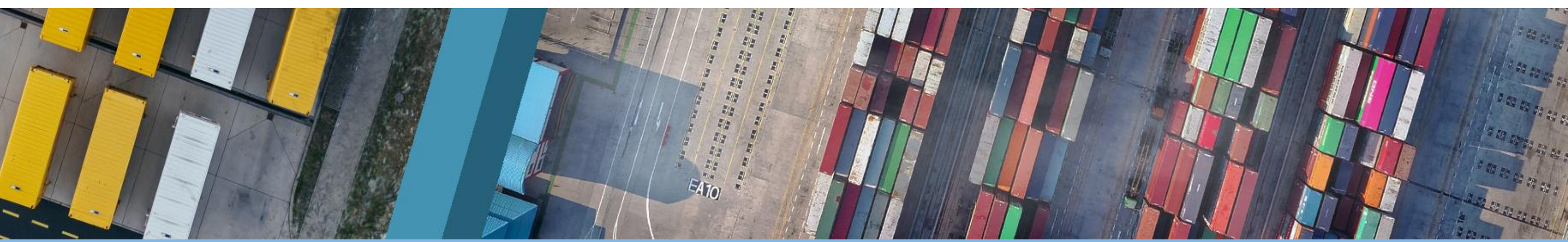
AWARD

Scaling autonomous logistics



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Automating freight transport and logistics: lessons learned from the European project AWARD

Wednesday 22nd of November 2023
15:00h-17:00h

SOLUTRANS
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Program

- 15:00 - 15:25 **Presentation of the project** Benieke Treverton (EasyMile)
- 15:25 - 15:45 **FMS and logistics operations: data and uses** Olav Madland (Applied Autonomy)
- 15:45 - 16:05 **First evaluation and testing results** Sami Koskinen (VTT – Technical Research Centre of Finland)
- 16:05 - 16:25 **Regulatory and governance frameworks: testing** Victoire Couëlle (IRU – International Road Transport Union)
- 16:25 - 16:45 **Emerging business models** Diana Reinales (CARA – European cluster for mobility solutions)
- 16:45 - 17:00 **Q&A**

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1. Presentation of the project

Benieke Treverton - EasyMile

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AWARD overview

H2020 framework

- **2018-2020** : Digitising and Transforming European Industry and Services: Automated Road Transport
- **DT-ART-05-2020** : Efficient and safe connected and automated heavy-duty vehicles in real logistics operations

AWARD : All Weather Autonomous Real logistics operations and Demonstrations

Project Coordinator : EasyMile

Budget : € 26M

Partners : 29

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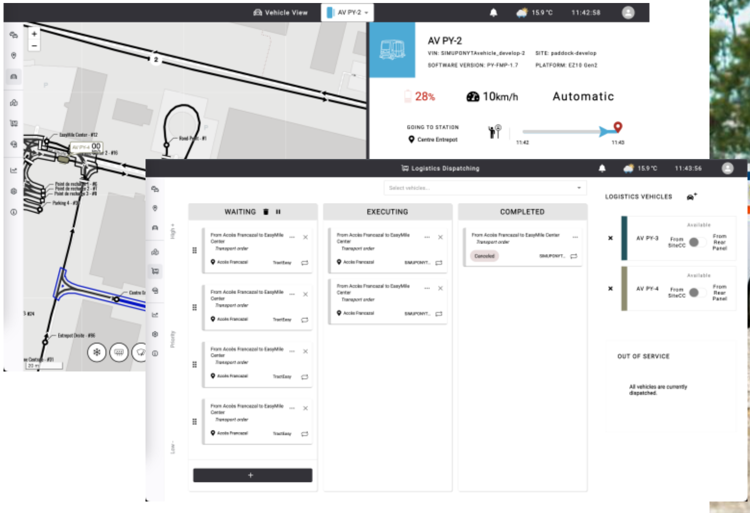
EasyMile's role



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Four real-condition demonstrations

