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AUTOMATED VEHICLES SYMPOSIUM 2016

USERS. VEHICLES. INFRASTRUCTURE.

Juhani Jääskeläinen | MH Roine Consulting | 22.8.2016

Automated Vehicle Symposium 2016

Introduction

Annual symposium on vehicle automation (AVS 2016) with hundreds of representatives all over the world was held in San Francisco 18-21, July 2016. This is a summary of some of the main topics of the symposium with related recommendations to Finland.

The author is Senior Adviser Juhani Jääskeläinen, who also participated the Symposium and the sessions.

Matti Roine

Helsinki
22, August 2016

Content

1. Overview of the Event

The AVS 2016 Symposium took place in San Francisco, California on19-21 July 2016. The symposium which is jointly organised by the Transportation Research Board/National Academies and AUVSI has a unique appeal and attracted this year 1176 participants from academia, government and industry representing 25 countries, 21% of participants were from outside U.S. The programme consisted of Plenary Sessions on three mornings with significant autonomy/automated vehicle figures, and in total 22 breakout sessions, or mini-conferences, over two afternoons. There was also an Exhibition and Poster Sessions with presentations. On the third day, all the break-out sessions reported on their conclusions. The EU-US-Japan Tri-lateral Automation Working Group met on Friday 22 July.

2. Highlights and Megatrends

AVS 2016 was again this year a big success, with very good world-wide attendance and program with Plenary Sessions, Break-Out sessions, Exhibition and Poster Session. AVS has established itself as the most important yearly automation symposium.

- The biggest news was what was not there, there was no Chris Urmson this year as keynote speaker (only a layer from Google) and nobody from Tesla.
- The US consumer unions are on the attack, they have the DoT and NHTSA, saying the soft approach and issuing guidelines for tests on open roads is not enough to protect consumers, and that regulation is needed
- The whole industry is talking about the big dilemma how to test autonomous vehicles, the Detroit vs Silicon Valley approach, and if tests on open roads should be allowed or are premature.
- A big issue is over-confidence, which was the reason for the Tesla accident. The related issue is the transfer between the automated mode and human take-over in Level 3 automated cars
- The defensive position of US DoT and NHTSA is that automation holds a huge promise, and something has to be done as the fatalities are again increasing in US (due to increase in car sales and increase in miles driven associated to the economic upturn)
- NHTSA has published its own Automation levels (0-4) which are similar to the SAE levels currently used by most experts, but not exactly the same
- Transport Secretary Foxx gave a keynote speak, highlighting actions needed for introducing automation in US. This should be of course seen against the background that he will be replaced after the elections.
- The Faraday Future new concept car (fully electric) is amazing, introduced at CES 2016 in Las Vegas. Nobody knows who is funding them but they have 850 automotive experts and are building two totally new factories.
- The infrastructure for automated vehicles such as lane markings and traffic signs does not exist, is of poor quality or ambiguous and confusing. There is an extensive test programme i.e. in Texas, the initial results show already that there will be huge problems for automated vehicles.
- In US the different approaches to testing by different states are a big problem and is leading to market fragmentation, federal DoT cannot control or influence it.
- The Smart Cities initiative collected a lot of useful information from the 78 applicants, Columbus was the winner, there are automation projects in almost all the proposals

- MaaS which is called MoD in US was talked about but not much is happening
- EU-US-Japan trilateral meeting gave a good overview of activities but collaborative activities between the three regions have slowed down
- Europe with ongoing activities and the H2020 ART programme is very strong, even in the lead, also we are strong on the policy issues
- Multiple national initiatives and pilots in Europe remain a problem, on the other hand there are important national projects which bring automation forward
- Everybody agrees that the way to go is a gradual approach to automation based on V2X connectivity (hybrid DSRC and LTE/G5), HD digital maps, multiple sensors (cameras, LIDARS and radars), sensor fusion and deep learning
- On technology side there has been huge progress especially in sensors and sensor fusion and deep learning. The trend is to go for cheap sensor suite and use the super processing power to combine and analyse the information
- Especially in LIDARS there has been a lot of development, they cost is now 200 USD, in a few years it will be 100 USD per sensor
- Data ownership, access to in-vehicle data security and privacy important and are discussed
- There is more and more focus on making the automated cars to behave as human-driven. This incudes that they should indicate to pedestrians and other road users their intention, however this is not yet possible due to current regulations
- Ethical issues are discussed but nobody was able to propose solutions how to solve then, with technology or regulation (Who will program the ethical decisions in the vehicle?)
- The new coordination action called CARTRE which is follow-up of VRA is very important, it will for example organise a workshop in Brussels next spring. CARTRE will also organise a stakeholder platform and working groups etc.
- Japan had a very large delegation, they clearly want international cooperation and to benefit from automation. They have published guidelines for testing and FOTs of automated vehicles in Japan.
- Russ Shields created havoc as usual with his unorthodox views, he said that getting Levels 1-2 right would take huge effort, nobody would go to Level 3 because the hand-over cannot be done reliably, next would be Level 4 in 25 years.
- Eetu Pilli-Sihvola, TRAFI presented a poster on the second day of the Symposium.

3. Symposium Welcome Day 1

Brian Wynne, President and CEO, AUVSI said that this was a great partnership AVS-TRB and the meetings continues to grow each year. There was also great media presence and a lot of attention to automation.

Jane Lappin, chair, TRB Intelligent Transportation Systems Committee and Toyota Research Institute welcomed everybody in behalf of TRB and said that some 1200 participants were expected. Besides plenaries there would be 22 break-out sessions.

