The AI future of connected and shared mobility

George Dimitrakopoulos
Eirini Liotou

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The 4 major trends in transport & mobility

Major trends in transport and mobility

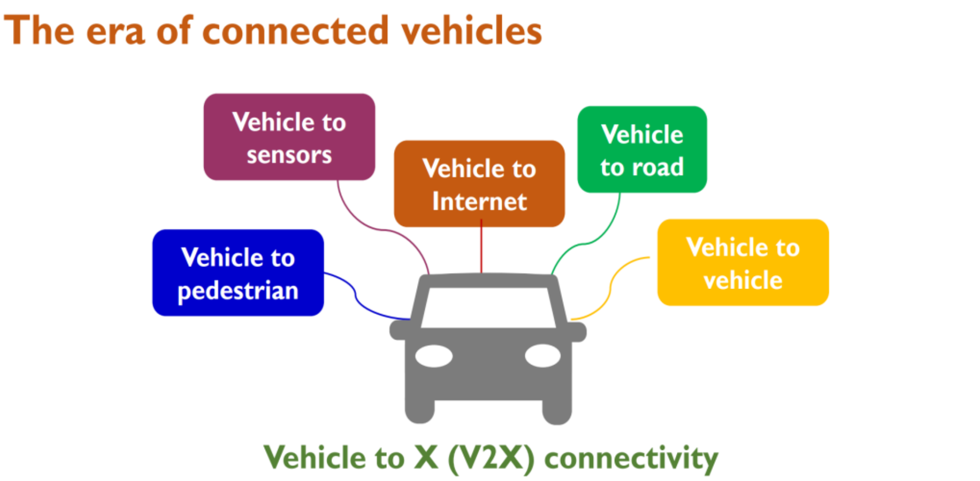
- **Digital transformation** in transport & mobility
  - Key digital technologies play a pivotal role
  - **4 major trends:**
    - Electrification
    - Standardisation
    - Automatization
    - Digitalisation
- The result:
  - Electric, Connected, Autonomous & Shared (**ECAS**) vehicles

1. “ECAS” - Electric vehicle (EV)

- **Smart energy management**
  - Energy consumption optimization
  - Real-time battery analytics and predictive maintenance
  - Adjust energy usage based on driving patterns and environment
- **Charging optimization**
  - AI balances grid loads (load management)
  - Provides location-based charging recommendations

2. “ECAS” – Connected vehicles

- Connected vehicles use wireless technology to “connect” to each other and/or to infrastructure
  - Cellular communication
  - Dedicated short-range communication (DSRC)
- Vehicular communications
  - V2V (Vehicle-to-Vehicle)
  - V2I (Vehicle-to-Infrastructure)
  - V2P (Vehicle-to-Pedestrian)
  - V2G (Vehicle-to-Grid)
  - V2B (Vehicle-to-Business)
  - V2D (Vehicle-to-Device)
  - V2C (Vehicle-to-Cloud)
  - V2X (Vehicle-to-Everything)



2. “ECAS” – Connected vehicles

- **AI-driven connectivity**
  - V2X facilitation, enhanced decision-making & optimization
- **Dynamic route optimization**
  - Real-time data insights
- **Enhanced safety**
  - Collision prediction & avoidance
  - Driver monitor & recommendation
- **Autonomous operations**
  - Seamless integration to fleets
  - Coordination
- **Over-the-Air (OTA) updates**
  - Vehicle performance
  - Dynamic adaptation
- **Integration into smart cities**
  - AI-optimized traffic lights, etc.

3. “ECAS” - Autonomous vehicles

- **AI-Driven Decision-Making**
  - “sensor fusion”
  - “perception”
  - “cognition”
  - “decision”
- **Support for different levels of automation**
  - Adapt behavior based on automation level & road conditions
- **Enhanced safety**
  - Predict potential hazards
  - Reduce human error
- **Integration with shared-mobility**

3. “ECAS” – Autonomous vehicles: SAE-levels

4. "ECAS" - Shared vehicles

- **Dynamic demand prediction**
  - Real-time data analysis to predict peak usage times
- **Intelligent resource allocation**
  - Fleet/shared vehicle distribution and allocation (avoid excess/shortage)
  - Minimize user waiting times
- **Predictive ride scheduling**
  - Based on user habits and patterns
- **Multi-modal integration**
  - End-to-end urban travel planning