Harnessing the expertize of all consortium members

Development of the system

- Able to handle adverse environmental conditions
- Targeting compliance with ISO 26262 and taking into consideration SOTIF recommendations
- Integrating an embedded teleoperation system to address 24/7 availability and multiple sensor modalities:
- Optimized fleet management & supervision system for logistics use cases

Integration into HDV and validation

Demonstrations

Port Trailer autonomous transfer operations

Hub to hub autonomous logistics on public roads

Airport autonomous ground support equipment

Autonomous loading and unloading operations

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Airport

About the vehicle

"EZTow" autonomous tow-tractor

- Manufacturer: TLD (Saint Lin, France)

- EZTow: airport and industrial towing tractor
- Vehicle speed: 15 km/h
- Towing capacity: 14 tons

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How we make sure it's safe

Tests and scenarios both at home and elsewhere

Simulation of airport environment:

- Vehicle running in autonomous mode under the rain tunnel
- Different kinds of obstacles: pedestrian and car dummies, suitcases, barriers
- Test in a straight line, on intersections

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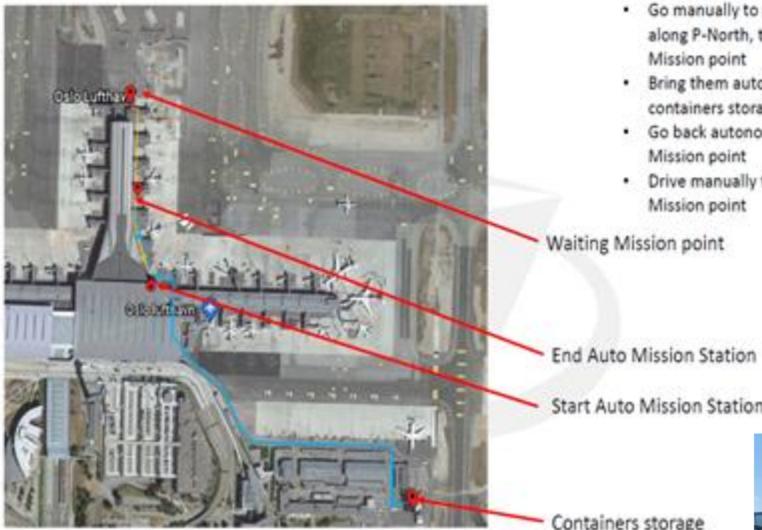
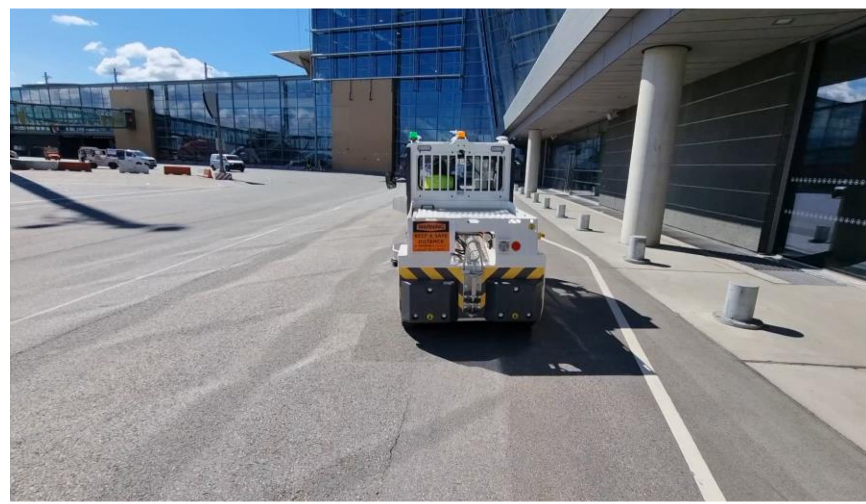
On the tarmac

Real-condition operations with AVINOR at Oslo Airport, Norway

Route Description

- Use Case:
  - TractEasy waiting mission point
  - Go manually to pick up empty dollies along P-North, then go to Start Auto Mission point
  - Bring them autonomously to containers storage
  - Go back autonomously to End Auto Mission point
  - Drive manually to TractEasy waiting Mission point