Secretary Brian Kelly, California State Transportation Agency welcomed everybody to California, and said that they introduced already in 2014 legislation allowing testing of automated vehicles, today 14 companies held the licence. Although there were new trends in mobility like Uber, people were still buying more cars than ever and safety remained a problem.

Opening Keynote Addresses and Plenary Day 1

Secretary Anthony Foxx, U.S. Department of Transportation (to be replaced soon) is sitting on top of 55 BUSD budget and 55.000 employees. He said that automation will be coming, and advertised the Smart City challenge. He laid out the following priorities:

1. Safety – fatalities are still increasing in US (!) and this is a huge problem, automation holds a promise to make roads safer
2. It will not be perfect, but we could aim at 80% improvement
3. We need Federal Motor Vehicle standards
4. Need also to work on cooperation between federal and state levels, cannot have 50 different standards.
5. Developing new tools and guidance for issuing test licences

Picture: Secretary Anthony Foxx, U.S. Department of Transportation addressing AVS 2016

Dr. Mark R. Rosekind, Administrator, National Highway Traffic Safety Administration was in the programme to talk about NHTSA and the Future of Automated Vehicles, but he was not present.

Dr. Maarten Sierhuis, Director, Nissan Research Center Silicon Valley was talking about Socially Acceptable AI-based City Driving. He said that urban environment were much more challenging and complex than the highway environments. Mobility is social, therefore the autonomous vehicles have to behave socially, which means like human-driven vehicles, i.e. communicating the intentions to other road users.

Dr. Jan Becker, Senior Director, Automated Driving, Faraday Future gave one of the most interesting presentations. He says that Faraday Future is a 2-years old “mobility company”. Nobody seems to know who is funding them (Apple is a suspect), but they have hired 850 automotive technology experts and are building two factories for their vehicles.

They made a big splash in Las Vegas CES 2016 when they introduced FFZERO concept car which is fully electric and has a lot of connected automation in it as well. Actually this is a platform on which

different vehicles can be built, with 3-8 battery packs and 1-4 motors. The concept car introduced at CES was the most powerful combination generating immense power (1000 hp). The company philosophy is to automation enjoyable and safe. They are already testing their vehicles in Michigan and California.

Colm Boran, Ford Motor Co was giving an automotive OEM perspective in binging Autonomous Vehicles into production. He said that Level 4 needs redundancy which increases cost. Real-life situations are very complex and collaboration is important in product development and testing. Ford is testing it vehicles (including weather related) in M-City.

Dr. Patrick Lin, Philosophy Professor, Emerging Technologies, California Polytechnic State University was talking about Ethics of Autonomous Vehicles. There are a lot of questions but no answers. In the end of the day someone (regulator, industry) jas to solve the ethical questions, like

- Is it ethical to beta-test automation on open roads (like Tesla is doing)
- Is it enough that automated vehicle passes the same test than humans?
- What are the large-scale effects of autonomous vehicles navigating the same roads?
- If the accidents and fatalities drop dramatically, is the end of insurance industry and end of organ transplants?

Kristin Kolodge, Executive Director of Driver Interaction and Human Machine Interface (HMI), J.D. Power and Associates spoke with the title Are Consumers Ready and Waiting for Automated Vehicles? He painted very pessimistic view of the situation. The consumers would want safer vehicles but are confused. They do not understand the functioning of even the systems currently in the car, like ACC. The dealers do nothing to help. The inconsistencies in approaches to automation are eroding trust (trust takes years to build, seconds to break and forever to repair).

Bryant Walker Smith, Assistant Professor of Law, University of South Carolina spoke about Automated Driving Law. He said that many OEMs already accept liability (as can be seen in call backs of vehicles if defects are detected). Automation should drastically reduce number of accidents, so there will be less potential liability cases.
Regarding regulators there is not much progress. They do not even know the right questions, not to talk about answers. The target could be that the automotive OEMs share their safety philosophy and product information, which is then assessed.

Marc Dziennus, Cognitive Psychologist, German Aerospace Center (DLR) spoke about. Human Factors Recommendations for Highly Automated Driving in the EU Project AdaptIVe which is a very important project, aiming at automation levels 1-3.
Most important part of this work relates to the hand-over between the car and the driver in Level 3 automation. The car should be able to give a warning when the limit approaches and the driver has to take control. This can be a problem in unexpected situations.

Sarah Hunter, Head of Policy, X, spoke about Policy Development and Automated Vehicles, Yes, the company is called X, formerly known as Google X and before that Google!

As a true representative of Silicon Valley, she was strongly advocating soft approach to regulation, supporting self-regulation saying that that was essential for innovation. At the moment everything is

open, starting from automation levels which are not well defined. Instead of writing new laws new approaches were needed, e.g. the new regulation for drones (allowing almost everything) is a good example. The industry should introduce automated vehicles gradually, with extensive pilots.

Dr. Joan Walker, Professor, University of California, Berkeley spoke with the title The Traffic Jam of Robots, pointing out the many societal uncertainties in the introduction of automation. In the US the situation back where it was before recession, last year the Americans bought more cars than ever, the sales of hybrids collapsed due to cheap oil price, the miles driven rose also causing increase in traffic accidents and fatalities.

With this trend and other megatrends as increasing urbanisation, increasing population, aging population and increasing number of vehicles per capita it is not clear what would be the effect of increasing number of automated vehicles. The simulation studies give conflicting results, some forecasting drastic reduction and others showing huge increase in number of vehicles and miles driven (i.e.as people stay mobile longer). In any case automation will not be able to solve the congestion problem. People are emotionally attached to their cars, and shared economy would need strong incentives or de-incentives to produce a real change in user behaviour. One of the threats is 0-occupancy vehicle!

