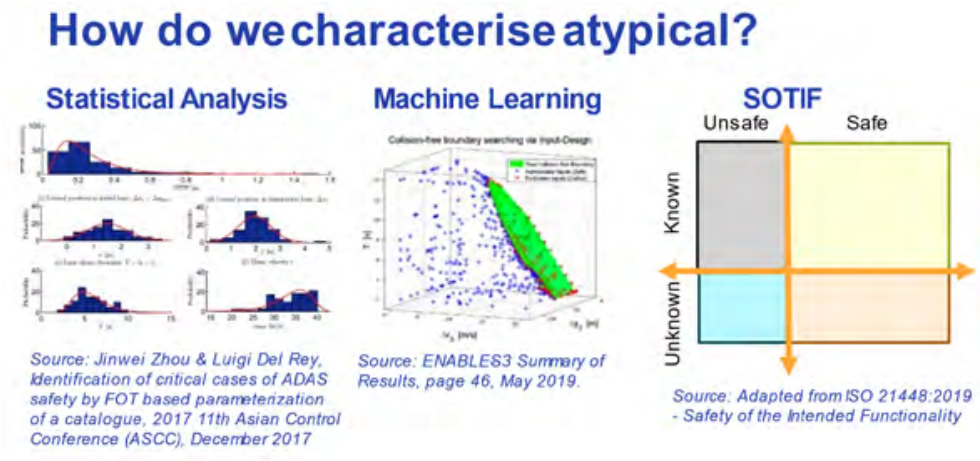
The use of AI and, in particular, the use of neural networks was explored in several cases. These included topics from building up information about parking space availability based on aerial photos to detecting traffic lights.

The challenges associated with the high volumes of data generated were considered, with emphasis on the need for reliable virtual validation.

The energy consumption of these systems was discussed and the use of spike neural networks as a less energy-intensive method was written about. Also related to the data generated, the ownership and privacy debate around the high volumes of data being collected was the topic of many questions in sessions.

The focus was on higher levels of automated driving (SAE levels 3 and 4) but a number of driver support systems (SAE level 1 or 2) were also addressed such as dynamic distance assist, infrastructure supported Adaptive Cruise Control as well as some after-market and Android applications.

The issues related to safety and security were highlighted. Specific attention wase paid to safety assurance, functional safety, risk estimation, and cybersecurity threats, and pedestrian safety. Specifically, responding to atypical situations was covered – a task humans are very good at, but a computer is not. Safety was addressed multiple times using the framework of Safety Of The Intended Functionality (SOTIF) where especially the number of 'unknown and



Jeremiah Robertson in session SIS 13 (ADS responses to adverse events)

unsafe' events should be reduced in order to create safe vehicles.
It was noted that a minimal risk manoeuvre is what the words say – minimal, but not zero risk meaning the best that can be established. We should try to get the dialogue going on what risk levels we still accept. Vehicle take over scenarios were approached in both a logistical sense and in the wider context of human-machine relationships. Factors contributing to building trust between the driver and the vehicle were considered, along with the role this plays in the interaction. Many experts presented the current knowledge on effects of automated driving on safety and network performance, energy consumption, and the whole transport system. Many of the results were obtained by simulation, which had also been the tool used for virtual validation of the automated driving systems and in various stages of system development. Interoperable advanced test beds, automated big data analysis, and automated driving scenario detection methods have been used for automated vehicle system testing and development.
Numerous living labs testing 5G enabled technologies were discussed. In particular, the ones based in ports and similar environments were able to provide high volumes of reliable and repeatable data, which was essential for testing the performance capabilities of services such as platooning which have critical latency requirements.

The social acceptance of automated driving and its use cases in different environments was discussed in detail, including the related citizen engagement. The business and governance models as well as the legal framework for the deployment and operation of highly automated driving use cases also attracted attention. Several papers explored the differences in legal approaches to CAV technology within different countries and looked into what role the law will be taking in this space in the future. Some collaborative projects to-date were described and the collaborative approach taken was presented. Results showed that companies need and want regulations more than authorities, which was a surprise to many.

A challenge discussed at many points was standardisation and the harmonisation of standards. Whilst it was widely recognised as being essential, a lack of collaboration and the rollout of specific standards not aligned with the more general ones was discussed many times. There is a lot of work to be done in this area.
The role and forms of physical and especially digital infrastructure support were discussed widely. The topics included AI-driven platform ecosystems, remote supervision of vehicles, C-ITS collective perception messaging, ODD support messaging, urban and traffic signal support, digital twins, road weather services, digital rules and regulations, transition areas, infrastructure support levels, infrastructure role itself, positioning support, 5G, and IoT. Basic questions of whether the road operator should provide any specific additional support to automated vehicles or should the road operator be given the ability to take over the control of self-driving vehicles on their networks in some specific conditions were raised but not solved. The possible responses may also have national differences as all agreed for instance that remote support was a must to have but remote control was illegal, at least today, in many countries.
The effects of automation on a network or city level were discussed only briefly. The most interesting contributions focused on the spatial impact of parking: what would happen if all automated vehicles parked in a central parking garage after dropping off their passenger? Another contribution discussed the implementation of demand responsive transit on a regional level, connecting a rural area. Although ridesharing has by nature the potential to reduce traffic, emissions and resources, this study showed that the occupancy rates were generally low, while total operator costs were higher, energy consumption was higher, and total vehicle kms driven had increased. Using demand responsive transit as first mile/last mile 'feeder' solutions for traditional public transport was seen as the most promising application. We should possibly accept that an increase of accessibility and mobility may come with negative consequences.

The benefits of data informed traffic management were commonly mentioned, yet there seemed to be few cases where these benefits were quantified or successfully modelled on a large scale, especially with consideration on the impact of those who will not or are not able to use the services. Increased, but still limited, attention was given to topics on sustainable transport, including climate change, energy consumption and possible fuel reduction due to using ITS. Vehicle manufacturers are investing in both electric and automated vehicles,

and it may well be that zero-emission will take priority over automated further delaying the rollout of automated vehicles. In general the importance of moving from small pilots and demonstrations to real fleets was highlighted. We need robot delivery vehicle fleets, robot taxi fleets, and robot truck fleets to show and experience real benefits, if such exist. The question of sharing was addressed at several sessions. While some claimed that automation without sharing makes little sense, some argued back that owning a vehicle for one's private use is natural human behaviour.

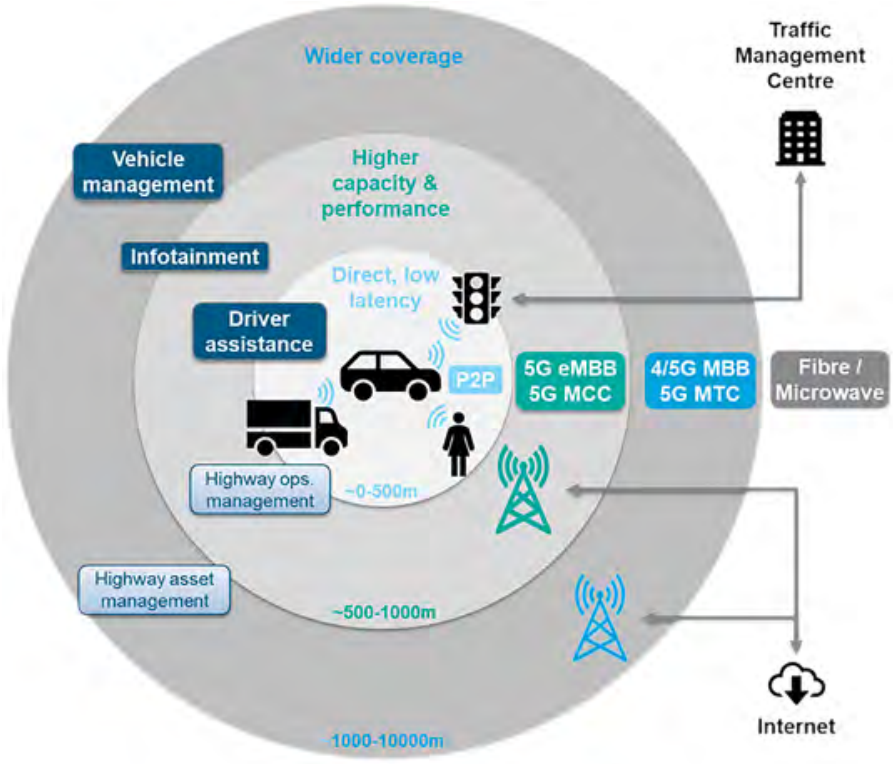
Cooperative and Connected

The state of the art for Cooperative ITS or C-ITS had moved forward and discussions dealt with its integration into day-to-day business of the stakeholders, lessons learned in deployment, and the impacts on the smart transport system. More than 80% of new cars today have cellular connectivity. The digital twin as well as roadside and cloud architectures were highlighted by many as important building blocks of smart transport. The presentation and evaluation of system architecture was a fundamental aspect of multiple papers. Data, metadata, data transfer and electronic architectures were some of the aspects discussed in detail. Considering commonalities and sharing lessons learnt with respect to making the systems interoperable and accessible were important aspects which featured in this year's papers and sessions.

The use cases included dynamic traffic management, weather responsive variable speed limits, road works warnings, intersection safety, FVD (Floating Vehicle Data) for queue protection, road surface slippery detection and eco-routing, and a number of traffic signal related use cases such as signal priorities, GLOSA (Green Light Optimal Speed Advisory), and pedestrian signals. The issues in sensor data sharing and in general, access to in-vehicle data were elaborated upon. Technical issues presented included indoor and tunnel positioning, cybersecurity of messaging, radar interference, and the comparison of cellular and wifi variants of direct short-range C-ITS communications. Special attention was given to Collective Perception Messages, ie using the information received by other cars or infrastructure sensors to form the perception of the environment.

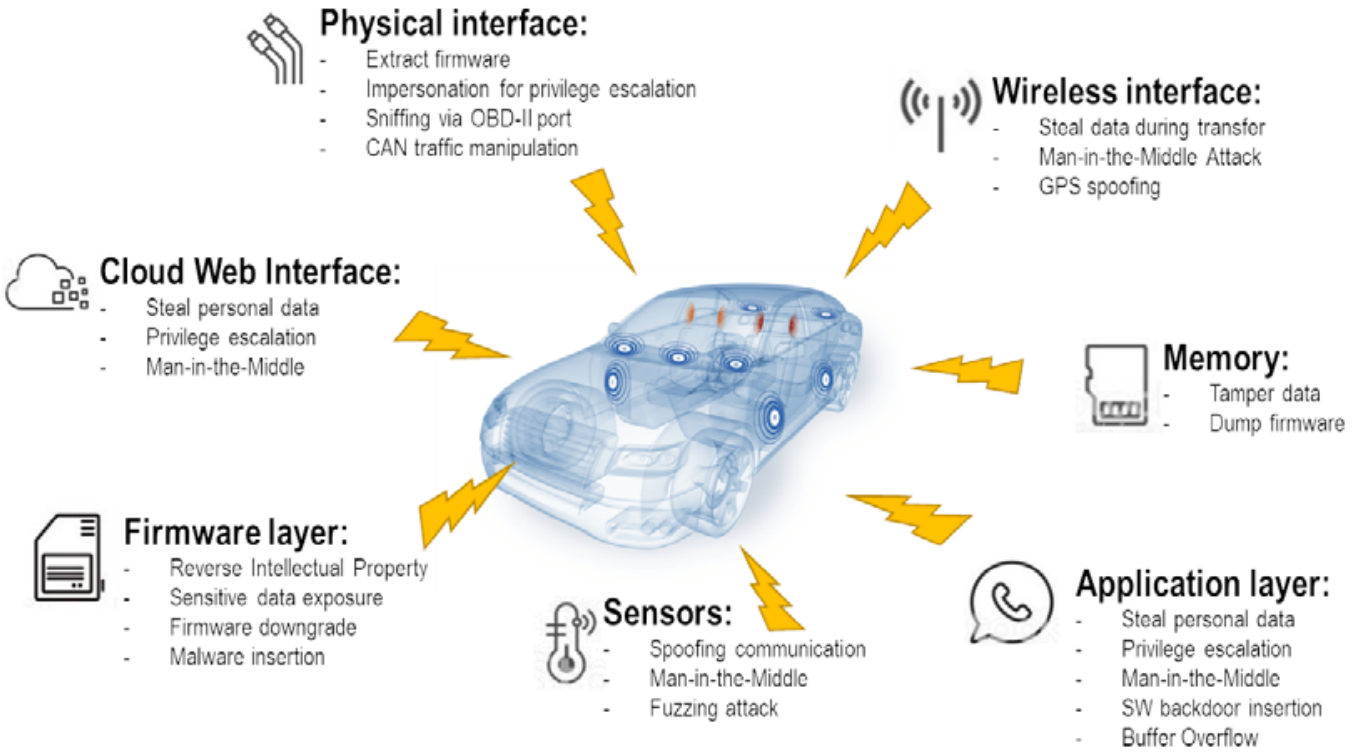
Typical attack surfaces of a connected vehicle. Michel le Rolland in session BP11.

