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Autoport Hinterland hubs/inland terminals and automation – A literature review

Teuvo Uusitalo

07/06/2021 VTT – beyond the obvious

Introduction

Objective is to review literature on automation related to transport between ports and their hinterland hubs/inland terminals.

Search using Google, Scopus, Google Scholar, Market study database

Keywords used:

- Automation, autonomous, technology, hinterland, inland terminal, satellite terminal, transport

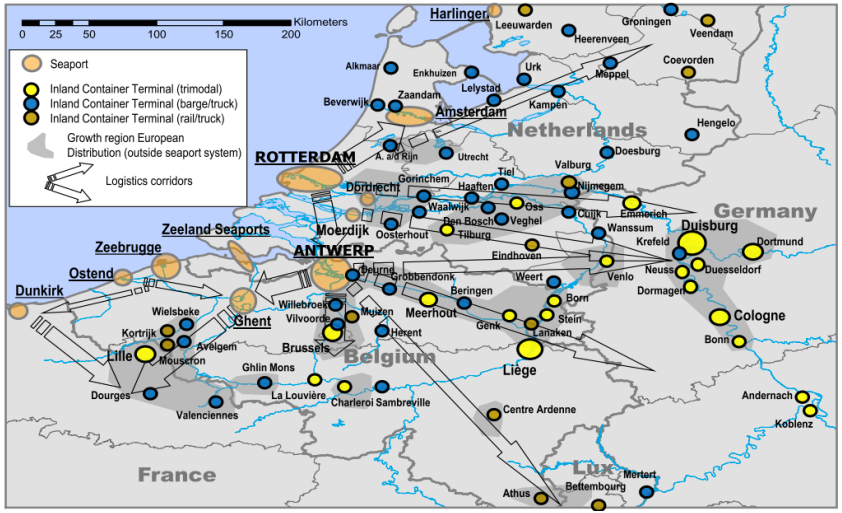
Results

Type	
Conference papers	3
Journal and magazine articles	6
Reports	14
White paper	5
Total	28

The growing importance of inland ports and logistics zones

- The concept of logistics zones in the hinterland is now well-advanced in Europe.
- Logistics zones are usually created within the framework of regional development policies as joint initiatives by firms, intermodal operators, national, regional and or local authorities, and or the Chambers of Commerce and Industry.
- The interaction between seaports and inland locations leads to the development of a large logistics pool consisting of several logistics zones.
- In the future, a further integration of intermodal transport and supply chain management will lead to new value-added services in inland locations.
- The availability of fast, efficient and reliable intermodal connections is one of the most important prerequisites for the further logistical development of inland terminals.

Figure 1.11. Logistics polarisation and logistics zones in the Rhine-Scheldt Delta



Notteboom, T. and Neyens, K. (2017) *The Future of port logistics*, *ING Bank Belgium*. Available at: http://www.portexpertise.com/wp-content/uploads/2017/07/ING-the-future-of-port-logistics.pdf

New technologies and their application to hinterland connectivity and inland transport

- Port hinterland connectivity and inland transport needs innovative approaches of various transport stakeholders, connecting road, inland waterways and rail networks, which can handle similar cargo volumes as the port itself.

- Particular attention should be given to
  - Robotics and automation,
  - Autonomous vehicles for port operations,
  - Drone planes and drone ships,
  - Internet of Things,
  - Big Data analytics,
  - Blockchain,
  - Artificial Intelligence.

Pérez, C. *et al.* (2018) *State of the Art of Port- Hinterland Connections*. Available at: https://www.corealis.eu/wp-content/uploads/2020/02/D.2.1-State-of-the-Art-of-Port-Hinterland-Connections.pdf.

Autonomous trucks and cars

- Considering the continued investments in the field, **it is only a matter of time** that in the future **fully automated driverless trucks and delivery vans** will be used by logistics firms.
- The main purpose and **expected impact** of autonomous trucks **is increased efficiency and greater safety**.
- Increased implementation of autonomous trucks and vans will effectively **reduce transportation costs and result in faster transit times**.
- Considering the expertise and reliance on data driven models to control such vehicles this **might change the type of companies running such solutions**. Companies like Uber or Amazon already have plans to expand into the logistics sector.
- Considering the fact that autonomous trucks will still be required to carry “drivers” for the foreseeable future and **levels 4 and 5 of autonomous driving are still some time away**, the **immediate impact on port operations** will most likely exist of **increased efficiency because of assisted maneuvering, improved planning and synchronized timing**, allowing for increased terminal and truck operator efficiency.