Gabe Klein, Fontinalis and Seleta Reynolds, General Manager of Los Angeles Department of Transportation spoke more positively of the change in mobility, Mobility on Demand (MoD), shared economy and the role of automation. Uber and Lyft are moving people in US and especially in California (not surprising as both have headquarters in San Francisco). Helsinki was mentioned as forerunner in MaaS (which in US is called MoD).

4. Welcome addresses and Plenary Day 2

The Symposium Welcome on the Day 2 of the event was given by Mark Norman, Director of Development and Strategic Initiatives, TRB. This was followed by presentations of connected automated driving initiatives and programmes in different European countries and some of the ongoing H2020 European Automation R&I projects:

- Connected and Autonomous Vehicles in the UK: Iain Forbes, Head of the Centre for Connected and Autonomous Vehicles, Department for Transport
- European Activities on Connected and Automated Driving; the Present and Beyond - The ADAPTIVE and AUTONET2030 Use Cases: Dr. Angelos Amditis, Research Director, Institute of Communication and Computer Systems
- Connected and Automated Driving in the Netherlands: Challenge, Experience and the Declaration of Amsterdam: Tom Alkim, Senior Advisor C-ITS and Automated Driving, Ministry of Infrastructure and the Environment, The Netherlands
- i-GAME: From Platooning to Cooperative Automated Maneuvering: Dr. Jeroen Ploeg, Senior Research Scientist, TNO Automotive, The Netherlands
- CityMobil2: Four Years of Demonstrating Automated Road Transport Systems in European Cities: Dr. Adriano Alessandrini, Università degli Studi di Firenze
- Drive Sweden: A National Effort on an Automated Transportation System: Jan Hellåker, Head of Automation, Lindholmen Science Park AB

The second part of Day 1 morning Plenary Session was devoted to automation issues including standardisation, cybersecurity and privacy.

Jack Pokrzywa, Director, SAE Global Ground Vehicle Standards US TAG ISO TC22 Chairperson spoke about. Connected and Automated Standards. SAE has a road map for connected and automated vehicles, there are already 36 standards. They are in three parts, Definitions, Safety and Privacy/Security. SAE automation levels are widely used but now NHTSA has developed its own definitions for automation (four levels).

Dr. Jonathan Petit, Principal Scientist, Security Innovation, Inc. introduced Cybersecurity Challenges for Automated Vehicles. He said that we need a systematic approach to cybersecurity, everything has to be covered: Sensors, sensor fusion and processing, on-board unit hardware and software, the whole vehicle, communications and infrastructure. There are many constraints such as cost and complexity of the problem.

Dr. Hermann Winner, Technische Universität Darmstadt, spoke about Safety Assurance for Highly Automated Driving: The PEGASUS Approach. Ty is the he problem in proving the safety is the huge amount of testing needed, the average interval between incidents is 12 million km and 600 million km between fatal accidents. With automation we will have old types of accidents (but reduced number), new accident types related to automation and transitional (manual-automated) accidents. PEGASUS is a German project running 2016-2019 and funded by Federal Ministry for Economic Affairs and Energy. Goal of the project is the development of generally accepted methods and tools for testing of highly automated car functions. Project partners include Audi, BMW, Daimler, Opel, Volkswagen, Bosch and Continental.

In the end of the morning plenary Bob Denaro, Chair, TRB Joint Subcommittee on Road Vehicle Automation moderated a panel discussion with the topic Starting Up a Transportation Revolution
The panellists were Dr. Louay Eldada, CEO and Co-founder, Quanergy Systems, Inc.; Nalin Gupta, CEO, Auro Robotics.and Sravan Puttagunta CivilMaps. Dr. Eldada said that sensors are getting cheaper, the cost of LIDAR is already down to 200 USD and is expected to drop to 100 USD. The TESLA fatal accident could have been easily avoided with LIDAR. Nalin Gupta said that technology development and regulation should go hand in hand, and standards are needed. Sravan Puttagunta was talking about data ownership, they provide maps to OEMs.

5. Symposium Welcome and Plenary Day 3

The welcome on Day 3 was given by David Agnew, Director of Advanced Engineering, Hyundai MOBIS North America and Member, AUVSI Board of Directors. Traditionally, he gave some statistics of the event: 1176 attendees (up almost 50% from last year, representing 40 U.S. States and 25 countries (21%of the participants were from outside US). As can expected California and Michigan are leading in US States, Japan in foreign visitors (60 attendees).

Liam Breslin, Head of Unit Surface Transport, European Commission, DG Research & Innovation gave an overview of the European Collaboration on Road Automation. There are a lot of activities in Europe both on policy/regulatory side and research. An important milestone was the adoption of the

Amsterdam Declaration in April 2016 under the Dutch Presidency of the European Union. The Declaration is a joint statement of EU, MS governments and the industry, and also developed jointly.

Picture: Liam Breslin, EC DG RTD addressing AVS 2016

On the policy/legal framework there are three cornerstones:

1. STRA, the Strategic Transport Research Agenda, which covers all transport modes and includes connected and automated driving and electro-mobility
2. GEAR 2030 which follows CARS 2020 with the goal to support the competitiveness of the European Automotive Industry. It has four Working Groups, one is focusing on the legal and policy issues of connected automated driving
3. The Oettinger Round Table which brings together the automotive industry and mobile communications industry, with special focus on the digital agenda, connectivity for cooperative systems and cybersecurity.