Cybersecurity was discussed in several sessions. As one speaker put it: "The question is not whether I will be attacked – it is when will I be attacked !". New challenges were rising up all the time and they needed to be solved meaning that cybersecurity was not just a destination but a journey! Unfortunately, in many cases the cybersecurity had been an objective only in arrears and after it had become a real problem, and it was then difficult to get the personnel best prepared to deal with the issues.



Communication needs of different use cases. Jill Hayden in session SIS30

Several papers took a holistic view in exploring the challenges associated with the limitations of locational sensors, in particular, in scenarios such as intersections and locations with unusual geometries and obstacles. Insightful discussions were had around how in-vehicle and infrastructure technologies can most successfully complement each other. The evaluations of C-ITS included assessments of technical performance and interoperability as well as benefits and costs. It is interesting to see the developments from test track to



Typical attack surfaces of a connected vehicle. Michel le Rolland in session BP11.

the real world including large stretches of roads and longer time periods. As C-ITS is currently making the move from the large-scale testing stage to widespread use the importance to road authorities and operators is also increasing. C-ITS is maturing to a renowned technology to improve safety and efficiency of road traffic and hence becoming part of the toolkit for road operators to reach their core goals.

The connectivity topic also included several interesting applications and use cases in diverse domains of multi-modal transport including battery management for electric vehicles, positioning, predictive maintenance and integrity monitoring of trains, multimodal ITS supply chains including maritime links with ports as central hubs, smart wheelchairs, electric micro mobility, demand-responsive transit, environmental mobility management, urban air mobility and queue monitoring by drones. Connectivity lays the foundation for various Internet of Things (IoT) solutions and services presented at the Congress and the exhibitions. In addition to the various benefits of the services, the take up was shown to be sometimes a nightmare for a potential smart city in terms of difficult choices on technologies, mass market vision, stakeholders etc. One speaker agued strongly: “IoT and data are not an end in themselves – we need multiple technologies for real use cases solving actual problems”.

Old v New

The Congress witnessed the introduction of new ideas and innovations. One of them was the use of policy labs where a wide range of stakeholders gather to solve the bottlenecks for innovations, in introducing autonomous vehicles. Some stakeholder engagement was also discussed around the impact on the workforce who are working in traditional transport roles- something not often discussed but important to consider.

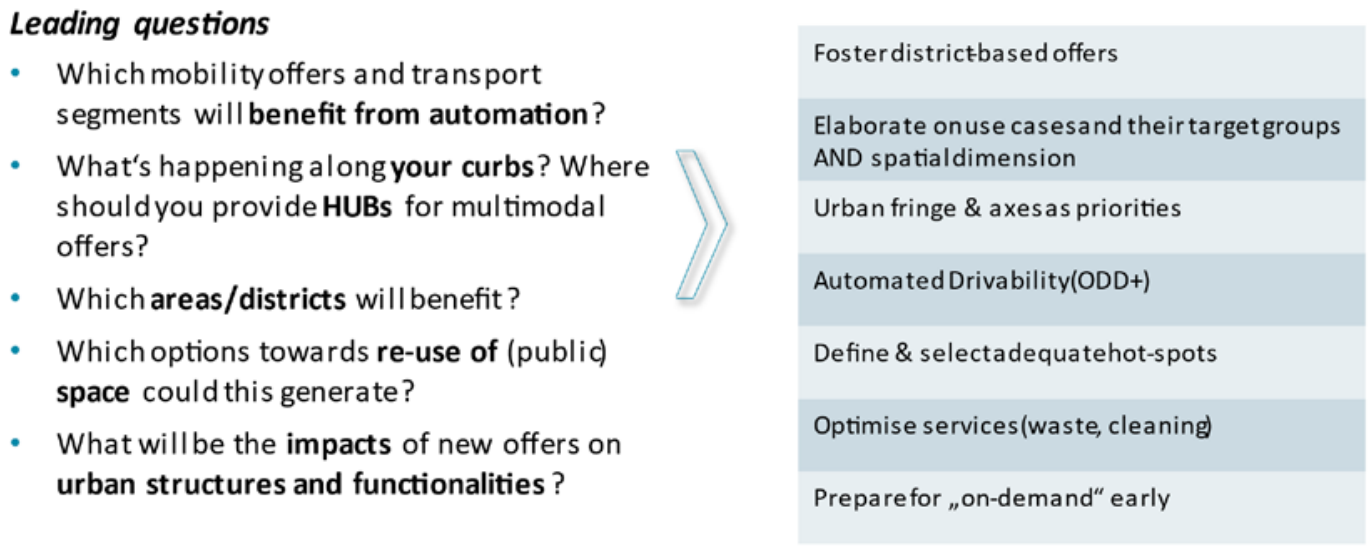
Some ideas were presented along the topic of remote or managed operation of highly autonomous vehicles – partly reusing ideas of automated vehicles running for long times in controlled environments such as industry applications. It was suggested that we try to improve the “brain” of the vehicle with support of the infrastructure, whereas a radical shift towards infrastructure-based automation might solve currently faced problems. An interesting idea was managed automated driving based on 100% monitoring by infrastructure with road capturing units (RCUs) – “at each lamp post a sensor” and 100% control by infrastructure with edge computing/ back-end – “vehicle as simple actuator only”.

The new developments in automated vehicle operations included cognitive management and non-causal reasoning as well as the empathic dialogue design for a conversational agent system based on visual information.

The C-ITS enabled Dynamic Traffic Management as a Service was a new concept for the provision of several C-ITS services as one combined service.

A platform for simulating a vehicular edge-computing environment was presented in order to generate task offloading strategies that can be deployed in a real-world environment based on proposed segmentation offloading mechanism and deep reinforcement learning.
Conflict charts were presented as promising effective design tools for cooperative driving strategies.
It was interesting to see a few observations on the actual introduction of highly automated public transport systems. A lot of successful pilot operations with automated shuttle buses have been deployed in the recent years, usually (partly) on dedicated infrastructure. However, they are hardly used permanently. Municipalities and transportation companies seem to have reasons that prevent them from operating automated bus. Today's shuttles are more entertainment than mobility – there is a need for speed and a need for fleet!
The question was raised "Why is getting an operational system up and running so much more than just running a pilot?". The road to running a commercial automated vehicle is not just technology, and is expected to gain lots of attention the coming years. In line, attention was given to the system as a whole: not just the vehicle, not just the infrastructure, but the position that an autonomous vehicle (or autonomous public transport) should get in the mobility system as a whole. Everything should come together: technology, legislation, business framework, user adoption. It was argued that we can only create more liveable cities by making a modal shift, requiring a switch from 'traffic management' to 'mobility management'.

The broad topic of accessibility, affordability, equity and diversity has been a neglected one within the ITS community for too long. In designing new mobility systems, it should be considered how travelling would look like accompanied with children, groceries, or the elderly. Accessibility in terms of wheelchair access, bars to hold, but also visually impaired, service animals and without smartphone usage is important to start with at the beginning and not just at the end of design process. In general, in designing vehicles and the system not only the "own reference" should be taken into account (eg the white, high income, men working at the transport companies).
Additionally, a lot of speakers discussed technology increasing connectivity services to include pedestrians and other vulnerable road users through small and portable devices but little talking about the social impact of this. It is important to consider how this may exclude those who can't afford it or those who don't want to wear it- how do people feel about the fact that you would have to wear a device to safety leave your house? What will this 'connected' world actually look like for someone just walking down the street?



Strengthen competences and build cooperations via engaging cities and regions to re-think mobility systems and services Wolfram Klar in session SIS 31

Forwards v Constrained

Key 'forward' issues

Digital twins and digital infrastructure support were highlighted as major building blocks of cooperative, connected and automated driving. Digital twins were being developed and deployed in several countries for various uses and use cases, still lacking a commonly agreed definition of what is a digital twin of a transport system. Future Congresses may well provide detailed proposals and answers as well as probably hosting numerous new open issues related to the digital twins.

The role of collective C-ITS perception is widely regarded to have an important role for the safe operation of automated vehicles.

In simulation, the cross-platform simulation architecture enabling the use of various software and utilising the most suitable one according to each use scenario was highlighted by many.

The shift towards a mobility user centred approach was highlighted by many. The current vehicle or vehicle driver centred approach was seen as not too successful and seen as delaying the take-up of connected and automated mobility. "Smart mobility technologies should not focus primarily on the car". A similar shift was the push for problem orientation. "Automation should always be a solution to a problem.

Key 'constrained' issues:

Comparisons of the performance of cellular and 802.11p communications attracted a high number of papers and discussion sessions at earlier Congresses; this has dramatically reduced as the hybrid communication solution has taken over as the agreed way to go forward.

The number of presentations and sessions on automated shuttles was lower than at the previous Congresses although not negligible. The interaction between the shuttles' automated driving systems and passengers (not the driver) in situations such as safely stopping at a bus station, comfortable driving, carrying passengers etc were not covered in any depth. Other than that, it was discussed that public transport operators are not always willing to upscale the pilots, and that shuttles will never replace existing public transport. We need business cases around why we want to have automated shuttles, and where we want to use them. As long as a safety driver is still required to be present there is hardly a viable business case. There was a rather stark question: "If automated shuttles are the solution, what is the problem they are solving?"

The Digital twin concept. Wolfgang Schildorfer in session SIS98

TOPIC 2 | Mobility on Demand (MOD) and Mobility as a Service (MaaS)

The overall situation

The Mobility on Demand (MOD) and Mobility as a Service (MaaS) topic area incorporated two distinct applications of ITS that provide travellers with technology-enabled solutions that facilitate trip-making, now helpfully defined by SAE JA3163 "The Taxonomy of on-demand and shared mobility" –

- MOD: A concept envisioning an interconnected and coordinated mobility ecosystem to meet the needs of all users by providing the safe, reliable, and efficient movement of travellers and goods.
- MaaS: A concept envisioning integrated mobility where travellers can access multiple transportation modes over a single digital interface.

MaaS has been discussed at the ITS World Congress since 2014, the year of the pioneering MSc thesis and remained one of the most popular topics at the Congress with a total of 50 papers and 19 Special Interest Sessions. The majority of interest in MaaS was around standardisation, data exchange, governance and platforms, impact on travel behaviour, how to account for MaaS in transportation planning, the potential to be self-sustaining, and the definition of readiness indicators.

The majority of interest in MOD was around rebalancing vehicles to optimise MOD service, fleet management systems, incorporating automated vehicles into MOD service, how to design MOD services, and the role of urban air mobility.

Subtopics covered in both MOD and MaaS were how equity and inclusivity can be addressed and how each impacts the environment; using living labs to design these services; using human-centred design in developing these services; and the need for open data and open data exchange within these services.

The most popular topics were:

- Diversity, Accessibility, Equity and Inclusivity
- The impact of MaaS on travel behaviour
- Using automated vehicles (AVs) in MOD services
- The impact of MaaS on the environment

There were also many discussions regarding the challenges associated with MaaS where key points mentioned were the need for collaboration across various organisations and multiple different stakeholders; a lack of trust and willingness to share data between and among the MaaS actors; and the difficulty of allocating public subsidies/revenues across the value chain when it included both public and commercial actors. One particular challenge was rather contentious – some European public transport agencies have not opened their ticketing systems or their data and so a monopoly had been created by only allowing a single app.