Kanellopoulos, J. *et al.* (2018) *Port of the future challenges , enablers and barriers*, *Corealis Consortium*.

Four stages of likely development of Autonomous trucks

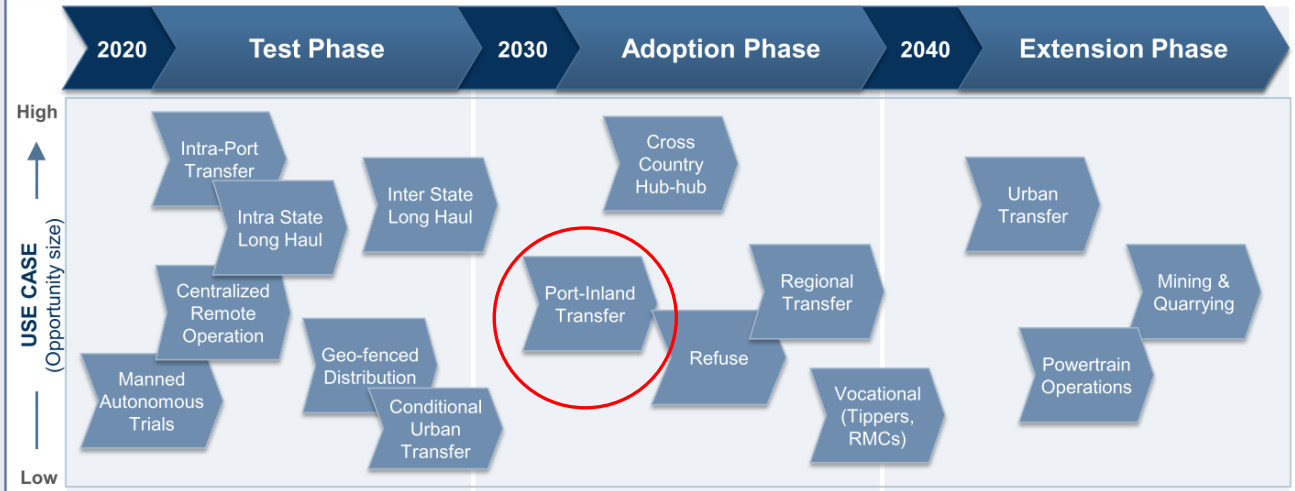
2018-20	2022 - 2025	2025 - 2027	2027 +
Driver in each truck	Driver in leading truck	Driver for pickup and drop-off	Driverless
2 drivers platoons 2 trucks on interstate highway Drivers drive individually on non-interstate highway	Platooning only on interstate highway between dedicated truck stops Drivers drive individually on non-interstate highway	Autonomous trucks ride on interstate highway without drivers Drivers drop off trucks at dedicated truck stops	Autonomous trucks drive individually on all highways and in platoons of 2 or more trucks Driver involvement eliminated throughout the journey

- Constrained platooning with driver in each truck. Platooning is a technique to connect wirelessly a convoy of trucks to a lead truck, allowing them to operate safely much closer together and realize fuel efficiencies.
- Constrained platooning with a driver in leading truck
- Constrained autonomy
- Full autonomy

Chottani, A. *et al.* (2018) 'Distraction or disruption? Autonomous trucks disrupt US logistics | McKinsey', *McKinsey & Company*. Available at: https://www.mckinsey.com/industries/travel-logistics-and-transport-infrastructure/our-insights/distraction-or-disruption-autonomous-trucks-gain-ground-in-us-logistics

Implementation Roadmap of Autonomous Trucks—By Use Cases

With regulatory support, on-highway applications will rapidly adopt autonomous trucks, mainly in the long-haul section; urban and off-highway vocations to adopt gradually as technology matures with operational precision.