Impact of ECAS

Impact of ECAS

- **Increased safety**
  - Reduction of human error and therefore number of accidents (90-95% of accidents are due to human errors)
  - Vulnerable Road Users (VRUs): Pedestrians and cyclists, road users with impairment, e.g. using a mobility aid, children playing on the road, elderly
- **Social inclusion & mobility for all**
  - Improved accessibility in case of e.g., physical, mental or age-related restrictions
- **More efficient road occupancy**
  - Traffic decongestion and less parking demand
- **Creation of new business models**
  - Car sharing services and shared mobility (community-centric model)
- **Reduced perception of travel as lost time**
  - Contributing thus to reduce the “cost” of travel time

Impact of ECAS

- **Environmental impacts**
  - Reduction in carbon emissions through electrification and integration of Vehicle-to-Grid (V2G) technology
  - Shared mobility, fleet management, route optimisation, fuel efficiency
- **Development of new transport services**
  - Traffic safety related warnings & recommendations, traffic management
- **Economic impact**
  - Build the basis for further growth in the automotive sector
  - Reduce of transportation costs
  - Drive innovation for startups, etc.
- **Educational impact and IP valorization**
  - Future mobility will generate manifold knowledge on which skills are required by the future semiconductor, automotive and digital industry workforce

Main technological enablers:

- H/W components
- S/W technologies
- IN-VEHICLE architectures
- NETWORK-ENABLING ARCHITECTURES

Data collection sources

- **Lidar**: Measures distance by illuminating the target with laser light and measuring the reflection
- **Radar**: Detects objects and measures their speed using radio waves
- **Cameras**: Capture visual information for object recognition and environmental mapping
- **Ultrasonic sensors**: Used for detecting objects at close range, often in parking assistance
- **GPS**: Provides precise location data for navigation

Data collection functions

- Goal: transform how cognition is realized and applied inside hardware

Function	Basic functionalities	Hardware required	Constraints and requirements
Perception	– Sense the environment using multiple modalities – Identify key actors in the environment – Identify their key characteristics	Highly efficient, edge processors for preprocessing of data	– Small and power efficient – <1 W power budget – 1–10 TOPS – Real time
Cognition	– Correlate information from multiple sensors to get a complete picture of each target – Relate the state of the vehicle to the scene – Develop a model of what is happening in the scene	Neural network (NN) accelerator hardware close to the sensor	– 1–3 W power budget – 10–100 TOPS – Real time
Context awareness and planning	– Understand static cues in the scene (detect if a pedestrian has made eye contact with your car…) – Understand dynamic cues in the scene (e.g., pedestrians hesitating, other vehicles moving to the side of the road,…) – Model the dynamics of the scene – Predict how the scene is going to evolve – Evaluate a set of possible decisions to execute	High-performance NN accelerator with temporal state memory	– ~1–10 W power budget – 10–100 TOPS – Latency is critical
Reasoning and decision-making	– Develop a reasoning for the situation and its outcomes—noncausally (i.e., the best outcome may be one that is known from past experience) – Identify a course of action that improves on the determined outcomes – Execute the action	High-performance NN accelerator for decision-making Safety controller for reasoning and control	– ~1–10 W power budget – 10–100 TOPS – Latency is critical (0.01–0.1 s) – Safety is critical

Type of collected data

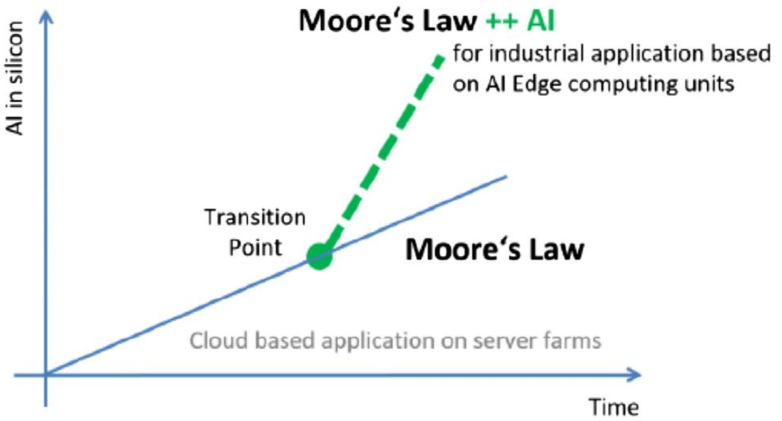
- Data sources
  - A mobile smartphone (inside the vehicle) and/or an on-board device
  - The vehicle itself (via an OBD-II device) (=on-board diagnostics)
  - Mobile Network Operator (MNO)-related data
- Indicative data
  - Smartphone/Tablet and/or on-board device (ADAS)
    - MNO-related info, such as: (a) Cell-id, Radio Access Technology (RAT) currently utilized, (b) Received Signal Strength Indicator (RSSI) and/or Reference Signal Received Power (RSRP) from the serving Base Stations and/or neighbouring ones
    - Information from motion sensors, environmental sensors and position sensors, such as, accelerometers, gravity sensors, gyroscopes and rotational vector sensors, barometers, photometers, and thermometers, orientation and magnetometers sensors
    - Location information (from GPS/Galileo) such as latitude and longitude