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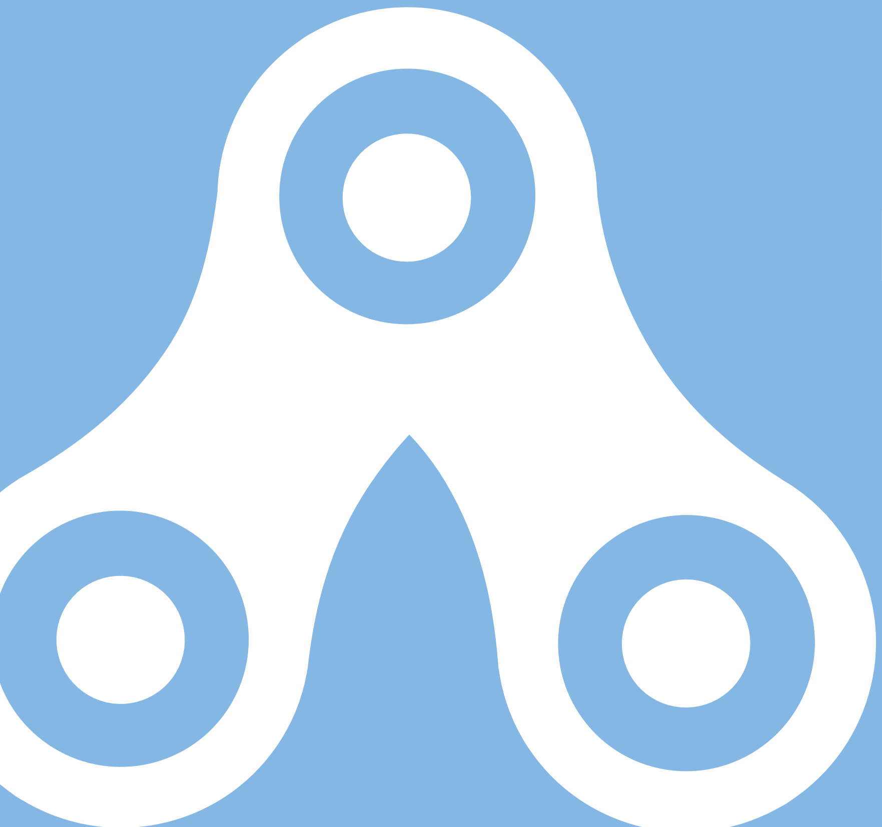

Hub-to-hub

About the vehicle

Autowiesel: Swap-body transporter

- Manufacturer: KAMAG (Ulm, Germany)

- Vehicle speed in autonomous mode: 20 km/h

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How we make sure it's safe

Tests and scenarios both at home and elsewhere

Simulation of hub to hub logistics operations:

- Vehicle running in autonomous mode under the rain tunnel
- Different kind of obstacles: pedestrian and car dummies, pallets, barriers
- Test in a straight line, on intersections, forward and backward

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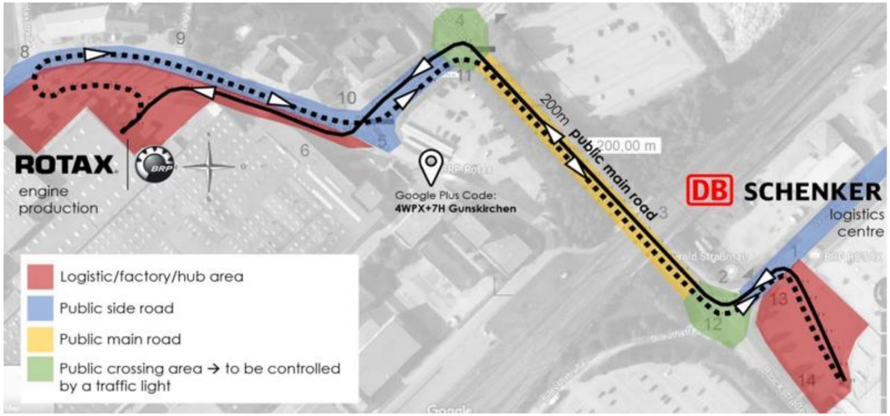
On the road