There was surprisingly little on utilising behavioural science to design MaaS; identifying performance measures and new metrics; and assessing how successful MOD systems have been, how MaaS systems impact the environment and travel behaviour, and are sustainable. A challenge for MOD designers has been how to transform a legacy demand responsive transit service (eg having to reserve 24 hours in advance) into MOD.

Discussions in different sessions emphasised the need for government agencies responsible for improving the mobility of citizens and travellers to be more agile, and more responsive to change – but little discussion about to achieve these improvements. There was also widespread agreement on the lack of truly integrated mobility ecosystems in the sense of an overall system view showing the interplay of different transfer nodes, much like an airline with a network of feeders and hubs. This lack of system view can be perpetuated by MaaS systems, which do not always cover all possible transport alternatives.

Old v New

We saw a number of familiar topics in Hamburg for example MOD fleet management systems incorporating established technologies, discussions on which have been around for a while. Another regular was whether and if so how MaaS will change travel behaviour. In reality there was little evidence to suggest that this had actually happened. Until standardised frameworks (like KOMPIS) are used to evaluate actual MaaS systems we

can only speculate about the MaaS impact on travel behaviour.

Discussion first started more than seven years ago on deploying AV shuttles to improve mobility and provide MOD, particularly 'first km-last km' transport journeys. However, there has now been a move to fully integrate AVs into the public transport system/network (see below).

Using a human-centred approach to design MaaS and MOD had been discussed in earlier Congresses reflecting the fact that mobility services still lack adequate accessibility, although now the discussion has expanded to incorporate equity and inclusivity. Similarly MaaS had the potential to improve the urban environment in which there was a move away from single-occupant vehicles. However, MaaS should strengthen the public transport services and provide information on attractive alternative mobility options as well as improve traffic management, facilitate innovative solutions and support tourism services.

We heard about many new ideas and services. The idea of MaaS readiness was introduced in Melbourne 2016 and has been developed into a comprehensive framework for scheme indicators, including those that measure the readiness of cities for MaaS, by identifying key factors considering infrastructure, technology, users, policies, and integration; developing assessment methods for measuring each indicator; and considering indicators' weights and scores. The MaaS Linking-of-Services (LOS) concept presented a decentralised, fully-distributed and standardised technical and organisational architecture to enable the collaboration of highly heterogenic mobility systems, across territories, modalities and business models. It was complemented by work on a novel data governance framework for MaaS called User Centred Trusts (UCTs).

Data and data exchange to support MaaS had a renewed focus. Data sharing is essential among MaaS stakeholders, but high quality data to support travellers using MaaS remains particularly important. This requires interoperability among data generators which should be based on existing open standards and the creation of new standards and/or extensions of existing ones.

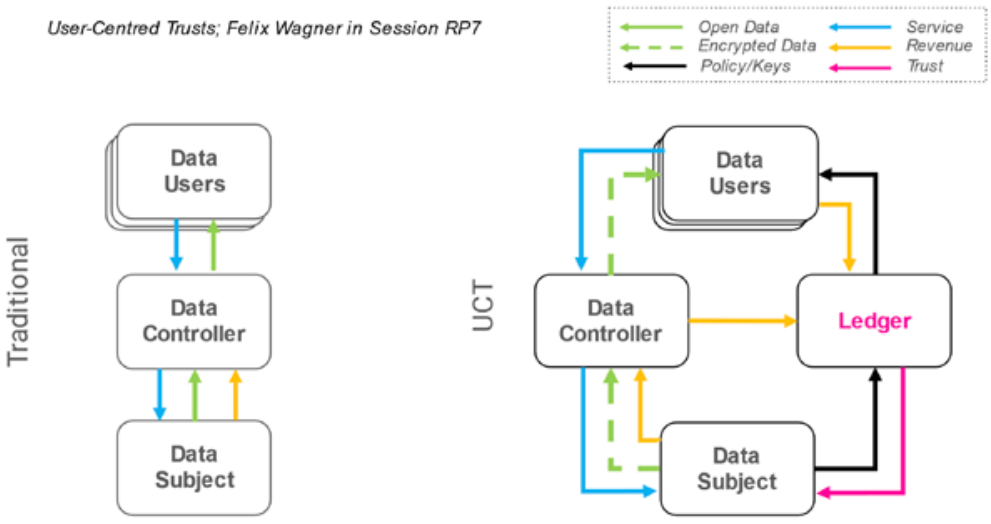
We can visualise a circular open data ecosystem in which:

- Mobility options and services are made discoverable to travellers thanks to public datasets expressed in open standards;
- More people gain access to them, their use fosters innovation in response to specific and diverse needs;
- Innovation leads to extensions of open data specifications to better describe available options and services; and
- Improved specifications and their use to produce public datasets encourage more discoverability.

Trust was mentioned in multiple sessions regarding data sharing. With whom do we want to share our data? While data sharing had increased during the time of COVID (we are sharing our data more), there was still a wish to know who was going to handle our data and be the owners of our data.

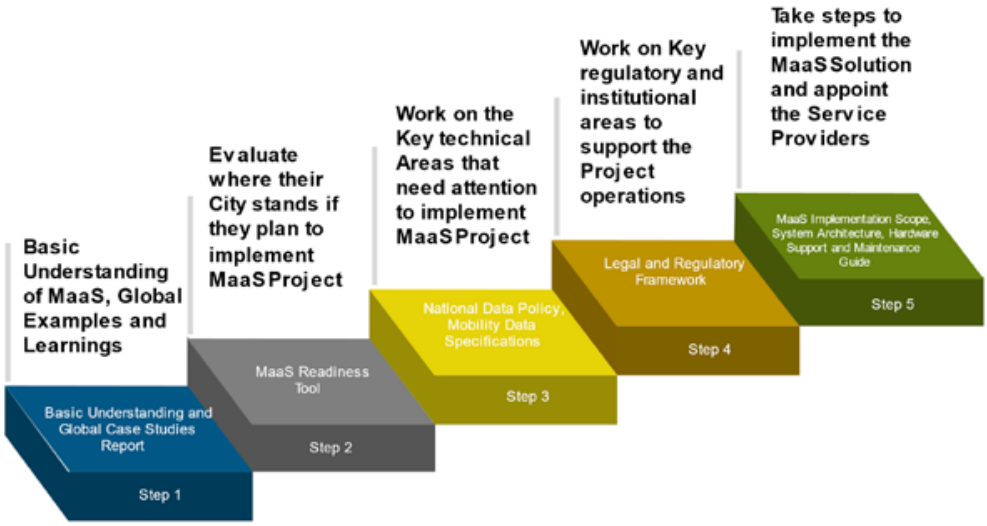
Researchers described using an improved "ant colony" algorithm to identify optimal paths in order to solve a dial-a-ride problem regarding the integration of autonomous vehicles in the MOD system with conventional public transport. As an example of another very practical outcome researchers presented the use of augmented emission maps to allow MaaS and MOD tool-builders, other researchers, and policy makers to give data-driven advice to engage and encourage drivers to modify their behaviour, and thereby reduce emissions.

We learned a new term

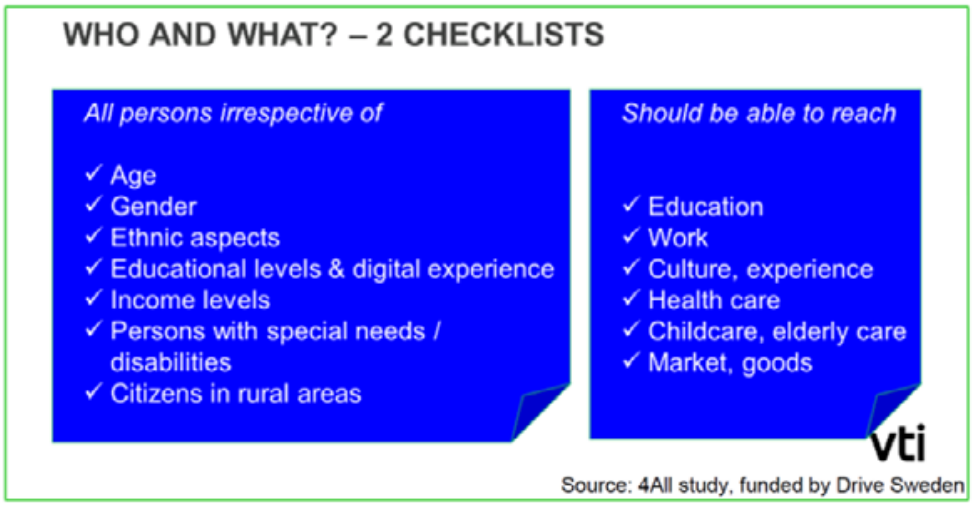


"nano-mobility" from the development of a customer-centred mobility approach in both urban and rural areas in Switzerland. The "nano-mobility" element is any section of a journey where a traveller has to cover a distance of less than 800m and which cannot be best serviced by micro-mobility solutions. For more details see Topic 6.

We heard about MaaS developments in China and India. Several cities In China were developing and deploying MaaS with multiple efforts to establish nationwide MaaS and platforms. In India the development was being guided by a framework specifically for Indian cities but likely to be usable world-wide.



How Indian authorities should take up MaaS implementation
Narendra Verma & Hohmann in session SIS 25



Ingrid Skogsmo in session SIS 44

The topic "Societal and ethical issues in ITS data generation and use" had never been discussed at a World Congress before and there were various contributions. The Swedish National Road and Transport Research Institute in Sweden used two checklists to consider equity and emphasise that "mobility choices were not only for those who have the money."

We should consider four major elements of ITS data to ensure that it could not be used in a negative way: (1) Design: who is designing the systems that are generating, analysing and reporting the data? (2) Data security: who has access to the data? (3) Data location: where is it stored? and (4) Data equity: how long is the data stored and how is the data being used. An example of data used in a negative way was the use of data from social media to identify women who were playing sports in Afghanistan. A different analysis process was the three key data layers of: infrastructure, vehicles and people. In each layer, we need to answer specific questions. For example, what vehicles types exists? where are they? when are they moving?

A new aspect of equity in ITS was being addressed in the development of an assessment tool as part of the US Transportation Research Board's Transit Cooperative Research Project : Impact of Transformational Technologies on Underserved Populations. An approach to the equality impact assessment of technology-enabled mobility services was also described by Professor Sarah Sharples, Chief Scientific Adviser at the UK Department for Transport.

There were a variety of new approaches to assessing what makes a MaaS system or platform successful, including the following:

• Mobility service providers cannot be bullied into joining a MaaS platform, they need to be convinced.

• Technology and policy should be aligned because MaaS solutions provide powerful levers to empower policy."

• Successful MaaS platforms have all modes in one app; should come from the industry for the industry; and require product thinking instead of projects thinking.

• Success was linked to four factors: (1) benefits for mobility service providers); (2) benefits for the City; (3) benefits for customers from the MaaS "Product;" and (4) benefits for the customer from new city infrastructure (eg mobility hubs).

There was more discussion about MaaS specifically for businesses. In the past, companies may have rewarded employees with the use of a car. Companies were now providing a "mobility budget" that could be used on any mode (with more sustainable modes costing less). This mobility budget incentivises a shift to more sustainable travel by employees, and can lead to a reduction in air pollution.