Type of collected data

- Indicative data (continued)
  - Vehicle/OBD-II
    - Current and average speed, acceleration, throttle/boost, coolant temperature
    - Timings
    - Current and average CO2 emissions (trip, overall)
    - Current and Average consumption (trip, overall)
    - Tank level, etc.
  - MNO data
    - Location of Base Stations (i.e., GPS coordinates)
    - RAT supported per Base Station (GSM, UMTS, HSPA, HSPA+, 4G, 5G)

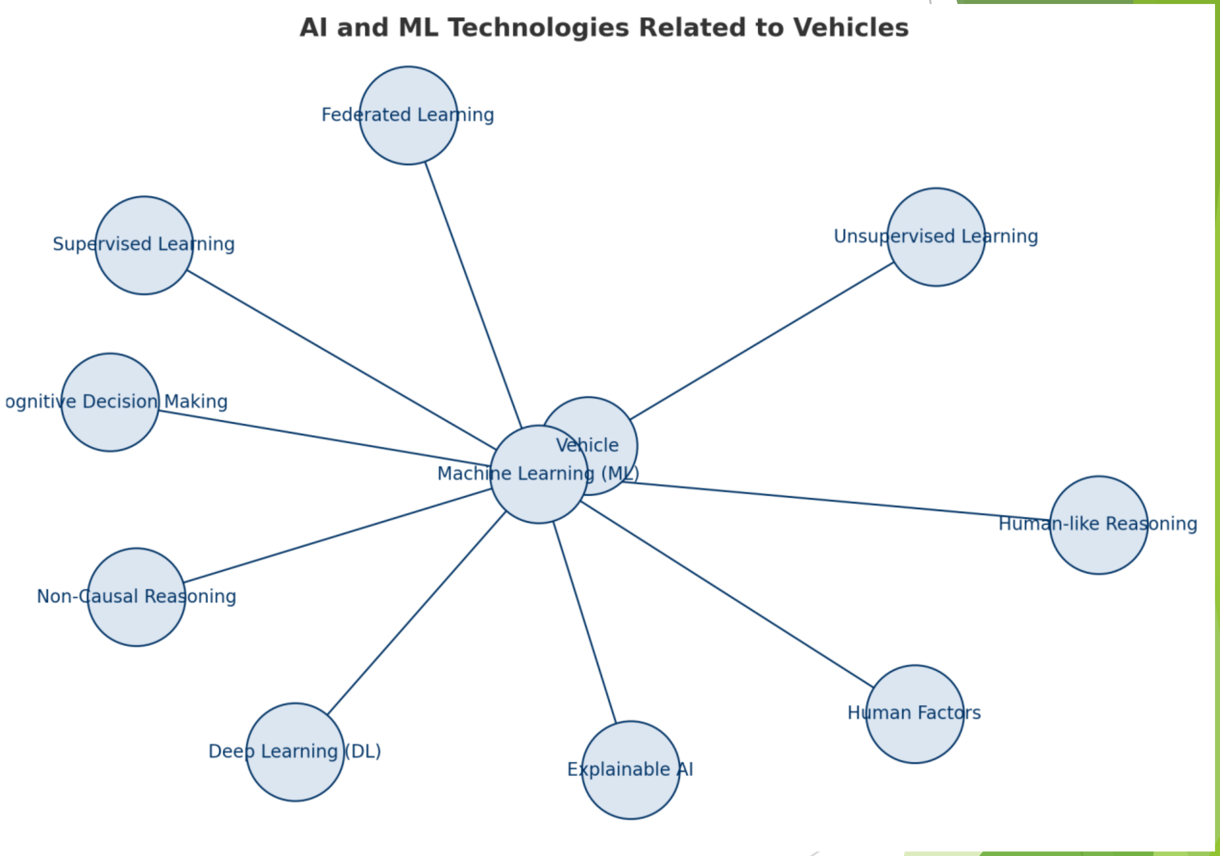
Silicon-born AI

- The adoption of silicon-born AI technologies can be substantially accelerated by making the required **computing power available at the edge**
  - Completely new AI applications, not available for industrial applications before
- **Moore's law** is the observation that the number of transistors in a dense integrated circuit doubles about every 2 years
- More heterogeneous integration enabled by "More than Moore" technologies will increase the AI functionalities, and both will enlarge the potential for industrial application of AI even further