EU has funded R&I in automation for many years, starting in FP6. Some of the most important projects in automation have been HAVE-IT, ADAPTIVE and CITYMOBIL. The focus in the ongoing framework programme H2020 which has special funding for automation is in Large-Scale field tests. There was already one call, the next call which will open in September has a budget of 50 M€ and has three topics, Infrastructure for automation, Multi-brand platooning and urban automation.
The ongoing call and the next call both identify topics for “twinning” with US. The process is led by the Commission, for example for the next projects to be selected EC will organise a meeting in January to discuss how to do it.

Hajime Amano, President, ITS Japan gave and update on the latest developments in SIP-adus and related activities in Japan. Japan is developing connected automation and its approach is the same than in US and Europe. Central part will be played by so called Dynamic Map. The data collection and processing follows the typical Japanese approach, which means that almost everything is done by the public sector and there is competition only in the final service provision and in in-vehicle devices.

On the policy side, Japan is developing guidelines for testing of automated vehicles. The 3rd SIP-adus workshop will take place in Tokyo on 15-17 November 2016 and it is free of charge.

Kevin Dopart, Program Manager, Connected Vehicle Safety and Automation, Intelligent Transportation Systems Joint Program Office, U.S. DOT spoke about USDOT Automation and Smart Cities Research. The proposed funding for the next five years is 50 MUSD per year, but if this will pass is unclear. This would cover technology research (including V2X, automation, safety), Policy Research and Human Factors research.

The presentation on the U.S. DOT Smart City Challenge was going to be given by representatives of City of Columbus who is the winner, but was given by *Brian Cronin who is now Director of Office of Operational Research, FHWA.*

It can be (and has been) criticised that in the Smart City challenge all the money, 50 MUSD goes to one city. The interesting issues are however, the whole process how the winner was chosen, and what happens next.

Overall, 78 cities sent proposals and seven were given 100 kUSD to make a full proposal. All data from the 78 cities was collected to a database which is online. Automation was one of the criteria, and 90% of the proposals had a part on automation. The seven finalists alone represent investment of 500 MUSD and had 150 partners.

In automation most cities are looking into public transport and freight. Automation is normally connected with electric vehicles, so the aim is electric connected automation. In public transport this means automating the first/las mile (i.e Columbus is planning to do that).

Most of the applicant cities are planning to go ahead with their Smart Cities projects, including automation, in any case even without DoT funding. If this will be the case the competition really had an impact!

Nathaniel Beuse, Associate Administrator, Vehicle Safety for Research, NHTSA spoke about Automated Vehicles; Accelerating Their Safe Arrival. NHTSA has been criticised by consumer organisations for not doing enough (especially after the Tesla accident). After all safety is their responsibility. They have asked for 50 MUSD for electric vehicles and 200 MUSD for automated vehicle pilots in FY2017 budget (included in the President's proposal, very doubtful that it will go through.

If the budget is there, NHTSA research would cover Human Factors (up to Level 2), System Performance, Electronic Control, Benefits assessment and testing and evaluation.

Karl Simon, Director, Transportation and Climate Division of the Office of Transportation and Air Quality, U.S. Environmental Protection Agency spoke about Automated Vehicles and the Environment. Overall, he was quite optimistic, the automotive industry is innovating and seems to be on the way to reach the 2025 CO2 reduction targets. This can be achieved with improvements and

innovation in the combustion engine, and does not need to move to hybrids or electric vehicles completely. Automation will surely have an impact, but nobody knows what will happen!

6. Breakout Session Summary Presentations

The results and conclusions of all the 22 Break-Out Sessions were presented by the session organisers or moderators. This took quite long, but was very interesting. Here are some of the main conclusions (for the complete list of Day 1 Break-Out Sessions see Annex 1)

Breakout 1: Public Transport and Shared Mobility

- In the future we will see shared automated vehicles
- The line between public and private transport will blur
- Automated vehicles are useful in service for the first/last mile and the “underserviced” population
- The session discussed user-centric approach and promoting PPP models, which are essentially European concepts

Breakout 2: Law and Policy as Infrastructure

- The general view is that the authorities should start by doing the same things they are doing now, like licencing, car inspection, standards etc
- .there is no change in the driver being in control and responsible
- Security and privacy frameworks are of course needed

Breakout 4: Impact Assessment

- Reported by Satu Innamaa, VTT
- The impact mechanisms are complex
- We should start from framework for impact assessment

Breakout 5: Enabling Technologies

- See the detailed report below

Breakout 6: Safety Assurance

- A scientific, unified framework for optimising and evaluating safety of automated vehicles is needed
- Cannot wait for a perfect system but have to start now
- Important to have open dialogue with the public
- The Tesla accident shows that the public does not understand how the vehicle and autopilot operate (overconfidence)
- There is great confusion with different levels of automation and different names and concepts

Breakout 8: Traffic Signal Control with Connected and Automated Vehicles (CAVs)

- We will need and will have traffic signals for a long time
- There are many research needs, e.g. network impacts, human factors, infrastructure adaptation, evolution, control algorithms and impact of shared mobility

Breakout 10: Ethical and Social Implications of Automated Vehicles

- There is no easy answer to the ethical questions
- All data needs to be open
- The big question is that who is doing the ethical decisions, are they going to be coded into the vehicle?

Breakout 12: "AV-Ready" Cities or "City-Ready AVs?"