Forwards v Constrained

Forwards:

Real-time traffic information systems, while not new, had been updated recently. In the Congress, several revised systems were presented including Austria's digital multimodal transport network call Graphenintegrationsplattform (GIP) that now contains VAO, a multimodal journey planner based on the GIP map. The future of MaaS remains where it becomes Unified Mobility Management. Key success factors and requirements to move beyond MaaS included:

• Cover all modes and infrastructure within unified governance and management

Integrate goods movement with mobility services

• Utilise a holistic and open data ecosystem

• Manage dynamically and regulate mobility service providers (MSPs)

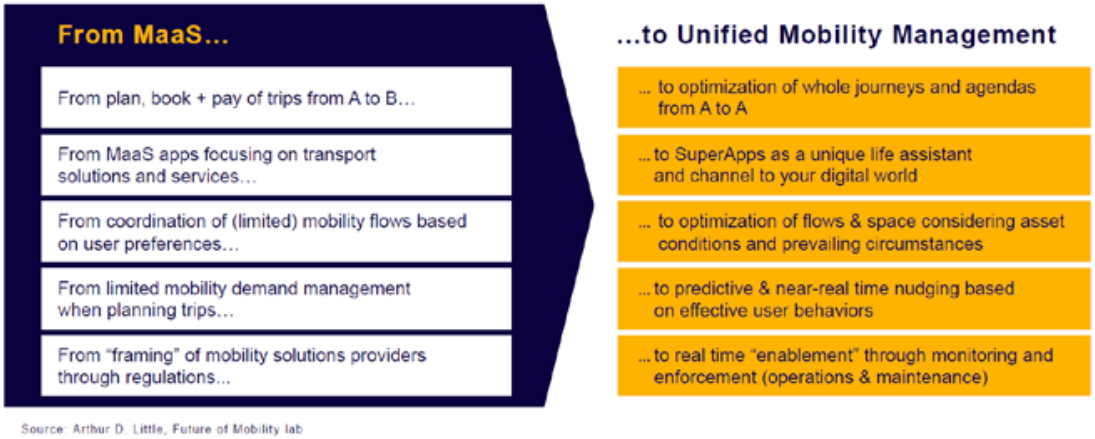
• Extend the platform geographically

The Mobility Token within the MyCorridor MaaS project would allow the traveller to enjoy a simplified travel experience without any further action required. This was the most innovative element of MyCorridor and reflected the validated B2B interactions occurring in the back-end. Mobility Tokens had been successfully demonstrated in Austria, Czech Republic, Greece, Italy and the Netherlands.

The TOMP-API has the potential to be adopted worldwide to provide a standardised language for the technical communication between Transport Operators and MaaS Providers within any MaaS ecosystem.

AI for inclusive mobility was presented from three perspectives: 1) The need for an open digital data platform to unlock the potential of offering inclusive mobility – and a mindset of sharing. 2) The need to for common international standards – and a mindset of an international vision. 3) The need for inclusive solution development – and the mindset that user-centricity is key.

A new approach to MaaS was presented by Feonix Mobility Rising. This model looked more like the original MaaS concept which connected the whole community (eg education, employment, government services, entertainment) through mobility and goods movement services. The centre is the "Community Leadership Circle" and it is surrounded by 7 areas that are accessible via MaaS: transport, health care, food, education, housing/utilities, employment, and social/community. This concept incorporates entities that we usually don't think of as part of MaaS, such as non-profit agencies that provide mobility services and fundraising if services cannot be funded through Federal, state or local means. The impetus for this MaaS was based on the fact that transport features in the top 3 barriers to healthcare.



Source: Arthur D. Little, Future of Mobility lab

Community Engagement Model (Valerie Lefler in the MaaS/MoD Global Forum)

mobility platforms that increasingly power transportation to collect disaggregated data."

Until there is more use of behavioural science in the design of MaaS we will continue to see pilots and longer-term MaaS deployments that may not be sustainable as they may not result in changes in travel behaviour. It is still not clear that MaaS will change travel behaviour without incentives, micro-subsidies or loyalty benefits.

Within Maas mixing private and public data, travel services and revenues in a fair way that benefits all requires trust and a trusted partner/orchestrator. The fact that we are still discussing trust in addition to other critical success factors suggests that this is still a barrier.

There were many MOD pilot projects around the world including many micro transit pilots in the US. The majority of these pilot programmes were conducted at a lower cost than the regular public transport services due to the nature of the service provider marketplace. They provided "discounts" for pilots in order to prove that the new system could achieve the public transport agencies' goals and to put them in a better position to provide MOD as part of regular public transport services. The actual costs of regularly operated MOD systems were not well understood and this could become a constraint to considering adding MOD services to the services provided by public transport agencies. Further, agencies should be aware that most small-scale pilots would not provide a meaningful lever for changing mobility behaviour.

We should be considering the overall value proposition of MaaS rather than discussing profit. The key was the role of MaaS in enhancing the mobility experience by incorporating features such as offering a subsidised first- and last-mile of a trip. Furthermore, where MaaS was provided to employers the value was a tool that could not only facilitate employee travel, but also reduce the need for corporate benefits like providing company cars to employees.

The areas of organisation, product development and leadership spanning joint working of public authorities,

Constrained:

There was no suggestion of a one-size-fits-all formula for MOD and MaaS systems – they must be local or regional. This is what makes cross-border systems challenging, and suggests that MaaS with urban goals (reduce car ownership and single-occupant vehicle usage) will not necessarily work in rural areas where cars are part of the mobility solution. Sometimes MaaS schemes had been limited by "MaaS cowboys," – providers that contributed to "walled gardens." (A walled garden is "a single app and the only source of combined public and private mobility service journey planning and booking in a city or region). These systems are independent of each other, meaning users are not able to travel between different cities or use the same app in different cities.")

Demographic diversity in MOD seemed to be subject to the "diversity data gap" that exists currently in much of transport, particularly pertaining to gender, age, ethnicity and disability. To help eliminate this gap MOD software providers, planners and operators must make explicit efforts to integrate diversity thinking into their everyday processes. Actionable insights can be unlocked if we acknowledge that different groups of people have different travel needs, and then use the

municipal companies and industry partners required more agility. The mobility sector operated under complex political, economic and social conditions sometimes summarised by the term VUCA (Volatility, Uncertainty, Complexity and Ambiguity). VUCA perfectly described the new smart mobility framework conditions for industry and commerce. What holds today will be superseded tomorrow, thus creating a fundamental uncertainty.

Digitisation as the greatest innovation driver has also produced an exponential increase in the complexity of products and services. While in the past a customer still felt loyalty to a company they tend now to buy – online – from one source today and another tomorrow. Market research and forecasts about future developments had become increasingly uncertain, because it was less and less clear who would be a market player, a competitor or a customer. Causality was increasingly subject to ambiguity."

We needed to have more discussion regarding the prerequisites for MaaS. They should include solutions to allow the unbanked and technophobes to use MaaS. It was also critical that small businesses operated in the MaaS space so there needed to be platforms that enabled them to operate mobility services. To complement this we needed technology interfaces for non-profits and service providers that are easy to use.

There were still issues associated with procuring MaaS and more work needed to be done.

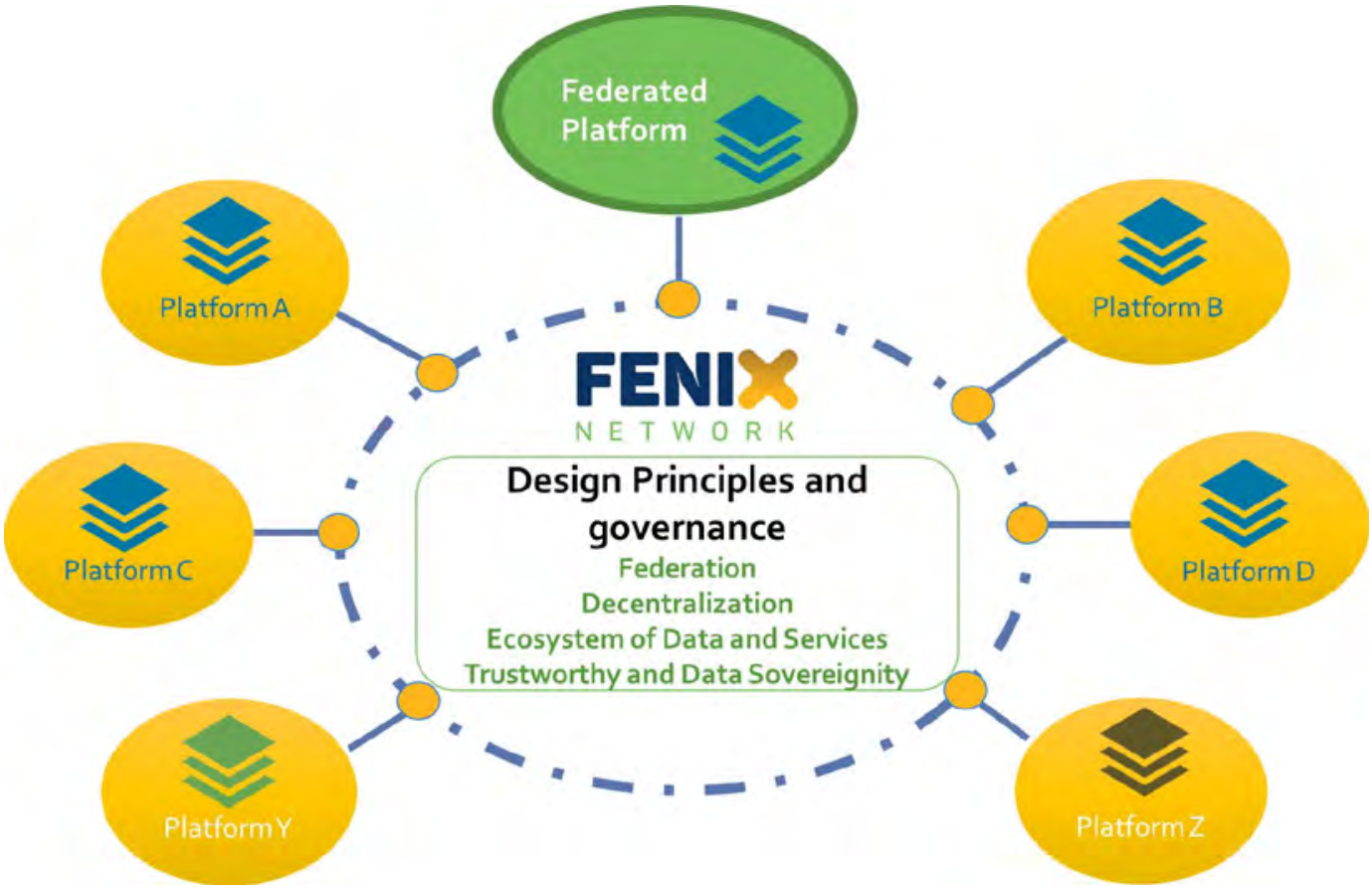
The overall situation

This has often been the smallest topic at Congresses partly as the subject matter is so broad, and partly as the supply side has many small organisations spread across road, rail, sea and air modes. However there was a strong response to the Call for Proposals and 24 papers and 8 Special Interest Sessions were selected. In addition, to recognise that Singapore (2019 host city), Hamburg and Los Angeles (2022) are all major ports, it was decided to organise a Global Freight Logistics and Ports Forum under the working title "From the factory to your front door" as a holistic approach to the topic.

Around three fifths of the papers were conceptual with the others split between researching existing work or discussing actual pilot and deployment efforts, and there was some thinly disguised marketing of products by companies. Several papers stressed the need for a universally accepted logistics architecture that can provide for both increased visibility and improved anonymity for multiple parties within the logistics chain. One solution discussed at length was a cloud federation of platforms that does not support central data storage and management – the FENIX Network (European Federated Network of Information eXchange in LogistiX). The federation is a network of nodes based on a technological, legal and business governance mechanism designed to guarantee use of data and services to the network platforms as well as trust and security. The FENIX Network architecture is shown below:

Autonomous vehicles for freight continued to be a common topic but there has been limited actual deployment reflecting the institutional requirements that must be in place and the differing demands/requirements and states of 'readiness' between jurisdictions.

Some papers reported a detailed look at water trans-



Catana, Fanti et al in session RP 13

port of goods (inland waterways) across Europe and the associated benefits of reduced energy requirements, reduced congestion and improved air quality. This approach reflects the proximity of many manufacturing locations to their primary freight destinations. Other papers reviewed the need for a total communication system approach embracing cargo on container ships to estimated and real-time traffic conditions to routing for final delivery. This was linked to the newer practice of Freight Signal Priority – benefiting the environment and producing shorter delivery times.