Hub-to-hub with ROTAX and DB SCHENKER in Gunskirchen, Austria



Use case

- Component pick-up at a logistic site
- Autonomous movement through mixed traffic with C-ITS
- Delivery at factory site

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Port

About the vehicle

"EZTug" autonomous terminal tractor

- Manufacturer: TERBERG (Benshop, Netherlands)

- Vehicle speed in autonomous mode: 25 km/h

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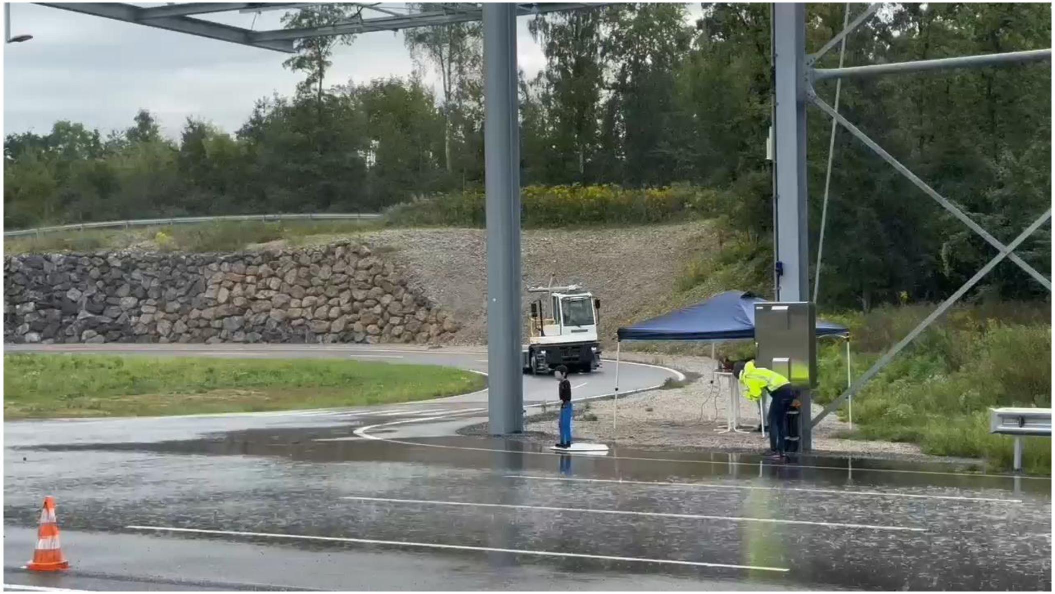
How we make sure it's safe

Tests and scenarios both at home and elsewhere

Simulation of port logistics operations:

- Vehicle running in autonomous mode under the rain tunnel
- Different kind of obstacles: pedestrian and car dummies, barriers
- Test in a straight line, on intersections, on the roundabout



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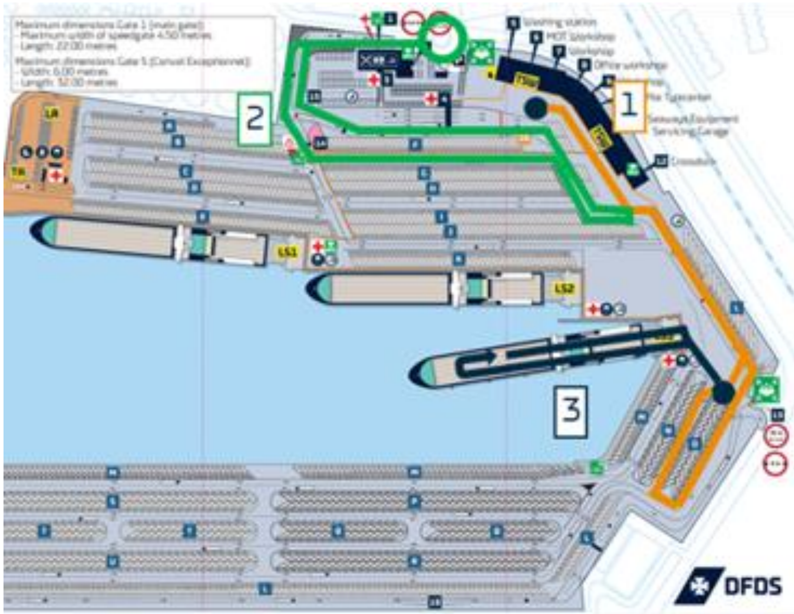
At the port