AI enablers

- Natural Intelligence (NI)
  - Evolution of human brain
- Artificial Intelligence (AI)
  - Imitates NI

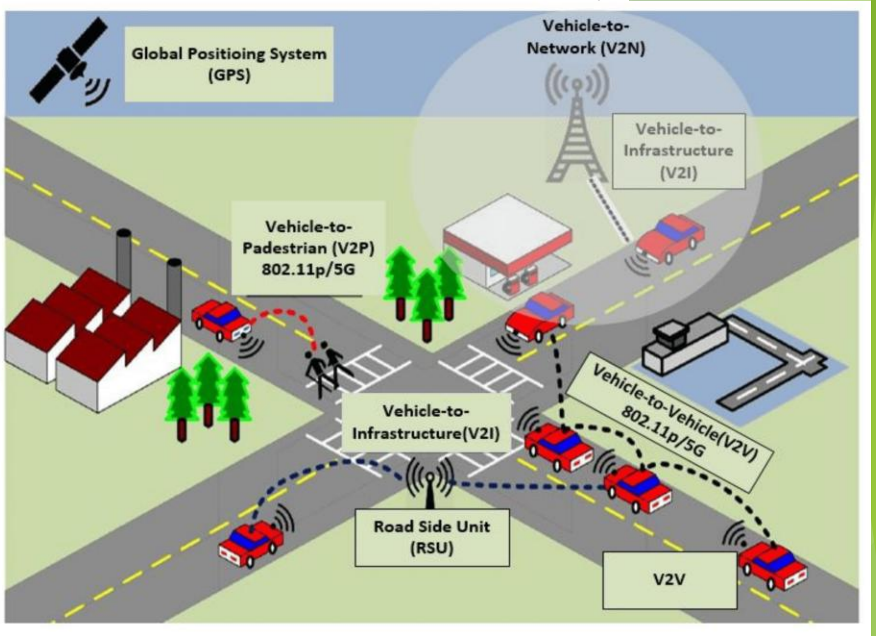


5G and beyond for transport & mobility

- Exploit 5G MNO infrastructure/data for V2V/V2I communications
  - Reduced latency
  - Increased reliability
  - Facilitation of highly automated vehicles
  - Efficient & pervasive market penetration
  - Significantly low infrastructure costs
- Applications areas and examples
  - **Road**: D2D communication, connected vehicles, innumerable apps in mass transport, car sharing
  - **Air**: BVLOS drones, logistics, taxi drones, robotic drones
  - **Sea**: Autonomous vessels, compliance, emissions management