The idea of autonomous freight deliveries on regional routes, local routes, and within closed freight terminal environments continued to gain momentum. Similarly autonomous vehicles for freight continued to be a common topic but there has been limited actual deployment reflecting the institutional requirements that must be in place and the differing demands/requirements and states of 'readiness' between jurisdictions.

Some papers reported a detailed look at water transport of goods (inland waterways) across Europe and the associated benefits of reduced energy requirements, reduced congestion and improved air quality. This approach reflects the proximity of many manufacturing locations to their primary freight destinations. Other papers reviewed the need for a total communication system approach embracing cargo on container ships to estimated and real-time traffic conditions to routing for final delivery. This was linked to the newer practice of Freight Signal Priority – benefiting the environment and producing shorter delivery times.

The idea of autonomous freight deliveries on regional routes, local routes, and within closed freight terminal environments continued to gain momentum.

Old v New

A number of sessions and papers looked at ways to address some long-standing elements of the sector

- significant labour market shortages so unfilled vacancies hamper growth opportunities for logistics companies and lead to higher prices for transport
- truck drivers work under unattractive labour conditions
- inefficiencies at port and warehouses often result in idle driver and vehicle time

Technical and research papers described the benefits of Tele-operated driving (TOD) as a complement to automated driving as well as a possible transition technology to fully automated driving. In TOD a vehicle has a communication link to a remote human able to drive it. The vehicle can operate semi-autonomously with the remote operator generally monitoring the vehicle's state but able to take full control in particularly complex driving situations.

An important subject was the use of a combination of conventional and electric vehicles, trams, and electric cargo bikes throughout entire delivery chains down to and including the last mile thereby offering strong alternatives to current urban logistics systems. When used together, these three modes of transport have the potential to provide sustainable, cost-saving, and comprehensive mobility solutions.

Machine learning as a component of truck inspection was allowing faster freight movement and accommodates selective human intervention only where necessary. This includes Weigh-In-Motion technology combined with tyre anomaly and tyre pressure monitoring technologies.

A number of truck parking innovations were discussed; these were presented as both well accepted and effective ways to optimise the productivity of scarce truck parking space which was frequently not used to its greatest capacity. Trucks sometimes park crooked, sometimes with too much space between trucks on each side, and trucks sometimes do not pull up closely

Jens Dierke et al in session TP 50

enough to the truck in front of them. All of these issues can reduce capacity by as much as 25% in a location that desperately needs more space. A smart managed parking project in Germany had already begun to prove itself in live operation. The ITS control system assesses a truck's length, the driver inputs an estimated departure time and VMS displays send position guidance to drivers. Better control of heavy vehicle parking delivers a significant public safety win as well as increasing the efficiency, safety and compliance of the trucking community.

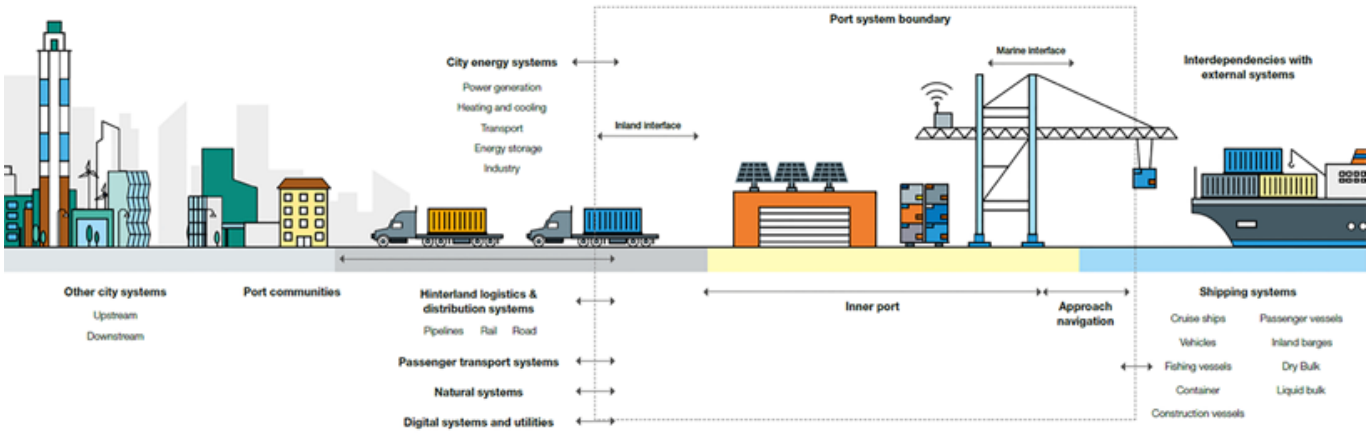
As part of a plan to raise the profile of the freight and logistics sector a Global Freight Logistics and Ports Forum was organised under the working title "From the factory to your front door". The Forum speakers were:

Chris Cannon, Port of Los Angeles, USA (recorded)
Henrike Etzelmüller, Microsoft, Germany
Juan Jesús Perea Rodriguez, Fujitsu, Germany
Magda Kopczynska, DG MOVE European Commission, Belgium
Tim Morris, ITS(UK), UK
Jens Meier, Hamburg Port Authority, Germany
Lee Hoon Quah, Maritime Port Authority of Singapore, Singapore (recorded)
Janneke Van der Zee, ITS Canada, Canada
Phanthian Zuesongdham, Hamburg Port Authority, Germany

Topics discussed at the Forum included:

- Ports as a System – how to encourage the application of systems thinking, both operationally and organisationally, to build port community systems underpinned by digital solutions, offering efficiencies across the supply and delivery chain.
- Intelligent hinterland operations – the value of connected, integrated data services, with Artificial Intelligence and Machine Learning used to secure new data insights to help synchronise and optimise port and hinterland transport and ease congestion in transit of goods (with focus on container blockages and shortages and adaptation to new customs regulations).
- Net zero challenge and the shift to green shipping & logistics – how best to develop the roles of ports as renewable energy hubs and drivers of zero carbon operations, and the value of applying circular economy principles when deploying technology.
- Sustainable ship to store supply chains and future ports – highlighting the importance of ports as inter-modal interface hubs and how technology can help overcome constraints linked to cross-border logistics challenges.
- Smart Ports 4.0 – how to meet the increased demands on ports and logistics from next day delivery, and the importance of strong collaboration and engagement across the industry to maximise the opportunity for efficient operations. There was also discussion on the need for cyber secure solutions to counter risks and vulnerabilities associated with implementation of connected systems in ports.

Discussions revealed how the sector is steadily becoming digitalised and connected but it remains a fragile system overall: the component parts – loading from origin to ship, ship management, port internal management, port hinterland, delivery fleet management, 'last mile' delivery – do not always connect well. The diagram below shows the functional and modal complexities involved:



The ports system and its key interdependencies Tim Morris in the Global Freight Logistics and Ports Forum

TOPIC 4 | Intelligent infrastructure

The overall situation

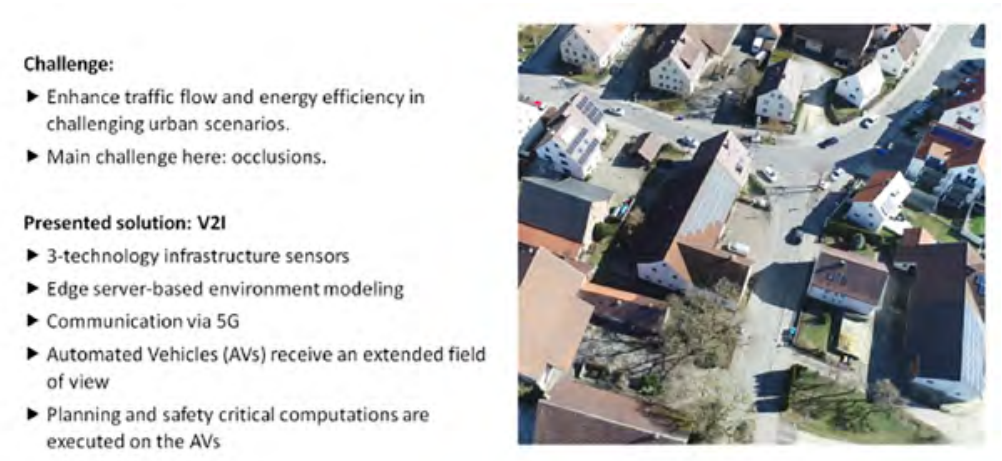
In previous years the term "intelligent infrastructure" was not very visible and the subject matter was incorporated in other topics. However in Hamburg there was much to explore and write about and it was appropriate to feature as a topic in its own right. There were 63 technical papers, 12 research papers and 9 special interest sessions. Many papers discussed artificial intelligence, machine learning and algorithms to generate intelligence to support network operations. Implementations described included scheduling, prediction, modelling and traffic management. While all of these implementations were novel individually there did not seem to be a case of "the one" – a "go to" solution implemented in different countries and cities.

AI was also being proposed to improve traffic detection. Any new machine learning algorithms will be relying on data collected by existing systems such as CCTV and inductive loops. These sensors may not always be of the best quality so the algorithms are needed to compensate in order to produce accurate results. Data was a big topic during this conference and it was easy to see why. It's possible to envisage a future with more data than humans can deal with, a problem not only about the quantity of data but the quality too. One idea mentioned was to set up "guard rails" for machine learning algorithms, therefore helping innovative risks to be accepted. At the moment whilst these algorithms are being developed it was seen as important to use the data collected by existing infrastructure to keep costs down, but recognise that in time upgrading infrastructure would help with the development of AI.

A significant number of papers covered the improvements in detection systems including Bluetooth, radar, Lidar and IoT. Detection of air quality and weather conditions were referenced as well as the many traffic detection methods. One paper proposed using drones to record detailed vehicle movements for 30 minute periods to support improved accuracy of microsimulation models. However this could also be used in future for real-time support to AVs eg by providing status updates in serious incidents.

There were several references to the need for roadside infrastructure to provide support to AVs and drivers, suggesting an acceptance that AVs cannot operate successfully without external data sources. This was particularly for detection of vulnerable road users (pedestrians and cyclists). AVs cannot see round corners due to occlusion from buildings, so roadside infrastructure detecting both VRUs and cars could be used to transmit the data to the vehicles. However, such solutions need very fast processing so a local comms solution is required such as 5G and edge computing or ITS-G5.

It was noted that the alternative method of pedestrians and cyclists becoming 'connected' and communicating with vehicles cannot be relied upon as not all are not



Benjamin Völz et al in SIS 30 (Connected automated driving based on roadside sensing and mobile edge computing)

keen to share their locations to improve safety. Video analytics of CCTV was cited as becoming very useful for detecting pedestrians and cyclists. This technique is currently used for count data but could be used for CVs and AVs in future.

The question emerged in discussions – who should pay for roadside sensors? If they are essential for AVs should OEMs contribute, passing the costs to users? Transport authorities might not be able to afford installation costs on their own so would OEMs be prepared to contribute if it made their vehicles safer?

On demand solutions was a hot topic just as it had been in previous Congresses. SIS session discussed how demand responsive systems were not just for inner cities but for suburbs too as that is where public transport isn't as efficient. Having the vision of an on depend system was crucial and there are 4 stages to it:

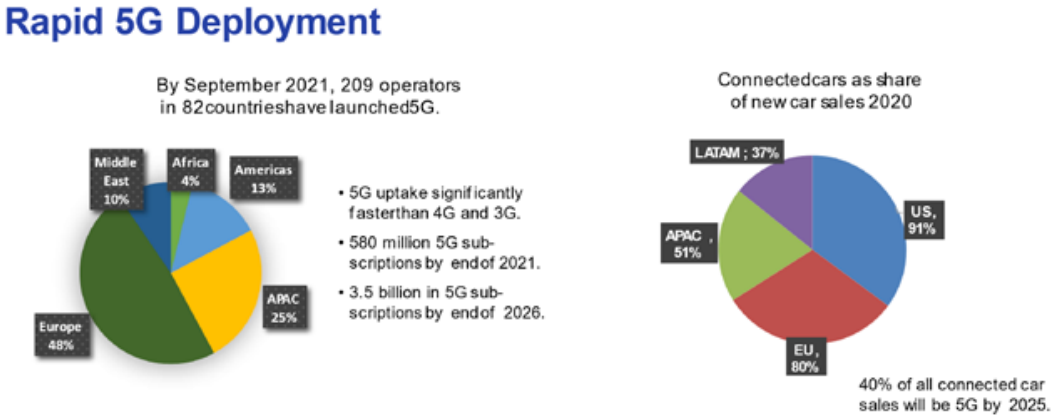
- Planning
- Designing
- Implementing
- Monitoring

There was a mention that even private on demand services should be integrated in with the rest of the network to give the "mobility as a service" feel to it. These services should be cost efficient and flexible and should focus on the user. Users come in various shapes and sizes therefore on demand solutions should not have just a digital app but analogue solutions too such as using the phone to call on demand services for the elderly or those without smartphones. The main conclusion from discussions on demand solutions was that they should be targeted at car users to hit climate change targets and low emissions. If they just attracted public transport users it would not have a significant impact. The key focus was on showing private car users other, potentially better, transport solutions for their journeys.