- Rudiment technology
- Widespread testing to commence
- First-generation autonomous trucks – operations and features tightly bound by regulatory supervision
- Centralized monitoring systems
- L4 autonomous trucks with V2V/V2I fleet interaction

- Applicability in easy to moderate difficulty levels of autonomy
- Shift from conditional to highly autonomous operation with comprehensive functional capabilities
- Level 5 (L5) autonomous trucks with V2X interaction in limited and controlled use case environments

- Interactive network of logistic interfaces
- Integration into urban transportation
- Advanced AI to capacitate composite operations such as traversing through high traffic with sublime ease
- Highly efficient and productive
- Fully automated freight management – loading, transit, docking and transfer

* Deployment of L4 or Above Autonomous Trucks

Source: Frost & Sullivan

Frost & Sullivan (2020) *Opportunities and Use Cases for Autonomous Trucking , Forecast to 2040*.

Port—Ship to Dispatch

Self-driving trucks integrated to a dock management system can perform automated operations for planned and efficient stock transfer; the limited traffic and controlled ambience are highly suitable for adoption.

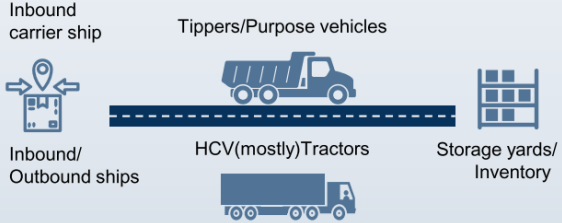
Autonomous Truck Market: Applicability in Ports, NA and EU, 2020

Sample Schematics of Freight Supply
Ship → Dispatch

Drayage

Inbound shipments are offloaded from carrier ships with the help of cranes and excavators onto the harbor quay

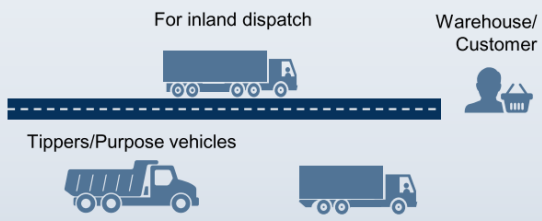
Operation limited to specified perimeter in a highly organized and controlled environment



Vehicles work round the clock to prepare for subsequent inbound carriers; productivity and turnaround time are vital to ensure timely docking and undocking of inbound freight ships

Last mile

Shipments are relocated to storage yards to maintain inventory and plan subsequent inland dispatch via road or rail; trucks dispatching shipments from the ports are charged based on the shipment's waiting time



Shipments are dispatched to regional warehouses industries, fulfillment centers, or to processing units

	Drayage	Last mile
Distance	<20 kms	100 – 150 kms
Speed	Very Low	Moderate to High
Traffic	Dedicated intra-port roads	Semi urban/Highway
Ease of AD adoption	Low — High	Low — High

Value chain depicted above is unidirectional; Ease of AD adoption is plotted for deployment of unmanned vehicles

Source: Frost & Sullivan

Frost & Sullivan (2020) *Opportunities and Use Cases for Autonomous Trucking , Forecast to 2040*.

Autonomous vehicles' impact on port infrastructure

- Ports face the challenge to prepare themselves for the arrival of autonomous vehicles at their gates.
- The required steps to prepare for autonomous vehicles depend on the existing degree of digitalization for a port and on its responsibility for the port infrastructure.
- Transport departments, infrastructure providers and port authorities should prepare themselves for the technology leap to come. Test applications are carried out testing the technology of autonomous driving in ports. The immaturity of the technology for autonomous driving still persists.
- Infrastructure planning should take into account the requirements for autonomous vehicles also in the emerging phase.

Fiedler, R. *et al.* (2019) *Autonomous Vehicles ' Impact on Port Infrastructure Requirements*. Fraunhofer Center for Maritime Logistics and Services CML.