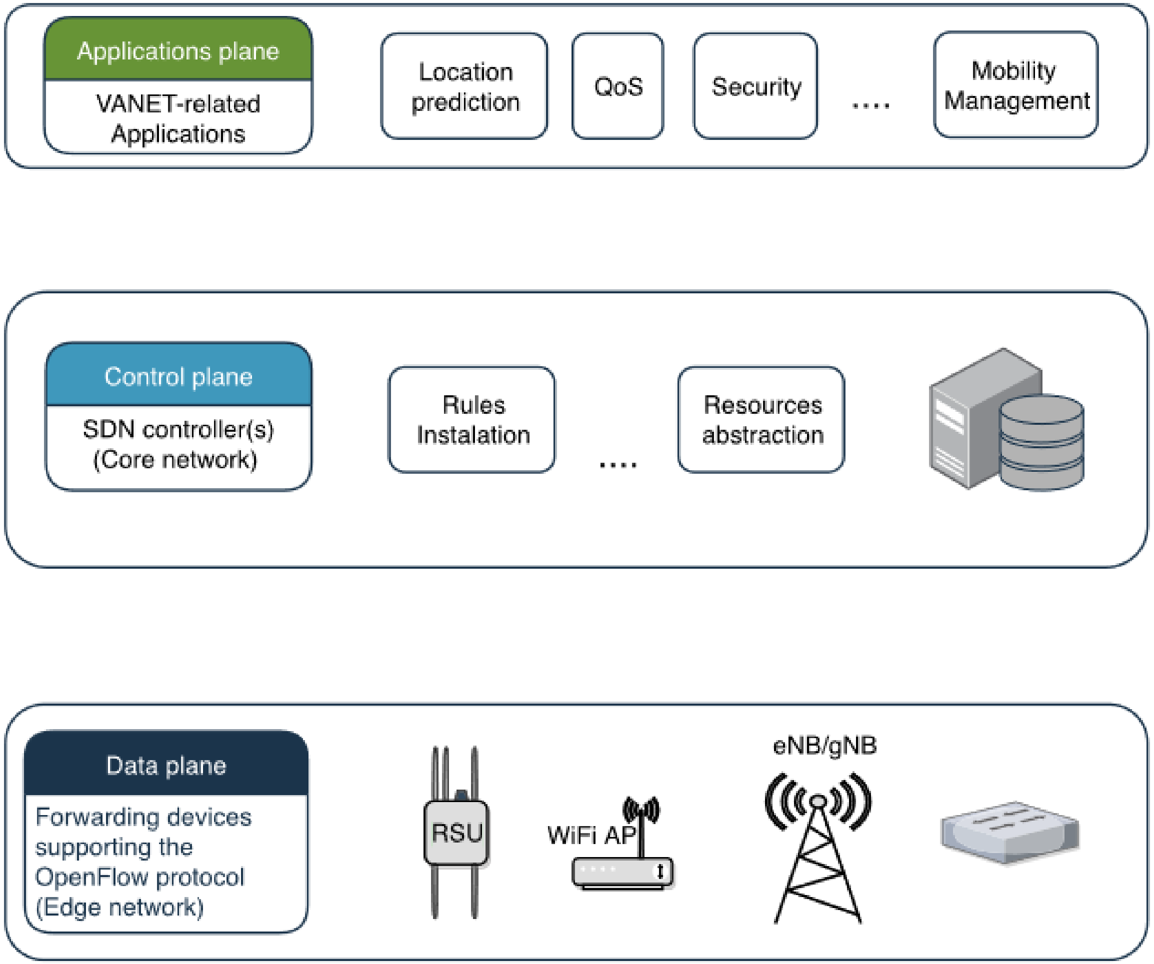
Vehicular Ad-Hoc Networks (VANETs)

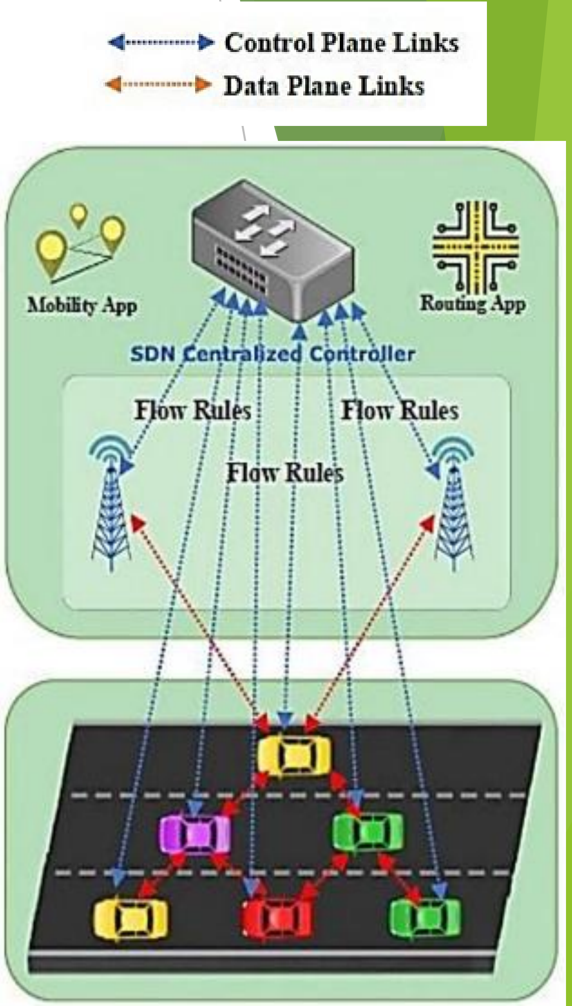
- VANETs allows vehicles to communicate with each other (V2V) and with road infrastructure (V2I) to enhance:
  - Safety
  - Efficiency
  - Entertainment
  - Comfort
- VANET components:
  - Road Side Units (RSU)
  - On Board Units (OBU)
  - Base Stations (MNO)



Tahir, M.N.; Leviäkangas, P.; Katz, M. Connected Vehicles: V2V and V2I Road Weather and Traffic Communication Using Cellular Technologies. Sensors 2022, 22, 1142.