It was seen as important to consider ways to disincentivise car use, not just incentivise alternative (preferred) modes such as active travel, DRT etc. One suggestion was from an audience member who had worked with business parks to encourage modal shift and achieved 50% reductions in car use. Now that businesses want to reduce their carbon footprint this should become more common. Could businesses provide DRT solutions or MaaS subscriptions to employees instead of a car allowance?

Connected vehicles and communications were big again. This included connecting with not just vehicles but buses, water vehicles, trucks, rail, UAS etc. The effects of C-ITS implementations on users were referenced several times showing the interest in human-centred operations. This was a significant move from previous conferences which had mainly just focused on simulated work and potential live trials. The live trials had happened and a lot of research was moving forward on taking C-ITS further and implementing it in everyday life. All the communication methods were referenced to support I2V / V2I which suggests that a mix of comms will provide the way forward – 5G, DSRC C-V2X.

Industry showed that 5G uptake was faster than 4G and that 6G would be even faster prompting the prediction that 40% of all connected car sales would incorporate 5G by 2025. This makes a large proportion of cars vulnerable to attacks.



Jan Ellsberger in SIS 42

Perhaps surprisingly there were very few papers on cyber security of ITS relevant to this infrastructure topic perhaps because it has already been addressed many times?

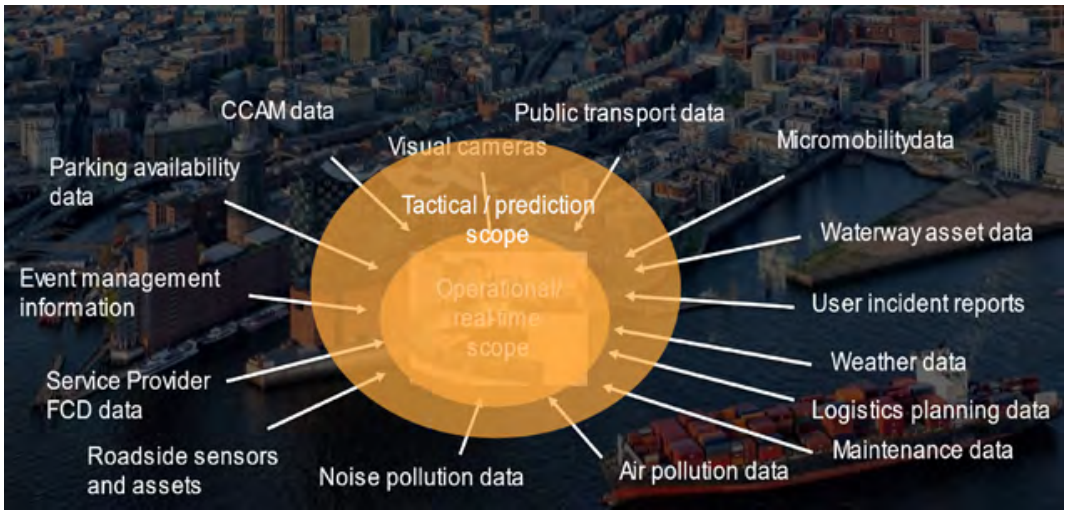
There were limited numbers of sessions involving electric vehicle charging infrastructure perhaps because given the increasing volumes of EVs it was not seen as a

classic ITS problem. Digital twins were also rather quite quiet in this Topic – perhaps because with the volumes of data that need to be tackled not many people have had publishable results so far.

Forwards v Constrained

Forwards

The development of new and enhanced sensors was clearly continuing at pace, with traditional inductive loops being overtaken by newer technologies. Many research projects and trials were ongoing around using machine learning to improve the functionality of a range of sensors including CCTV / video analytics / IOT. One session drew attention to the richness of data sources now on offer:



An incredible time for ITS IoT / Data enthusiasts – Jop Spoelstra in session SIS 55

An incredible time for ITS IoT / Data enthusiasts – Jop Spoelstra in session SIS 55

Floating vehicle data from sat nav suppliers was being used to supplement or reduce the need for roadside detectors and there was a feeling that it had reached a tipping point where it could be used on both strategic roads (for speed detection) and local roads (for traffic signals optimisation). Several trials were ongoing so within a couple of years Congresses might see reduction in infrastructure, bringing cost savings for highway authorities. AI / machine learning was also moving forwards in other applications.

The larger regulating bodies and funding were getting more involved in intelligent infrastructure, providing direction for stakeholders to follow. For example Horizon Europe was creating Infrastructure Supported Automated Driving (ISAD) levels to classify smart roads.

Vulnerable road users was becoming a topic of more research in ITS, particularly the potential for C-ITS use cases for pedestrians and cyclists for example:

- Using C-ITS with other technology such as using thermal detection of vulnerable road users in order to generate messages to be sent to On-Board Units (OBUs).
- Using statistical methods to provide a probability of collision with a VRU and sending those messages to OBUs.
- New use cases were being developed such as sensors at pedestrian crosswalks to improve safety for pedestrians.
- As well as developing use cases and trialling them, probe vehicle data was being gathered to determine user behaviour at the same time.

There was a big focus on cycling at the Congress with discussions on possible changes to increase the sharing of bike related data. For example, National Access Points in the European Union will be required to include data relating to bike scheme stations, bike lanes and bike parking. The aim is for bike information and related data to be as good as that for vehicles to make active travel more attractive.

Constrained:

Some awkward topics such as path planning for vehicles including HGVs and UAVs had apparently not moved on a great deal – might this be because while there were a number of good solutions there was no outstanding "to-go-to" solution?

C-ITS services were also only moving forward slowly. A good (or rather bad) example was adapting vehicle use cases for other methods of transport such as buses. There seemed still to be a chicken - egg situation – it was evidently not worth operators' investing in CV systems when only a small number of vehicles were ready to use them. And users were not buying as they were not being made aware of the benefits. This circular logic

applied particularly to DSCRC, but even to mobile internet data because drivers need to want to use the apps. Today GLOSA was completely feasible technically but many drivers did not know it existed, and how many would actively choose to download it and follow it? In such circumstances many operators would not feel incentivised to make it available.

In many cases the technology was almost ready and awaiting the next step of getting the environment ready for the technology – for example implementing 5G-enabled sensors so that eScooters and MaaS become easily deployable.

As a closing thought: during the time of the Congress many participants enjoyed the e-scooter ride from the hotel to the conference centre!

TOPIC 5 | New Services from New Technologies

The overall situation

Judged solely by the overall number of submissions this was not the most popular topic; which might be a reflection of current trends to do more around using new technologies to improve existing services and applications rather than develop new ones. Consequently there were very few highly innovative ideas, although hyperloop was presented in one of the business presentations as an application for moving cargo in ports and there were two unique solutions designed to tackle very specific issues – transporting holiday luggage and assisting people with visual impairments to travel safely and independently. Nevertheless there were 16 Business presentations, 19 papers and 12 Special Interest Sessions.

Drone applications and the use of urban air space was the single most popular theme. Drones themselves are not a particularly new technology but several papers and sessions looked at new developments in Urban Air Mobility (UAM) or Advanced Air Mobility (AAM) including air traffic management, city air space regulation and the take-off and landing infrastructure. Studies on mobility in the third dimension included concepts and business models for air taxis and other passenger or delivery vehicles while applications looking at the commercialisation of drones included traffic management and responses to medical emergencies by expanding the role of drones as a delivery services to hard to reach locations.

SIS 89 looked at drone technologies and cargo services for emerging African markets where there were some startling statistics on the numbers of people living more then 2km away from an all-season road or more than 2 hours away from a hospital to illustrate the challenges of, and opportunities for, last-mile delivery in remote locations. As well as humanitarian uses there was much interest in the commercial application of drones for cargo or passenger use in urban environments.

Volodrone applications in Logistics – Frisch & Pesce in session SIS 103

A number of sessions looked into commercial approaches to using the air space; areas raised for consideration now and in future included:

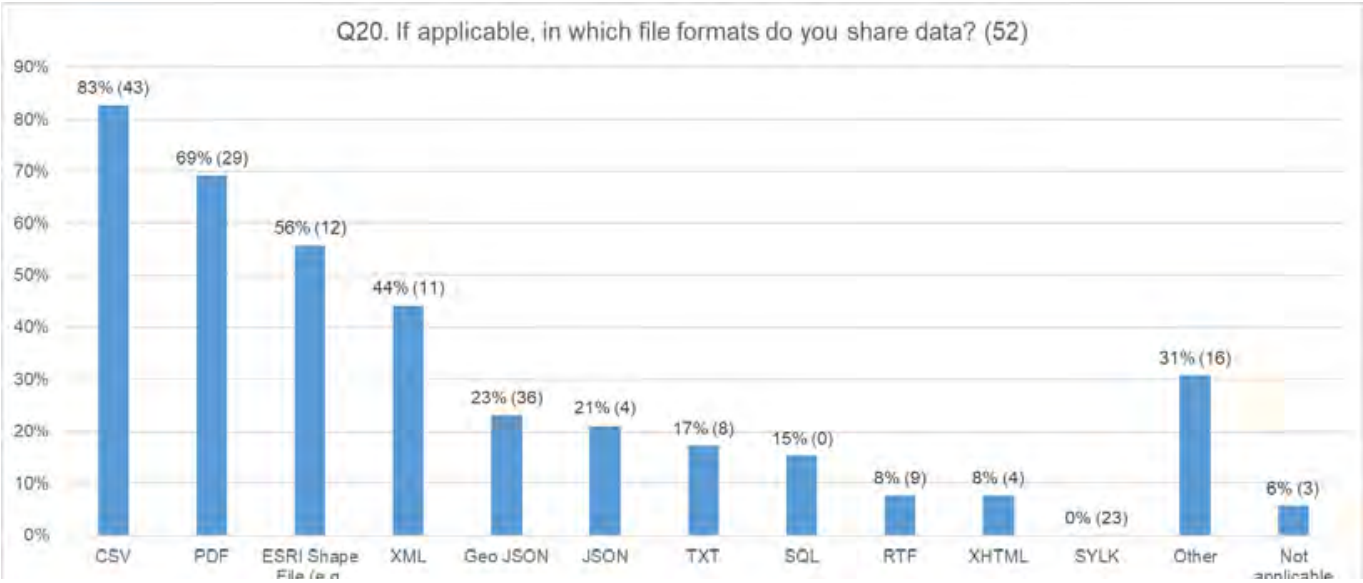
- Safety and legislative issues of integrating drones into operational air space and avoiding incidents
- Future management of air space
- Management of drones in beyond visual line-of-sight operations in urban airspace
- Training and certification of drone pilots and supervisors
- Integration of ground and air traffic management

Traffic management and Tolling have been Congress regulars for many years but Hamburg offered some new approaches using AI, machine and deep learning to manage traffic signals adaptively with presentations of a variety of new input sources and case studies of applications in live environments. Papers and sessions also discussed new approaches to modelling, simulation and optimisation to model and assess large number of scenarios to optimise traffic flows with adaptive traffic signal control. We did not see radically new solutions or applications for monitoring and incident detection, but instead new ways of comparing different approaches either monitoring the road network or receiving information directly from stopped or braking vehicles.