Autonomous vehicles' impact on port infrastructure

Recommendations for action for ports

	Road	Rail	Waterborne	Air
Hardware	High infrastructure quality	Keeping track with main network	Shore control centres	Aerial corridors / Flight zones
	Sufficient road markings		Auto-mooring facilities	Framework for new services
Digital infrastructure	Sensor technology	Sensor technology	Sensor technology	Safe navigation systems
	HD maps	Data transmission systems	HD maps	Data transmission systems
	Data transmission systems		Data transmission systems	

Fiedler, R. *et al.* (2019) *Autonomous Vehicles ' Impact on Port Infrastructure Requirements*. Fraunhofer Center for Maritime Logistics and Services CML.

Recommendations for action for ports

- For road infrastructure:
  - Prepare the road with high quality road surfaces
  - Ensure a high quality of formation, contrast and regular maintenance of road markings
  - Provide as further support road guidance systems and road demarcation markers
- For railway infrastructure:
  - Prepare the port owned railway infrastructure to keep track of the developments on the main network
- For waterborne infrastructure:
  - Prepare shore control centers for remotely controlled vessels
  - Prepare the integration of advanced data transmission technology systems to support autonomous shipping
  - Prepare for auto-mooring facilities
  - Plan for training the involved personnel with
- For aerial vehicles:
  - Prepare the installation of aerial corridors for the flight of UAV

Fiedler, R. *et al.* (2019) *Autonomous Vehicles ' Impact on Port Infrastructure Requirements*. Fraunhofer Center for Maritime Logistics and Services CML.

Platooning Automated Ground Vehicles

- Automated ground vehicles (AGVs) are essential parts of container operations at many ports. Forming platoons may allow these vehicles to directly cater demand points such as dry ports in the hinterland.
- Research on automated trucks and AVs has demonstrated the effectiveness of platooning to save fuel, costs, and emissions.
- Paper proposes a multi-objective mixed-integer programming model for AGV platooning as a transfer mode between the port of Rotterdam and its hinterland.
- Results provide first evidence for the advantages of this concept.
- Findings may motivate further case studies and alternative concepts of AGV platoons in the port hinterland as well as gradual infrastructural investments that could allow scaling up the approach.

Pourmohammad-Zia, N. *et al.* (2020) 'Platooning of Automated Ground Vehicles to Connect Port and Hinterland: A Multi-objective Optimization Approach', in Lalla-Ruiz, E., Mes, M., and Voß, S. (eds) *Computational Logistics. ICCL 2020. Lecture Notes in Computer Science, vol 12433*. Springer, Cham, pp. 428–442. doi: 10.1007/978-3-030-59747-4_28.

Toward implementing a fully automated truck guidance system at a seaport (1/2)

- Research aims at the following three objectives.
  - It puts forward the functionalities and the architecture of a truck guidance system (TGS) to be developed at a seaport. By doing so, this research points out the steps needed to be undertaken in achieving a fully automated TGS.
  - The costs and benefits of the proposed TGS are pointed out.
  - The paper aims at identifying the roles of both technology developers and maritime supply chain stakeholders in achieving an enhanced TGS.
- The port of Antwerp was taken as case study, where the port authority is confronted with a high demand for supporting the implementation of a TGS.

Carlan, V. *et al.* (2019) 'Toward implementing a fully automated truck guidance system at a seaport: identifying the roles, costs and benefits of logistics stakeholders', *Journal of Shipping and Trade*. Springer Science and Business Media LLC, 4(1), pp. 1–24. doi: 10.1186/s41072-019-0054-5.

Toward implementing a fully automated truck guidance system at a seaport (2/2)

- Having in mind the achievement of a fully dynamic TGS, two intermediary versions are foreseen to be operational.
- Firstly, a basic TGS (bTGS) collects, processes and presents in a user-friendly way data necessary for planning operation at the port level.
- Secondly, an enhanced TGS (eTGS) ensures the connection to own systems of port stakeholders.
- Lastly, a fully automated TGS (faTGS) takes the condition of each stakeholder for operational purposes and enables them to build further cost-effective operational planning.

Carlan, V. *et al.* (2019) 'Toward implementing a fully automated truck guidance system at a seaport: identifying the roles, costs and benefits of logistics stakeholders', *Journal of Shipping and Trade*. Springer Science and Business Media LLC, 4(1), pp. 1–24. doi: 10.1186/s41072-019-0054-5.