- Cities will be early adopters, automation is coming to the urban policy agenda
- Tests are already ongoing e.g. in London. Los Angeles, San Francisco, Columbus and Toronto
- For cities automation is a tool and not a goal on itself
- Cities need long-term transportation plan, accepting the “new normal” and engaging the local community
- Automation goes hand-in-hand with shared mobility and Mobility on Demand
- Cities do not have qualified staff to deal with automation
- The modelling does not work, too many uncertainties
- The co-existence of automated and non-automated vehicles

Breakout 14: Reducing Conflict between Vulnerable Road Users and Automated Vehicles

- there has been significant progress in developing pedestrian detection and avoidance systems
- open issue is how the vehicle should communicate its intentions
- in a futuristic view the cities will not have traffic signals

Breakout 17: Policy Making for Automated Vehicles: A Proactive Approach for Government

- policy makers have to prepare, automated vehicles are coming
- public needs to be educated
- the danger is in premature introduction of vehicles, but also in premature regulation without understanding the impact

Breakout 20: Physical Infrastructure, Work Zones, and Digital Infrastructure

- See the detailed report below

7. EU-US-Japan Tri-lateral Automation Working Group

I established this Working Group in 2012 and it is still going well. The most interesting part of the meetings are the regional reports, which give in very compact form information on the activities in each region. The EC participation has been problematic for a couple of years but is now returning to normal.

Country Report – Europe

Liam Breslin, HoU EC DG RTD gave an overview of the EU policy initiatives in the automation area and the H2020 ART Programme.

Maxime Flament, Ertico who is the project manager of support action VRA and the new coordination action CARTRE gave an overview of the new European H2020 projects:

- SCOUT: A coordination action, coordinated by VDI/VDE, looking into safe and connected automation, also includes dissemination actions
- MAVEN: Management of automated vehicles, approach is infrastructure based including cooperative traffic control, budget 3 M€
- ADAS&ME: total budget 9.6 M€, coordinated by VTI, looking into the interaction of ADAS with you, 20 partners and also piloting.
- VI-DAS: Looking into vision based driver assistance systems
- CARTRE: The new support action, bit different from VRA. Coordinated by Ertico, two years and budget 3 M€. There are already 65 organisations interested and 35 of those will receive funding. The proposal was developed jointly by ERTRAC, EUCAR, CLEPA and EARPA. There will be a stakeholder forum and a yearly symposium in Brussels. The project will also work on the European vision on automation

It should be noted that next year about 10 new projects will start funded by H2020 ART, including a very large project on passenger car automation.

There were also short reports from UK, Germany, Netherlands and Greece.

Country Report – Japan

The report was given by Amano-san and Takahiko Uchimura. It focused mostly on the work on the guidelines for public road testing of automated vehicles. The guidelines cover system performance, responsibilities, safety measures, driver requirements measures to report accidents. Japan is planning to commence testing of automated vehicles soon, first on expressways and then on arterial roads.
In Japan transport is a hugely important issue, In the greater Tokyo area there are 36 million people and 25 million commuter trips per day! The largest group is now over 75 year olds who will continue to be mobile.

Country Report - USA

The report was given by Kevin Dopart. He explained about the funding (JPO and NHTSA) for 2016 and the President's proposal for 2017. The ongoing research in automation covers the following:

- Functional testing of various levels of automation
- Naturalistic study on automated vehicles in mixed traffic
- CACC research
- Driver acceptance
- Benefit models
- AV policy research
- Management support
- International cooperation support

8. Breakout Session 5: Enabling Technologies

Overview:

This was the Breakout Session I helped to organise and moderated partly. The Session focused on key technologies that enable vehicle-highway automation. Session was very crowded, there were 70 seats but an equal number of people had to be standing or sitting on the floor.

The session investigated what is under the hood, starting with a set of vehicle-highway automation scenarios to which expert panellists will use to discuss key enabling technologies in five topical areas.

Organizers:

- Jim Misener, Director, Technical Standards, Qualcomm Technologies Incorporated
- Cristofer Englund, Research Manager, Viktoria Swedish ICT
- John Estrada, CEO, eTrans Systems
- Juhani Jaaskelainen, Consultant
- Frank Serna, Director, System Engineering, Draper Laboratory
- Surya Satyavolu, CEO, Sirab Technologies
- Sudharson Sundararajan, Lead Technologist, Booz Allen Hamilton

Picture: The crowded Breakout Session on Enabling Technologies

The goals:

- Explore a wide range of technologies needed to establish automated vehicles
- Gain an understanding of how these technologies will need to work together to address needs of the applications, with recognition of data ownership, regulatory and standardization perspectives
- Realize the potential shortfalls in these technologies, ranging from pure technical capabilities through the conformance to the perspectives listed above

The scenarios

To kick-off the session John Estrada, CEO, eTrans Systems presented a number of possible future deployment scenarios.

Scenario 1: Required Connected Capability
Scenario 2: Retirement Community
Scenario 3: Mandated Platooning

Scenario 4: Small City Taxi Service
Scenario 5: AVs in Hot Lanes
Scenario 6: Delivery Platooning

1. Position, localization, mapping.

Mark Tabb, HERE gave an overview of the HERE HD Maps which contain detailed lane-level information (accuracy 10cm). HERE has collected a lot of probe data which is useful in making the automated vehicle drive as driven by human driver. New methodologies for collecting data are swarm mapping and crowd sourcing.

Rob Hranac, VP, Business Development, Swift Navigation said that automated vehicles have to combine maps and all sensors, vision, LIDAR and radar. The company is selling a product which they call high precision GNSS which is accurate to 10 cm and low cost (Solutions are based on real-time kinematics (RTK) technology that is 100 times more accurate than traditional GPS.