Other applications covered the use of AI and recognition systems in tolling applications to identify and charge vehicles based on physical characteristics, and new approaches to tolling payment including GNSS and app based charging solutions.

The view that "data is the new oil" has receded considerably and data was seen as more of an enabler than either new technologies or new services. There were many discussions on approaches to sharing and managing shared data, designing collaborative business environment for sharing services and exchanging mobility and logistics sector data, and the recurring issue of collecting and utilising data from autonomous and connected vehicles.

Two informative and topical sessions presented the use of traffic and connected vehicle data to counter the pandemic. COIVID brought into sharp focus the use and potential for insights from close-to-real-time transport information regarding which journeys continued to be made and their possible interpretation as being critical either for business or people's ability to work. Information presented from a UK study showed 70% of transport related data shared via email and that the two most common formats used are.csv and.pdf files – both situations implying that there is a very long way to go before open, shareable data is a reality.



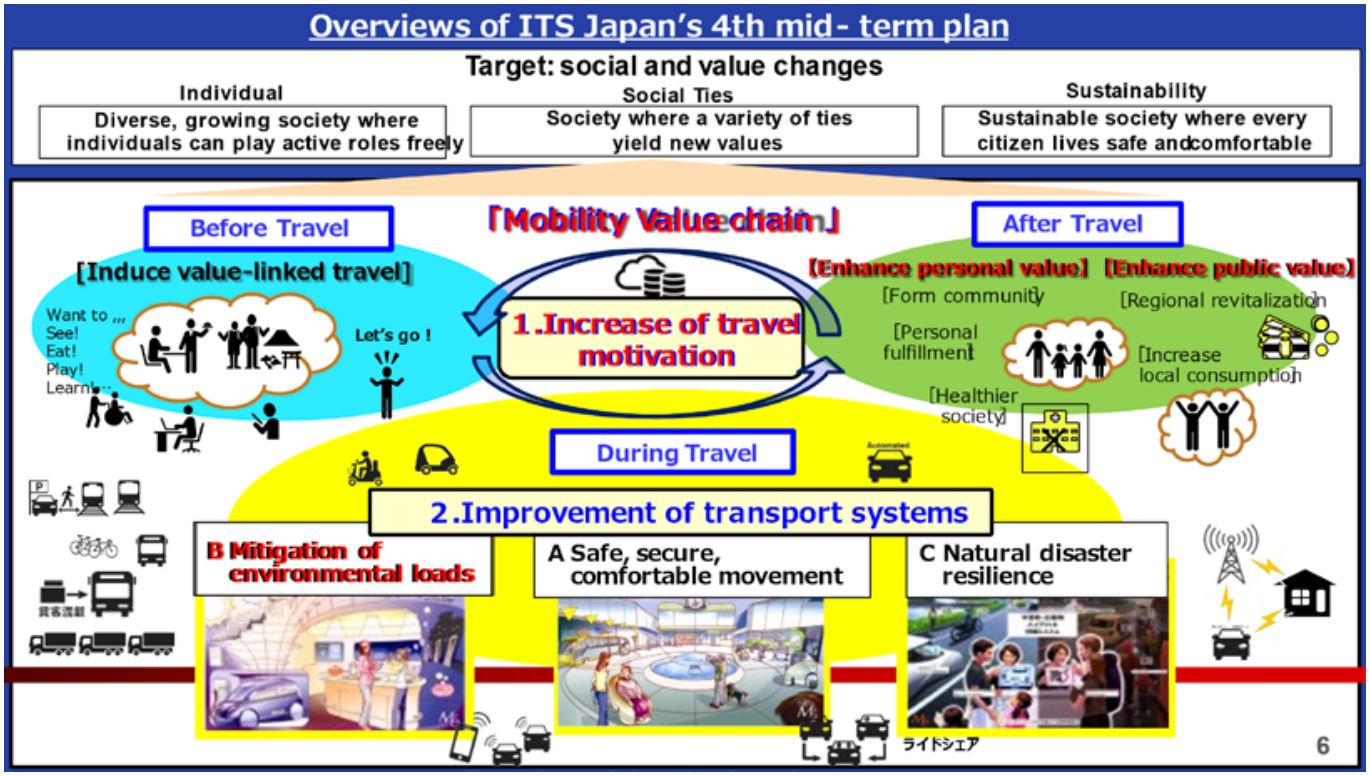
The local transport data landscape in the UK; Jill Hayden in session SIS 64

5G Communication and its role as a "key enabling technology" featured in many sessions even though it is not new! There was considerable interest in real-world applications and use cases for 5G linked to other communication networks to enable seamless use of ITS and connected vehicle technologies without losing signal coverage in remote locations. Cybersecurity issues were regularly considered.

Safety was not a dominant topic but there were some interesting solutions such as a novel approach to water depth management to provide precise information on depths in port areas. Serval presentations described projects to incorporate AI and vision systems as a tool for monitoring the condition of infrastructure such as roads and rail networks, and one paper presented an approach for using a drone coupled with AI video analytics to inspect aircraft prior to maintenance.

Reflecting a steadily growing Congress presence there were a number of discussions on behavioural and social impacts.

The most thought-provoking presentations appeared to be those not directly linked to technologies, but rather approaches for nudging the travelling public towards lower carbon and carbon neutral transport. A presentation from Japan incorporated both traditional approaches to encouraging modal shift to consideration of issues around the resilience of the transport network to natural disasters. It recommended an approach that acknowledged the role of the individual traveller in supporting the greater good through encouraging use of MaaS approaches even when it is not as convenient as using a personal mode of transport.



Akio Yamamoto in session SIS 72

Old v New

We heard relatively little about new business models. The SIS on new business models as an enabler of a circular economy of mobility suggested a new approach, and a potentially fascinating area likely to have long term relevance in ITS and mobility as a whole. However, the presentations explored the use of hired micro-mobility vehicles – e-scooters and e-bikes which is already well established and doesn't function as a circular economy. We did hear about two outstanding ideas, both highly practical for different user groups. People using public transport for holiday travel often have problems managing their luggage and a presentation in BP16 described "Nano-mobility" – managing the last 800m. This next generation solution described the development of a concierge robot to follow skiers and carry their luggage and skis from the bus stop to their chalets.

Zeir, Duval and Leffler in session BP 16

SIS 16 addressed improving the social participation or people with reduced mobility and presented an interesting and potentially highly beneficial approach to using technology to improve the ways in which blind and partially sighted people in particular can use the mobility network

A joint venture of the German National Charity for the Blind and Partially Sighted and a wide range of other parties created a light-touch Meta-App that interacts with a range of transport apps and Internet of Things solutions to bring them together in one place to simplify travel for their users. The solution has funding for three years and incorporates a human service centre element to ensure that vulnerable travellers are never left alone in an unexpected situation. This approach is something that other applications might usefully consider in future to ensure that travellers who are elderly, young, tourists – or simply lost – can always access a human to ask for help.

It was inspiring to see that the presenter Thomas Krämer was himself visually impaired and presented his speech from Braille notes.

Thomas Krämer and partners in session SIS 16

Forward v Constrained

All of the solutions and ideas reviewed were very much evolving and "business as usual" However they were also forward focused in the sense of building on ideas that have been presented and developed across previous Congresses. For example, looking at ways of continuing along the path of modal shift to micro-mobility within urban areas; increasing the use cases and business opportunities for the commercialisation of drones. Ensuring that enabling technologies: V2X, 5G, EV support infrastructure including battery improvements, charging networks and the like keep pace with other developments and are there to support evolving mobility trends.

Presentations linked to the newest developments stressed the need to link to behavioural and social impacts, and explore how to incorporate future mobility needs and MaaS thinking into town and city planning perhaps using new planning approaches and tools.

Solutions were often focused on urban areas with large populations and constraints in uptake or commercial viability are regularly seen in rural or poorer areas or amongst those who may not be so physically mobile. These areas are unlikely to become attractive to the private sector and likely to require public sector involvement if they are to keep pace with developments elsewhere.

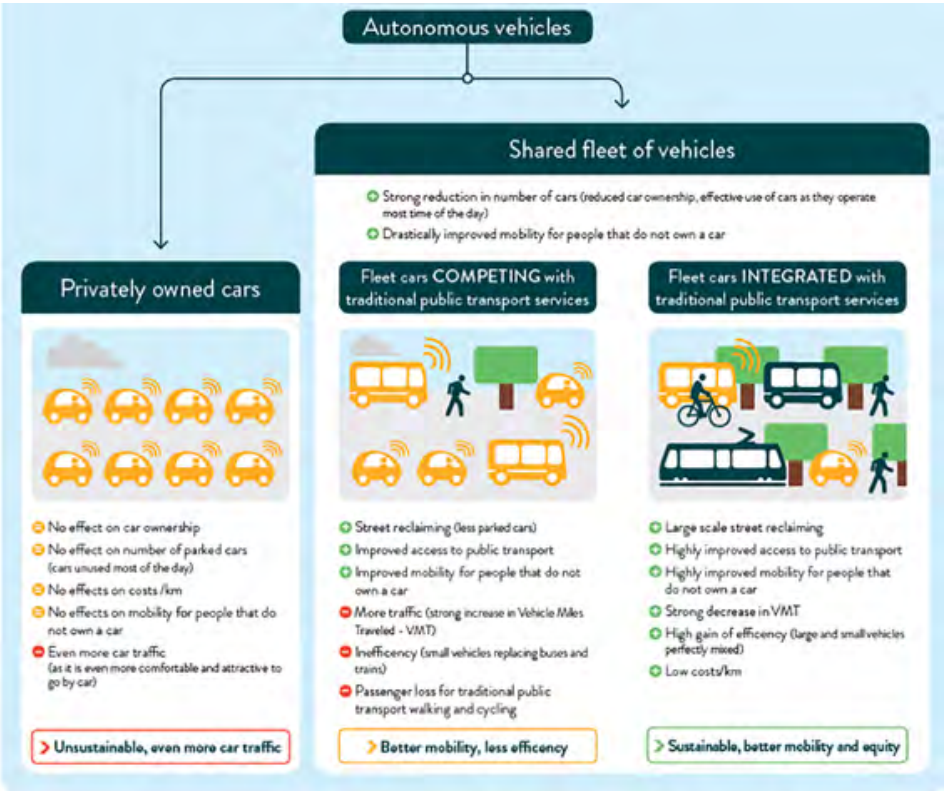
TOPIC 6 | Cities and citizens' solutions

The overall situation

The essence of the content in this Topic was ways to address the intense demand for urban space – by passenger and freight vehicles, active modes such as walking & cycling, and also parking – while reducing travel time for the community, giving optimal services to individual customers and delivering better air quality. Achieving success with these aims is often described as being a 'Smart City'. The term 'smart city' was interpreted as an umbrella term referring to cities deploying technology-enabled, multimodal mobility solutions, including innovations in public transport, Mobility as a Service (MaaS), Mobility on Demand (MOD) and more. Accordingly, the smart cities and citizens' solutions topic was a wide ranging field that covered an array of subjects. Some presentations focused on using technology to increase or improve levels of citizen engagement. Interestingly, the 15 Special Interest Sessions did not share the same trends and findings as were discussed in the 46 research and technical papers.

Although 'smart cities' covers many possible nuances and interpretations the majority of papers focused on a narrow range of private vehicle related topics, including both hardware and software solutions to reduce vehicular congestion by innovative means – but not, in general, by diverting motorists into other travel modes. A number of papers also addressed innovation in leveraging technology to gather and analyse data related to air quality and vehicle emissions in order to enable decisions to achieve air quality-related goals. A small number of notable papers did include a broader focus – which might perhaps point to an opportunity or even a need for ITS practitioners to collaborate with other professionals in order to have a more holistic and system-wide approach to smart cities.