Port hinterland intermodal information systems

- The planning of hinterland operations needs to be supported by ports.
  - The port authority of Zeeland Seaports (Netherlands), for example, has developed a web-based search engine to support the planning of intermodal transports and provides an overview of intermodal terminals and their connections using dynamic data from transport operations (barge, rail, feeder), terminals, and connections in Europe.
- In recent years, many innovative cloud-based applications have been developed to better coordinate available truck capacities and demanded container transports.
  - MatchBack, for example, offers a cloud-based SaaS solution to match the demand for transports of import and export containers in order to reduce empty trips.
  - A solution developed at the University of Hamburg, port-IO, aims to better coordinate truck movements by providing a multi-tenancy cloud-based web platform for managing and planning container transport orders taking into account the current positions of trucks and real-time traffic information in order to minimize costs and empty trips.

Kanellopoulos, J. *et al.* (2018) *Port of the future challenges , enablers and barriers*, *Corealis Consortium*.

Design and Simulation of a New Intermodal Automated Container Transport System (1/2)

- The Korean government has launched a research project to study the development of a new intermodal automated container transport system (ACTS) via a roll-on/roll-off (RO/RO) method that connects ports to hinterlands or uses a logistics hub between ports and the inland.
- This study aimed to design a new intermodal ACTS via an RO/RO method that connects ports and an inland logistics hub to develop a model for simulating the system in consideration of various operation methods for container terminals. The processing capacity of the system was predicted, and the optimal input equipment scale and operation method were derived.

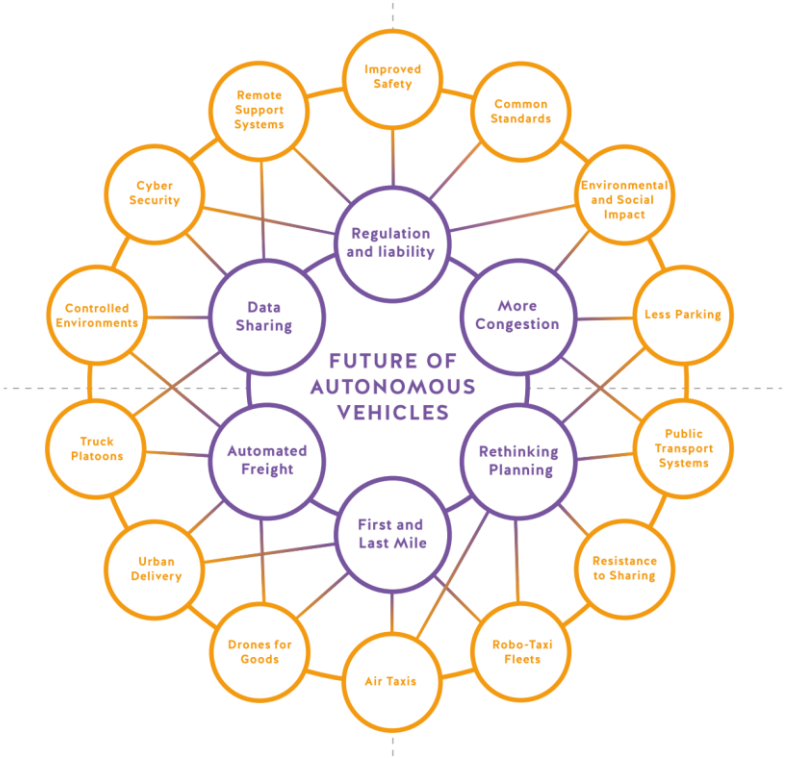
Hur, S. H. *et al.* (2020) 'Design and simulation of a new intermodal automated container transport system (ACTS) considering different operation scenarios of container terminals', *Journal of Marine Science and Engineering*, 8(4). doi: 10.3390/JMSE8040233.