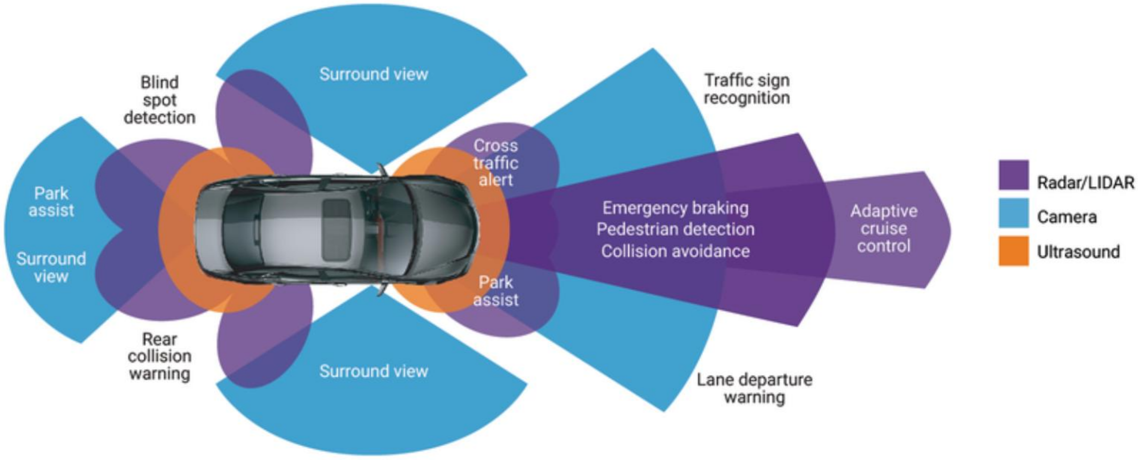
Software-Defined Vehicular Networks (SDVN)





Advanced Driver Assistance Systems (ADAS)

- Research since the '90s
  - Automate/adapt/enhance vehicle systems for safety and better driving
  - Avoid collisions and accidents by offering technologies that alert the driver
  - Avoid collisions by implementing safeguards and taking over control of the vehicle



Advanced Driver Assistance Systems with AI

- Reconfigurable driving styles
- Driver fatigue detection systems
- Distraction detection
- Obstacle recognition
- Lane keeping and lane departing
- Proactive emergency braking
- Remote vehicle monitoring
- Research still ongoing…

Users’ acceptance & barriers

Barriers towards market adoption

- **Technical**
  - Implementation, transition, scalability, feasibility
  - Cybersecurity attacks
- **Economical**
  - High initial investment costs, potential job displacement
- **Regulatory**
  - Laws not designed with driverless technologies in mind
- **Social**
  - Data privacy concerns, over-reliance on technology, equity issues
- **Ethical**
  - When an accident is deemed by the vehicle as non-avoidable eventuality, the decision upon which course should be taken to minimize damages could be perceived as wildly controversial when damages affect lives
  - AI bias?

Consumers’ perspective

- The impact of AI-enabled ECAS vehicles could be enormous!
- Fundamental prerequisite for all these potential societal benefits
  - **These vehicles are accepted and used by a critical mass of consumers**
- Important to understand consumers’ acceptance
  - Not yet 100% clear to what extent users accept automation technologies in vehicles and what the factors and determinants of user acceptance of automation are
  - Impact of automated systems on drivers’ workload and situation awareness, as well as human drivers’ levels of acceptance, trust and reliance on automated systems
  - Level of supervisory control and the role of the human in the case of an emergency

The way forward

- Electric-connected-autonomous-shared
- Innumerable novel services and applications
- Huge impact - social inclusion

- Enable people to move, socially communicate and act easier
- Personalization
- Constitute the 2nd extension of oneself since the smartphone

- Ethical issues are still unsolved
- How close / far are we?

Many images in this presentation were created using AI tools powered by OpenAI's ChatGPT. The images are custom-generated and not sourced from third parties.

Thank you!