2. Algorithms, deep learning techniques, sensor fusion, guidance and control.

Prof. Trevor Darrell, Faculty Director PATH and Director of the Berkeley DeepDrive Industry Consortium spoke about DeepDrive. DeepDrive Industry Consortium is a research alliance which investigates state-of-the-art technologies in computer vision and machine learning for automotive applications. The multi-disciplinary Center brings researchers from PATH, various other Berkeley faculties and the Berkeley Vision and Learning Center (BVLC). The Center's private industry partners are: Audi/VW of America, Bosch, Ford, Honda, NVIDIA, Samsung, Panasonic, Qualcomm, and Toyota. The consortium is highly regarded by the industry and has already produced great improvements in object detection.

Serafin Diaz, VP Engineering, Qualcomm Technologies, Inc. said that the sensors were developing rapidly going to lower cost, lower power and higher precision. This combined with advances in deep learning, algorithms and computer vision substantially reduce the price and increase tremendously the performance of the vehicle sensor suite. Localisation needs both ground truth (GNSS and maps) and computer vision.

Shahrokh Daijavad, Distinguished Research Staff Member at IBM spoke about IBM Watson and Olli. IBM Watson is a technology platform that uses natural language processing and machine learning to reveal insights from large amounts of unstructured data. Olli is a Self-Driving vehicle using the cloud-based cognitive computing capability of IBM Watson IoT to analyze and learn from high volumes of transportation data, produced by more than 30 sensors embedded throughout the vehicle.

3. Hybrid communications

Dr. Gaurav Bansal, Senior Researcher, Toyota InfoTechnology Center, USA, was highlighting the approach of Toyota to automated driving and connectivity. Toyota sees connectivity as essential element of automation and safety, as it works as additional sensor. Safety applications need low latency, maybe 10 ms, which can be achieved now with DSRC and in the future with LTE/5G.

Dr. Thierry E. Klein, Head of the Innovation Management Program for Vertical Industries, Nokia said that in principle all “things”, including vehicles needed to communicate. With DSRC we will never get the coverage we need, so therefore the future solution should be LTE/5G.

Sanjeev Athalye, Senior Director Product Management, Qualcomm Technologies, Inc. spoke about the cellular technology standardisation efforts in ITU and 3GPP. There is a rich roadmap of standards based on the existing LTE standards.

4. Sensing and perception

Roger Berg, VP North America Research and Development, DENSO International America, Inc. said that DENSO I very much investing to the future including trying to model the societal changes. DENSO supports connected automation, that is V2X with sensors.

Michael Maile, Daimler AG was showing some very impressive videos on neural network based object detection and classification. Sensor data comes from video, LIDAR and radar sensors and is then fused. Daimler is clearly world leader in this tehnology.

5. Technologies for data ownership and privacy

Dr. Angelos Amditis, Research Director, Institute of Communication and Computer Systems (ICCS) talking about data ownership reported on the work of the C-ITS Platform. The Platform achieved many results but this (access to in-vehicle data and data ownership) was not one of them, and the work has to be continued. The alternative approaches promoted by on the one hand OEMs and the service providers are In-Vehicle Platform, Interface specification and Extended Vehicle (Cloud server). On privacy there was more progress, even if it is considered that all data coming from the car (including CAM and DENM messages) is private. The categories of accessing certain data are consent, vital interest and public interest.

Dr. Jonathan Petit, Principal Scientist, Security Innovation spoke about data ownership, privacy and technologies for privacy (see his Plenary speech).

9. Breakout Session 20: Physical Infrastructure, Work Zones, and Digital Infrastructure

Overview:

There is a growing interest related to the connection between the physical highway infrastructure, digital mapping, and autonomous vehicles. The first third of this session featured speakers who will be sharing their research and views on how the physical highway infrastructure may evolve or be managed differently. The middle third of the session moved toward a more specific and dynamic scenario —accommodating work zones. The final leg of the session focused on digital infrastructure and dynamic mapping needs for autonomous vehicles.

Organizers:

- Paul Carlson, Texas A&M Transportation Institute
- Carl Andersen, USDOT
- Jerry Ullman, Texas A&M Transportation Institute

1. Physical Infrastructure

Jina Wang, Carnegie Mellon University spoke about smartphone based infrastructure monitoring. The system captures video image and stores it. It is then analysed and a map of the road network showing damaged areas, cracks etc is produced. The advantage is that it is much cheaper than conventional technology based on special vehicles and lasers. The system is being tested on Pittsburgh, and CMU is planning new functions e.g. traffic sign inventory.

Hideki Hada, Toyota spoke with the title Vehicle Machine Vision Interactions with Traffic Control Devices. All Toyota cars are already equipped with cameras and radar for ADAS functionality. Toyota is moving towards more cooperative driving and automation by adding connectivity and digital maps, also adding connectivity with infrastructure. DSRC based V2X will be introduced shortly in Japan.

Paul Carlson, Texas A&M Transportation Institute spoke about Road Markings for Machine Vision which is a NCHRP Project. The project aims at producing guidance to State DoTs and agencies, and has established a joint AASHTO/SAE Task Force. There is an extensive test programme for testing different colour, width and quality level of road markings, and in different conditions, day-night and lighting, shadows, curves, wet surface, debris etc. The initial results show already that there will be huge problems for automated vehicles in detecting road markings in all conditions.

Chris Davies, Potters Industries spoke with the title Pavement Markings Guiding Autonomous Vehicles – A Real World Study. Rather than working with OEMs or suppliers, Potters has made its own study on how well a lane departure warning system really works. As one can imagine, the project did not get enthusiastic response from the automotive industry. The project is ongoing.

Scott Kuznicki, TOXCEL spoke about AI (Ambiguous Infrastructure) - When Signing and Pavement Markings Don't Make Sense to Drivers or Machines. The truth is that signs can be totally misleading, and not even a human can understand them. Scott was showing a lot of examples of such cases, signs are legal but ambiguous. Obviously this will represent a huge problem to autonomous vehicles.