Design and Simulation of a New Intermodal Automated Container Transport System (2/2)

- The new intermodal ACTS was designed from the standpoint of practical use
- It assumed the use of general freight tractors and yard tractors, as in most port operation cases.
- AGVs, which have been widely used in the recent development of automated container terminals, were not considered in this study, because they can be regarded as yard tractors moving the chassis in the proposed ACTS system.
- A simulation program using GPSS/H to examine the system capacity and efficiency in the planning stage of the new ACTS currently under development.
- The simulation program models a new, unprecedented type of RO/RO rail system, and it can be used to directly connect and operate logistics hubs, such as ports and hinterland logistics complexes or ports and industrial complexes. As this system is still in the development stage, a limitation exists in that the actual area for implementation has not been determined.

Hur, S. H. *et al.* (2020) 'Design and simulation of a new intermodal automated container transport system (ACTS) considering different operation scenarios of container terminals', *Journal of Marine Science and Engineering*, 8(4). doi: 10.3390/JMSE8040233.

Future of autonomous vehicles



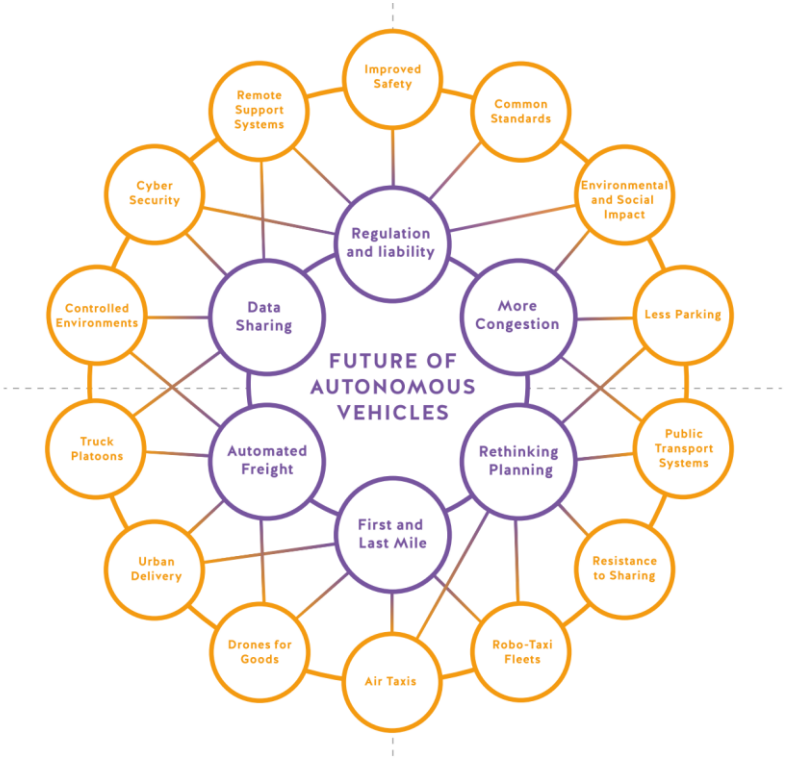
There are many perspectives of how, where, and why autonomous vehicles may have impact. Six pivotal high-level macro drivers of change that can be considered to be the focus of greatest debate:

- Regulation and Liability
- More Congestion
- Rethinking Planning
- First and Last Mile
- Automated Freight
- Data Sharing

Underlying and connected to these, there are also fourteen additional priority topics of focus. These are related to the macro drivers and can be mapped as shown in the diagram.

Future Agenda (2020) *The Future of Autonomous Vehicles. Global Insights gained from Multiple Expert Discussions*. Available at: https://www.futureautonomous.org/pdf/full/Future of Autonomous Vehicles 2020 - Final LR.pdf.