There was a strong thread running through sessions to emphasise the need for greater attention to diversity, accessibility, equity and inclusiveness when planning mobility systems; for example when addressing the possible deployment of autonomous vehicles:



AVs will only help to meet public policy goals if they come as shared fleets integrated with public transport – Henriette Cornet in session SIS 75

The technical sessions covered 10 main themes:

Advanced sensor and monitoring technology – the research reported tended to be focused heavily on new European Union emissions standards and the efforts that public agencies were taking to gather data effectively, monitor carbon levels, and measure progress towards emissions reduction. These studies were frequently part of regional traffic management schemes. A more general approach was taken in projects on the use of low-power sensors to transmit data, and a review of sensors as a data collection and mobility tool.

Climate goals and citizen engagement – papers here presented several innovative ideas ranging from public participation focused on a smart cycling hackathon, dialogue-based workshops regarding the acceptance of big traffic projects, and on-line participation and co-creation focused on the development of mobility visions. Other papers looked at the energy consumption of electrified buses, and the EV charging needs of urban transport with electric vehicles.

The role of data in advanced mobility management covered a wide range. One paper described how central government worked with local agencies to collect and analyse massive amounts of raw data to understand travel behaviour during the COVID pandemic and in turn feed the conclusions back to medical advisers. Other case studies reported how to use real-time data and standard operational procedures in designing future mobility services, and data exchange between public real-time traffic data and private routing apps.
Improving mobility and safety through ITS was a popular subject with papers ranging from building an environment friendly to support traffic management, the design and testing of a self-driving electric wheelchair, and the use of localisation information derived from satellite data. A paper titled Net Zero x Vision Zero: integrated through ITS" discussed how digital transformation enabled transport to embrace data, technology and connectivity to work towards the delivery of "Net Zero" and "Vision Zero".

Influencing traveller behaviour was seen as an essential but difficult activity – difficult as the lack of direct surveys and other data collection tools on traveller preferences, relative to other industries, hampers the transport industry's ability to understand and analyse behaviour. This creates opportunities for creativity in leveraging other datasets and methods to support this objective, for example using real-time geofencing data to assess the effectiveness of demand management programmes or creating an app with an accessible user interface for vision-impaired travellers to check real-time bus information with the aim of increasing riders' likelihood of using transit and improving their experience.

Innovative applications for congestion management and smart cities featured strongly with a paper proposing creation of a Smart Mobility body of knowledge to prepare for the future, inclusive of MaaS, urban air mobility, and connected and automated vehicle technology. Simulation tools to assume demand scenarios with future technology were described and the design of a "Smart Commuting Masterplan".

Using ITS to minimise environmental impact was featured in a number of papers and sessions with work going beyond carbon emission reduction in order to reduce the environmental impact of travel. A broad view of the role of environmental traffic management and air quality was described a Dutch study estimated the use of space and the benefits and costs of Smart Mobility measures in order to weigh them against each other. The idea of shifting freight into underground tunnels was also explored.

Management strategies for sustainable transport were acknowledged as difficult given the complexity of the transport industry and the many stakeholders. Swedish researchers presented a system dynamics tool to capture the dynamics of the uptake of battery electric vehicles, shared mobility services and connected autonomous vehicles; a Dutch study described smart travel information across multiple partners including measuring performance and the contribution to pre-defined goals. A study "Toward Vision Zero in Asia" explored crash analysis and how that can inform a general V2X safety system.

Managing the supply and the demands has been a regular Congress topic and sessions explored methods for assessing supply and demand, including the use of sensors to detect vehicle and pedestrian travel and the use of smart card data to evaluate whether bus-rapid transit improves travel efficiency. Case studies included intelligent traffic control for urban feeder routes and a broad

look at how major traffic disruptions affect travel and the idea that 'predictive network management' could help mitigate their impact.

Traffic and information management papers on this topic included a case study on traffic congestion mitigation using real-time third-party data and signal retiming, a "Safer Streets" initiative using existing safety-related data to identify risks earlier and avoid crashes using timely warnings or preventive measures; the development of a freight logistics framework and its application for road maintenance planning; and a project to assess how data can be used to reduce NO_2 concentrations and increase service levels during periods of traffic congestion.

By contrast with the sharper focus of topics that comprised the majority of the research and technical papers, broader themes emerged over the course of 15 SISs. These included

- The importance of Mobility as a Service as a way to understand and change travel behaviour, and a tool for gathering data. MaaS continues to dominate many conversations among technologists and practitioners who work in transit, walking, biking, and any form of trip sharing or trip hailing. There was a growing acceptance by some MaaS advocates that there must be multiple access points for customers to use a MaaS platform, not just multiple travel options. Integrating multiple platforms to broaden the net of new users was likely to be necessary in order to gain wide adoption of any MaaS service. This should also help stakeholders who provide mobility options and technologies to overcome the largest hurdle to adoption – getting users to access and continue to use a service.
- Policy, and the relationship of policy and regulatory processes with transport operations, technology solutions, and the virtuous cycle of feedback between stakeholders working in all of these arenas, was a fairly prominent theme. Many presenters tied technology solutions to larger policy goals and some identified policy solutions related to further behaviour change. Presenters noted that, in particular, MaaS data and practices should be connected to larger goals to create smart cities and more customer-focused mobility solutions—although there were few examples of this occurring to date.
- Data challenges were present, but very different, across the transport landscape. Multiple presenters noted that there were huge amounts of data on traffic and vehicular travel, which may not be analysed well or may not be possible to analyse due to funding or technical limitations. At the same time, there is not enough data on walking and bike trips and on travel preferences of people who walk and bike. Finally, one or two presenters noted that data should include qualitative data—that is, conversations with travellers to fully understand their travel behaviour, rather than relying on numbers or static data about demographics in order to make decisions.

Other SISs discussed ways to develop cycling including the benefits from the emerging field of connected cycling; a future perspective on real-time traffic information; a briefing on the European Commission thinking on a new ITS Directive to help to make connected and automated multimodal mobility a reality; and how to go beyond eco-driving with intelligent systems to help drivers and road authorities reduce emissions.

Old v New

For a mix of reasons the implementation of "smart cities" appears to be more challenging than originally anticipated – partly because "smart cities" is a rather broad, vague policy concept. Lacking precise definition means that almost any ITS solution can be considered as contributing to a "smarter city" but also that no one is equipped to say when a city has met the goal of being "smart enough."

Cities should exchange lessons learned about deploying foundational transport technology solutions, such as technologies to monitor traffic and public transport fleets and parking management systems. Next cities could consider integrating data sources and making data available to developers (eg the General Transit Data Feed Specification or GTFS) to incorporate into their products (eg multimodal trip planners.) Cities could also identify needs of specific underserved populations and, with a laser focus on those target audiences, design services to meet their needs. These strategies may contribute to what we might label "smarter cities", but would hopefully deliver tangible benefits to citizens along the way.

Most papers and many of the SISs focused on particular elements of "smart city" solutions which suggested that implementing a truly integrated and comprehensive Smart City vision was not being fully realised. Topics ranging from micromobility to freight management and data management were all noted as contributing factors to a Smart City concept but the premise that these tools

have even greater value when used together remained theoretical given the relative lack of evidence.

Forwards v Constrained

Organisational silos continued to be a challenge to an integrated Smart City concept, along with differing target markets and unclear policy goals. Knitting the information sources together is difficult and multimodal governance examples were lacking. Papers in this track offered discrete project examples but did not offer a vision or define a pathway for cities to integrate projects to become and remain "smart." Better organisational case studies, draft policies, and proposed definitions of success are needed.

Tools that were identified as potentially contributing to smarter cities included – Data-driven solutions: Smart Cities should rely on and support the development of data-informed decisions used to drive measurable outcomes. Despite a greater availability of some kinds of data, gaps often existed between data capture and turning data into actionable information.

Promoting mode shift and minimising environmental impact: An idealised Smart City would rely on multimodal solutions with travellers taking advantage of appropriate technologies to suit particular trips. There was not much emphasis on mode shift and while papers gave minimising environmental impact as a goal of smart cities they did not offer much concrete evidence of better environmental outcomes.

User-Centric solutions are needed: the Smart City contributions focused too little on individual travellers and traveller types. There was no mention of customising traveller information or managing customers' personalised needs. As with Mobility as a Service, traveller behaviour will be key to reaping the benefits of smart cities. That being the case, we need to see more research on how travellers/customers respond to data and to mobility offerings.

One of the key policy elements required was achieving an integrated view on urban planning and operations – long-term strategies to enable sustainable mobility services that also addressed diversity, accessibility, equity and inclusive mobility. A number of speakers presented aspects of Sustainable Urban Mobility Plans (SUMPs) and the diagram below illustrates some of the key factors that have to be considers.

Plazier & Elting in session SIS 974

The overall aim of the ITS Summit was to encourage cross-sector discussion on transport concerns and priorities. This year's Summit discussions were focused on reaching conclusions on five prevalent challenges that include modal shift, public acceptance, avoiding regional stand-alone solutions, market dynamics and regulations, as well as coping with increasing city-logistics.

Over 80 Ministers, Mayors, Industry Leaders and senior representatives of national and local governments from over 20 countries/states met in Hamburg to review how intelligent and green mobility can contribute to sustainable growth and a better environment for all citizens. Opening the ITS Summit Hamburg Senator for Transport and Mobility Transition, Anjes Tjarks, said "We live in a globalised world. In no other city is this more evident than in Hamburg. With the port as a gateway to the world, and as a European hub for rail transport, it is clear that we can only overcome future mobility challenges together. This is why we need close collaboration between municipalities and states as well as on an international level. We cannot accomplish the mobility transition or overcome the climate crisis on our own. Instead, we want to improve the quality of life and mobility for people everywhere by promoting the development and implementation of smart and climate-friendly technologies. Hamburg is a digital model city and provides real-world conditions for these technologies. We develop and test the future here so we can share our findings and solutions with others. Ultimately, policies are good if they're specific and effective. In Hamburg, we want to turn many theoretical ideas into practical policy."

In a series of managed discussions delegates shared experiences of ITS solutions and services that are ready to support these themes and also identified areas where solutions are incomplete, where more fundamental research is needed to enable progress to be made, or where more trials and demonstration projects would be beneficial. This group of high level policy makers and heads of industry concluded that:

- The deployment of ITS can reduce congestion AND emissions AND energy consumption, while enhancing safety and mobility for people and freight. However the knowledge of how to do this was not evenly spread across countries and regions.

- ITS has given resilience and alternative solutions to mobility services which has helped them survive the pandemic; the pandemic has also been a catalyst for digitalisation.

- Hamburg 2021 had the strongest freight elements in a Congress so far. However, there was still more to do to find the best way to integrate freight and passenger movements in cities.

- Sustainable mobility and modal shift goals have to be designed into policies and procurements from the start. Adding these later increases costs and performance risks.

- Improving public acceptance of policies can be helped by city/public/supplier collaboration before procurement specifications are set.

- Many cities seemed unaware of what has been done and what works elsewhere – duplication is slow and costly. More work was needed to publicise what is known; this is an essential development to counter skills shortages.

- More open 'platforms' were needed on which specialist applications could be run in interoperable environments with more use made of 'data spaces'.

- Innovatory services were too often seen as a threat by regulators; regulation should be a partnership. However, proposers of innovatory services needed to remember that transport infrastructure is designed for a

very long life and the public sector has to protect this investment. There was strong support for 'innovation 'sandboxes' as a mechanism to develop a partnership approach at the earliest stages.

- Although there was a clear endorsement of the value of standards there were still regional standards that needed to be extended to national level and national standards that needed to be extended to global level. Cities needed to be far more involved in the standards-setting processes.

- The three Regional Organisations* were urged to work with public and private sector stakeholders to publish "State of the Art" documents describing ITS implementations;

The Summit participants:

- were keen to continue to work together in addressing city mobility challenges through the deployment of efficient and sustainable ITS solutions;
- thanked the City of Hamburg and ERTICO- ITS Europe for organising the event.

The ITS Summit was a key element of the 2021 ITS World Congress which had as its main theme: Experience Future Mobility Now. The participants enjoyed this first opportunity since the Singapore ITS World Congress in 2019 to meet their global counterparts face-to-face to align on common transport challenges and possible solutions. They also looked at emerging issues where a global partnership on research could benefit all parties. The participants of the ITS Summit were keen to ensure that their conclusions should continue to be a motivating factor for the organisers of the Los Angeles ITS World Congress 2022.

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