Real-condition scenarios with DFDS in Vlaardingen, The Netherlands)



Use case

- Phase 1 : Trailer move on site – prepared for loading onto the ship
- Phase 2 : Public road access and gate-process without trailer
- Phase 3 : Loading of a trailer onto a ship

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Forklift

About the vehicle

Remotely-controlled forklift

- Palfinger Crayler
- Outdoor and off-road machine
- Usually used for loading and unloading at sites without logistics infrastructure

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On-site

Demonstration of autonomous truck loading

Use case

- Truck parks at arbitrary position
- Driver or freight management system (FMS) assigns an area to unload
- Crayler starts autonomous unloading
- Operator responsible for supervision

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2. FMS and logistics operations: data and uses

Olav Madland - Applied Autonomy

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Process of logistics between port and a factory in Norway
What is the role of the FMS and operational tools?

APPLIED AUTONOMY

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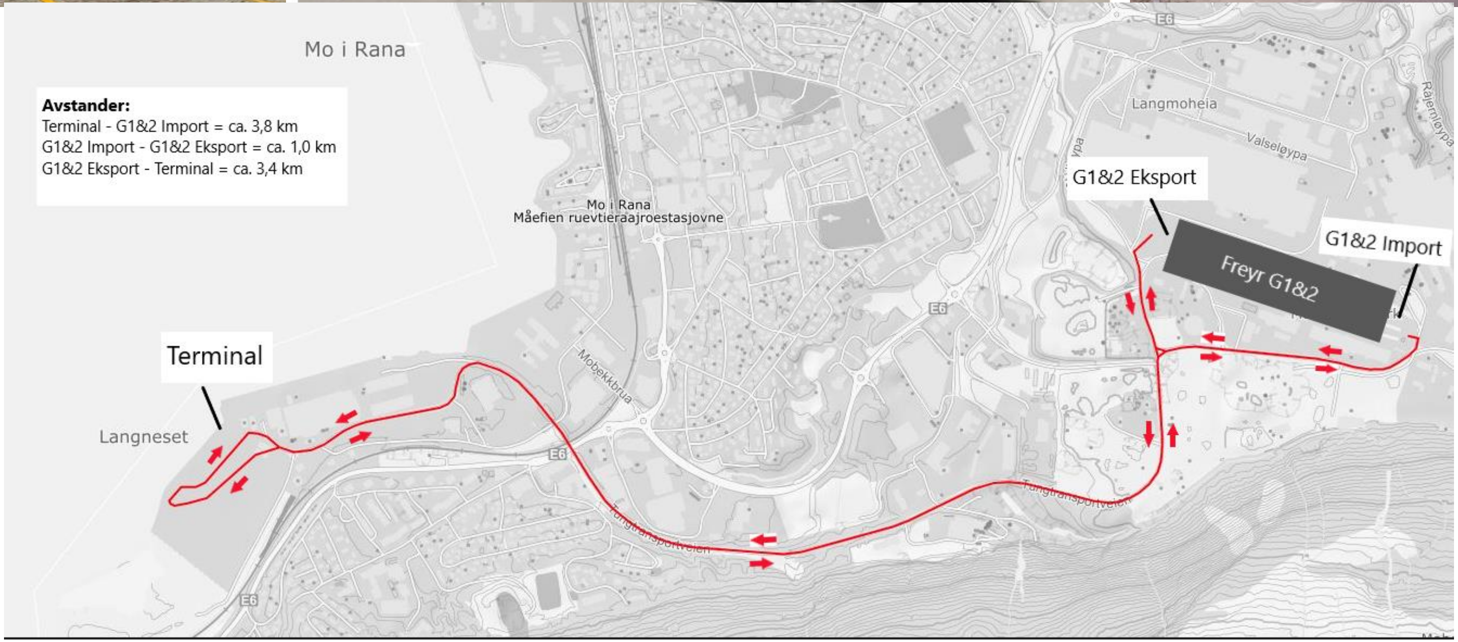
Existing tools for transport and handover