2. Work Zones

Collin Castle, Michigan DOT spoke about the Michigan Connected Work Zone Initiative. Michigan has a lot of infrastructure which means a lot of Work Zones. The problem is how to get the data, it has to be input manually at the moment. They are developing an APP which the person in the field can use, including information on reduced speeds, closed lanes etc. Michigan is also testing DSRC based work zone warning which would need standardisation of the message.

Ross Sheckler, iCone Products spoke with the title what do Automated and Connected Vehicles Need to “Know” About Work Zones? In principle all data is useful, such as work schedule, lane shifts and closures, if flagging operations are active, crash truck active.

3. Digital Infrastructure

Ryota Shirato, NISSAN: Update on Year 2 of Japan SIP-adus. In Japan everybody goes to the same direction, now it is SIP-adus and building dynamic maps which will then push forward automation. The coverage of dynamic maps is extended, quality of data remains a problem.

Maxime Flament, ERTICO spoke about Mandatory Road Data in the EU, mainly referring to the specifications in the ITS Directive and Delegated Act on real-time traffic data. The Member States are

obliged to make the data available through the National Access Point. The data format is DATEX II, and Member States have to provide static road data, dynamic road data and traffic data. Geographic coverage is the comprehensive network (specified in the TEN-T regulation) and other priority networks.

Interesting also is the continuation of the work of the C-ITS Platform. Its work is extended towards automation, there are four topics and one is Physical and Digital Infrastructure.

Ahmed Nasr, HERE spoke about the SENSORIS initiative which is initially a HERE proposal for universal interface specification for accessing in-vehicle sensor data. The idea is that everything is based on messages which are sent through this interface. Ertico has accepted to coordinate the initiative, and is forming a global forum with also US and Japan OEMs. First meeting was in June 2016.

T. Russell Shields, Ygomi LLC spoke with the title Probe Data for Automated Driving. Russ manages always to create havoc, whatever the session or topic he is talking about. He said that automation is coming much later than we think. We need to get Levels 1 and 2 right first. Nobody should go to Level 3 because the hand-over is not reliable and liability issues have not been solved. Level 4 is 25 years ahead.

The first step is to get static data right. This is a huge task, HD maps are not enough, we need to collect full information of the environment the automated vehicles will use. Expressways are naturally easier than cities.

There are some 200.000 unique situations and 6-7 million variations which all have to be programmed to the system. Level 4 needs precise position with 10 cm accuracy at all time.
ITS G5 (DSRC 802.11p) was initiated by Russ but according to him is brain-dead, LTE and 5G is the way to go.

10. AVS 2016 Recommendations

General

- Automated vehicles are coming and they hold a huge promise on improving safety, and bringing benefits to mobility and also to the environment. They are, however, still in the research phase and next we need large-scale field tests (FOTs), which answer to the many open questions, like user acceptance, safety and their real impact on transport and society at large.

- Finland is a special case in many respects, including a large network of secondary roads and the weather conditions. We need urgent actions and partnerships between the public and private sectors to avoid becoming a dumping ground for automated vehicles developed in central Europe or US West Coast and not suited to our conditions.

- First of all we need to develop a Public-Private Roadmap which builds a realistic scenario on the introduction of automated vehicles in Finland. It should be noted that majority will be passenger cars, some electric, and we will live for the next 20 years with mixed fleets.

Recommendations public sector

- It is premature to regulate the certification or technical inspections and use of automated vehicles, as there are still too many open questions on technology, performance, liability and ethical issues, as well as definition of automation levels (SAE and NHTSA have both published definitions)

- To complement the current framework of issuing test licences TRAFI should take the lead in developing guidelines for the testing and piloting automated vehicles in Finland. Similar guidelines are under development in US (Federal and State level) and in Japan. They are public available and can be used as examples.

- The physical infrastructure (lane markings etc) will be huge problem in Finland. To certain extent it is opposite to the problem in other countries and regions like US and Japan (and e.g. UK, Germany and France) which consider that automated vehicles operate better in highway environment, and at least the main network can be upgraded with high-quality lane markings etc.

- Finland has to make a realistic study on what the automated vehicles need as physical infrastructure, and a multi-year investment plan to cover it. There are extensive test programs ongoing e.g. in Texas on road signage and lane markings, their results could be used in Finland.

- The Tesla case shows that the public is largely ignorant on what automation is, and what can be expected from the automated vehicles, this could and already has led to over-confidence. We should plan immediately public awareness campaigns to educate drivers, it is never too early!

- Finland should continue to participate in the work of the C-ITS Platform, especially its new working group on connected automation.

Recommendations private sector

- There is huge ongoing effort world-wide on automation, which is supported by EC, US DoT and Japanese ministries, as well as about 20 countries world-wide. Industry's efforts are equally large, both from the traditional OEMs and new Silicon Valley players like Google and Tesla, and soon Apple.

- Finland can, however play a role if it finds a suitable niche and plays on its strengths, such as mobile communications and very advanced ITS infrastructure, including the ongoing efforts in projects like NordicWay and hopefully soon C-SMILE.

- In Finland we could specialize in testing and piloting automated vehicles in built environments, such as cities. Our strength could be that we start from real mobility problems, and use automation to solve the mobility of people and goods, for example the first mile/last mile public transport. Although complex, there is no problem with physical infrastructure in cities as there is plenty of information for navigation, so we avoid investing in physical infrastructure.