Future of autonomous vehicles

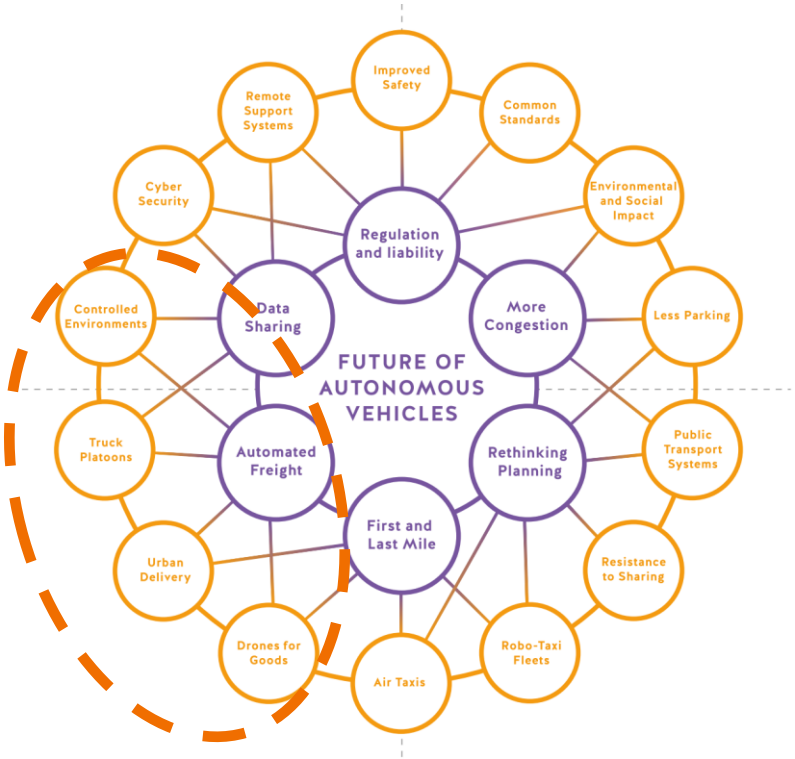


Nine key interlocking issues that are emerging as significant:

1. **Fleets are now driving progress:** In terms of the dominant business models, momentum is clearly behind both robo-taxis and truck fleets.
2. **Automated trucks are coming:** Freight has much to gain in terms of efficiency; this has regulatory momentum and wide industry support.
3. **Safety is a pre-requisite:** Expectations are high, but as many advances are already in process, improvements look likely.
4. **Congestion is a conundrum:** While the aim is for less congestion and the role of connectivity is pivotal, user behaviour and Transportation Network Company (TNC) strategies could initially mean more congestion.
5. **Multiple options for the last mile:** There are many alternatives in the mix, all bridging different needs and location gaps.
6. **First vs widespread deployment:** Where and why we see initial AV services may not necessarily align with where mass impact will occur.
7. **Deeper collaboration will be needed:** Moving from partnerships to long-term multi-party collaboration is seen as a critical enabler.
8. **Standards may not be pivotal:** Although comprehensive technical standards are advocated, they are not essential for AV; in some regions, safety standards will support regulation.
9. **Regulators are influencing deployment:** Proactive regulation is attracting companies, but the balance of light vs. heavy regulatory approaches may impact this

Future Agenda (2020) *The Future of Autonomous Vehicles. Global Insights gained from Multiple Expert Discussions*. Available at: https://www.futureautonomous.org/pdf/full/Future of Autonomous Vehicles 2020 - Final LR.pdf.

Future of autonomous vehicles



Goods Transportation

Drones for Goods

- Investment in timely drone delivery services accelerates deployment in multiple locations. Concerns about safety and collisions are overcome with automated UAV air traffic control.

Urban Delivery

- Small, slow-moving, autonomous robots offer attractive ROI and act as an accelerator of technology deployment. They enable safe, clean, convenient and low-cost delivery and help to raise public confidence in AV.

Automated Freight

- Driverless expressway trucks will transform long- haul journeys and the wider logistics sector. As safety goals are met and haulage costs are reduced, regulatory support evolves with deployment.

Truck Platoons

- As the first level of deployed automation, truck platoons help build wider momentum while delivering tangible improvements in efficiency, cost of transportation, energy use and safety.

Controlled Environments

- Automation within controlled environments continues to expand steadily. AVs within airports, port terminals and logistics facilities start to venture onto the open road.

Future Agenda (2020) *The Future of Autonomous Vehicles. Global Insights gained from Multiple Expert Discussions*. Available at: https://www.futureautonomous.org/pdf/full/Future of Autonomous Vehicles 2020 - Final LR.pdf.

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