APPLIED AUTONOMY



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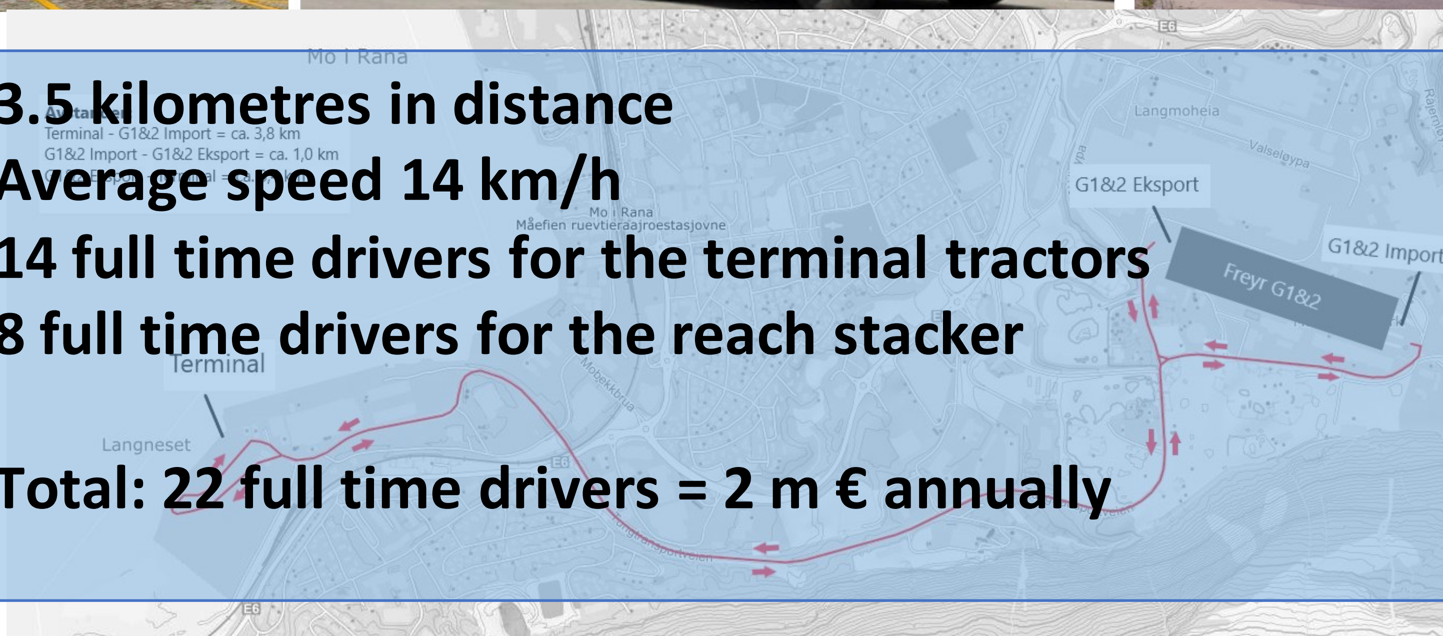
Existing tools for transport and handover