- We could also build expertise in LTE/5G based connectivity (which will be pre-requisite for automation). We should ensure in the appropriate standardisation bodies that 5G evolves to technology fulfilling the automation needs (i.e. latency).

- Finland should seriously look into the participation in the next H2020 ART call (ART-01 and ART-07) which opens in September.

- CARTRE is an important coordination action, all interested parties should join the new stakeholder platform which will be established.

- Carnegie Mellon University's smartphone based road condition monitoring technology is very interesting, Finland could start a similar project.

Annex 1: List of Breakout Sessions

Day 1:
Breakout 1: Public Transport and Shared Mobility
Breakout 2: Law and Policy as Infrastructure
Breakout 3: Human Factors in Road Vehicle Automation Part One
Breakout 4: Impact Assessment
Breakout 5: Enabling Technologies
Breakout 6: Safety Assurance
Breakout 7: Future Challenges for Automated Trucks
Breakout 8: Traffic Signal Control with Connected and Automated Vehicles (CAVs)
Breakout 9: Methods for Assessing Market Acceptance, Adoption, and Usage of AVs
Breakout 10: Ethical and Social Implications of Automated Vehicles
Breakout 11: Early Implementation Alternatives for Automated Vehicles
Breakout 12: "AV-Ready" Cities or "City-Ready AVs?"
Day 2:
Breakout 1: Public Transport and Shared Mobility
Breakout 2: Law and Policy as Infrastructure
Breakout 3: Human Factors in Road Vehicle Automation Part Two
Breakout 13: Design and Operational Challenges/Opportunities for Deploying Automated Vehicles on Freeways and Managed Lanes
Breakout 14: Reducing Conflict between Vulnerable Road Users and Automated Vehicles
Breakout 15: Behavioural Experiments for Modelling Adoption and Use of Autonomous Vehicles
Breakout 16: Aftermarket Systems (ADAS- related)
Breakout 17: Policy Making for Automated Vehicles: A Proactive Approach for Government
Breakout 18: Effects of Vehicle Automation on Energy- and Carbon- Intensity
Breakout 19: Cyber Security and Resilience Challenges and Opportunities for Self-Driving Vehicles
Breakout 20: Physical Infrastructure, Work Zones, and Digital Infrastructure
Breakout 21: Traffic Flow of Connected Automated Vehicles
Breakout 22: Can Our Research Processes Keep Up in an Age of Automated Vehicles & Other Transformational Technologies?

Annex 2: Glossary of Terms

AAHSTO	American Association of State Highway and Transportation Officials
ADAS	Advanced Driver Assistance System
AV	Automated Vehicle
AUVSI	Association for Unmanned Vehicle Systems International
AVS	Automated Vehicles Symposium, a yearly event organised jointly by AUVSI and TRB
ART	Automated Road Transport research programme, part of the Horizon 2020 Smart, green and integrated transport challenge.
CAM	Co-operative Awareness Message – it has the role of a heartbeat of the cooperative communications network.
DATEX II	DATEX II has been developed to provide a standardised way of communicating and exchanging traffic information between traffic centres, service providers, traffic operators and media partners. The specification provides for a harmonised way of exchanging data across boundaries. The current standard is CEN TS 16157 1-3.
DENM	Decentralized Environmental Notification Message – it provides information about a location based situation detected by vehicles or roadside units
DSRC	Dedicated Short Range Communications: these provide low-latency data-only V2V and V2I communications under the IEEE 802.11p standard. Also referred as ITS G5.
FHWA	Federal Highway Administration – a major agency of the USDOT charged with the broad responsibility of ensuring that America's roads and highways continue to be the safest and most technologically up-to-date.
FOT	Field Operational Test – a real world test activity conducted in real traffic using naïve drivers and near production systems. The intent is to get empirical data on benefits, feedback on user acceptance, and an understanding of unintended consequences.
GEAR2030	High Level Group for the automotive industry launched by the European Commission in January 2016 to ensure a co-ordinated approach and to address the challenges faced by the European automotive industry
HMI	Human Machine Interface
IoT	Internet of Things
JPO	The U.S. DoT ITS Joint Program Office (ITS JPO) is charged with executing Intelligent Transportation System Research The JPO has Department-wide authority in coordinating the ITS program and initiatives among all DOT Offices.
LTE/4G/5G	Long-Term Evolution (LTE) is a standard for high-speed wireless communication for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies. 5G (5th generation wireless systems) denotes the proposed next major phase of mobile telecommunications standards. 5G planning includes Internet connection speeds faster than current 4G, and other improvements when available.
MLIT	Japanese Ministry of Land, Infrastructure, Transportation and Tourism
NHTSA	National Highway Traffic Safety Administration – a major agency of the USDOT with the mission to save lives, prevent injuries and reduce economic costs due to road traffic crashes, through education, research, safety standards and enforcement activity.
MaaS	Mobility as a Service
MoD	Mobility on Demand. U.S. term for MaaS
SAE	SAE International, initially established as the Society of Automotive Engineers, is a U.S.-based, globally active professional association and standards developing

	organization for engineering professionals in various industries. Principal emphasis is placed on transport industries such as automotive, aerospace, and commercial vehicles.
SIP-adus	Japanese Cross-ministerial Innovation Promotion Program (SIP) is aiming to realize innovation through promoting R&D at all stages by enhancing cross-ministerial cooperation. The project Innovation of Automated Driving for Universal Services (SIP-adus) is developing Automated driving technologies
TRB	Transport Research Board. The mission of the TRB is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal.
US DoT	United States Department of Transportation
V2X	“Vehicle to anything” communications, i.e. it covers Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I), Vehicle to Central Systems