3.5 kilometres in distance

Average speed 14 km/h

14 full time drivers for the terminal tractors

8 full time drivers for the reach stacker

Total: 22 full time drivers = 2 m € annually

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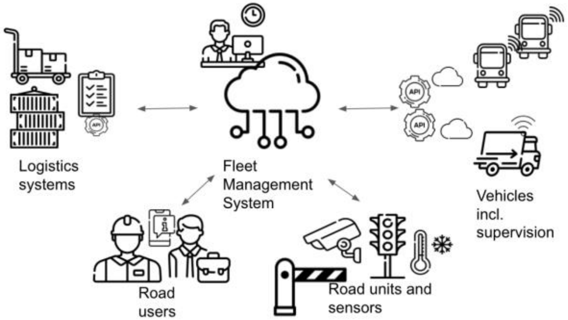
What if ?

The best vehicle and "virtual driver" Autonomous vehicles

The best FMS and operational tool Automated logistics

24x7 operations



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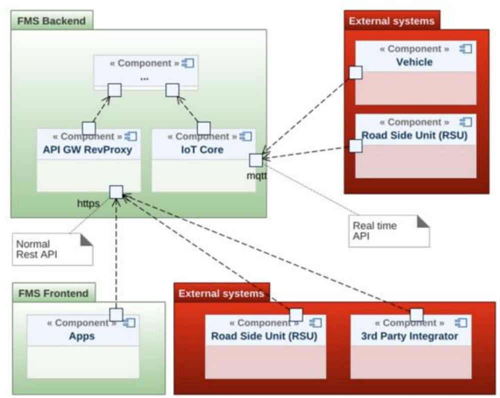
Vehicle role and FMS role in the flow

The best vehicle and virtual driver
Autonomous vehicles

More than 95% auto. mode
Less than 5 % intervention by a remote driver to be usable as a solution

The best FMS and operational tool
Automated logistics

Automates flow of containers with full control of all units, where they are and their weight



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Fleet managment and operational tools
Transport from port to factory - Import gate

APPLIED AUTONOMY

7 system integrations to automate the flow

External system 1 | External system 2 | External system 3 | External system 4 | External system 5 | External systems 6 and 7

FMS and operational tools

Load → Transport → Port gate → Transport → Factory gate → Transport → Remote driving → Unload





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Fleet managment and operational tools
Transport from import gate to export gate

APPLIED AUTONOMY

3 more system integrations to automate the flow

External system 8 | External system | External system | External system 9 | External system | External system | External system 10

FMS and operational tools

Inspection → Remote driving → Transport → Cleaning → Transport → Remote driving → Unload




Some containers go from cleaning to the storage for empty containers before they go to the export gate to be loaded

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Fleet managment and operational tools
Transport from export gate back to port for shipping

APPLIED AUTONOMY

1 more system integrations to automate the flow

External system	External system	External system	External system	External system	External system	External system	External system

FMS and operational tools

Remote driving → Load → Transport → Factory gate → Transport → Port gate → Transport → Unload






External system 11

Containers go to storage and customs processing before shipping

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Is it usable and affordable?

APPLIED AUTONOMY

Autonomous driving and automated logistics	Save usage of reach stacker	Existing process and tools
Usability might be good now, but more pilots are important to make the solution mature, trusted and known	Expensive and not usable	Expensive but known solutions to all stakeholders

<u>Conclusion</u>

More pilots and relevant pilots are important to make the solution usable, trusted and known

This implementation will need 11 integrations to be a fully automated process

Data about performance builds trust. Remote driver must be removed to reach the goal

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3. First evaluation and testing results

Dr. Sami Koskinen - VTT

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Introduction to AWARD evaluation

- The AWARD EU project has four test sites: a port, an airport, and two industrial sites
- This presentation discusses preliminary results from three of the first sites to carry out tests
- FESTA methodology for field operational tests has been used to set up tests and evaluate data
- Besides the vehicle tests, simulation is used to examine results further: what if more vehicles were automated
- Final evaluation results will be presented in summer 2024

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Oslo airport tests with an automated luggage tractor – the need for safety operator support

- During June 2022, first tests were carried out at the Oslo airport, which involved 57 hours (34 automated) of logged driving. 12 days of testing.
- Roughly 15% of automated operations driving time was supported manually, but this time included test documentation. In average, 30 m had to be driven manually at a time, 30–40 seconds

- **First estimate: 5 min human support or teleoperation per operational hour.**
- Baggage carts were left by human drivers at turning points. <u>If the turnaround locations would be clear, there would be much less need for teleoperation.</u>

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Oslo airport first results

- Operators felt safe in the automated vehicle, and no critical situations came up
- Based on operator reports, 7 min manual driving time for one selected trip, about 10 min automated. Both numbers are acceptable when considering requirements and plane turnaround time.
- The automated vehicle drove max 15 km/h and humans 20–30 km/h. This caused a lot of overtaking. The overtaking could become a safety concern. There may be ways to separate traffic more, or speed up the automated vehicle

Figure: other vehicle cutting in

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Airport future integration lessons

- Other ground handling vehicles take various positions near an airplane. Some of these, like a fuel vehicle, could be placed in three different angles.
- The positions for all actors would have to be better controlled or at least known/detected (by an automated vehicle or fleet management), so that the automated vehicle could use a few alternative stop locations.
- Hooking and unhooking trailers is needed because Oslo airport's current luggage processes require it. Luggage is loaded into several carts and driving them is a separate process. For automated vehicles to carry luggage, automated hooking and unhooking would have to be developed.
  - Maybe even new type of luggage carts?
- Changes to processes? Consider automating wider processes than just driving

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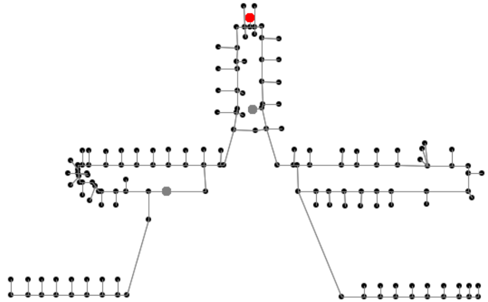

Airport efficiency simulation

- At least 30 human-driven vehicles and 30 automated vehicles are needed to fulfil the quality requirement of 15 minutes for delivering luggage.
- Human work time 51% in automated mode of fully manual operations, assuming teleoperation requirements of 5 minutes per operational hour and three full-time field/maintenance workers are needed for support.
- Automated vehicles drive 4% shorter distance due to human drivers taking breaks and driving to pause locations.
- Costs for automated vehicles were around 20% compared to human-driven vehicles (only driving, not including investments). If human waiting time is not considered (assuming they could do some other task), the cost of an automated vehicle is about half that of a human-powered vehicle.
- On the AV side, this assumes that trolley connecting can be automated and AVs are better integrated in the luggage processes

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Hub-to-Hub logistics in Austria

- Automate the existing goods transfer between the engine production factory of BRP Rotax and the logistic center of DB Schenker
- 86 hours testing (26 automated), mainly in September 2023. 23 days of testing.
- Tests went well, especially driving at the industrial sites at the ends of the route
- Public road segment with speed limit 60 was the most challenging, as automation max speed 25–29 km/h. Queue formed, fast.
- In average, humans operate the route with 16 km/h and automation with 6.4 km/h
- AV also entered the high-speed segment carefully, requiring an extra traffic light to stay red for others

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H2H lessons

- A red light was set up to stop other road users for the AV could enter the road. They started sometimes to ignore it after 30 seconds, in evenings.
  - Synching the light more accurately to vehicle movement helped
- Eco-driving: automation used more energy, but this was due to several stops (11 times more braking events than a human driver). Accelerating a heavy load requires a lot of energy.
  - This one vehicle was missing a lidar data filter, which caused unn ecessary braking events due to e.g. falling leaves. Other vehicles showed better eco-driving performance
  - From past experiments we know that the result can as well be –20%, if there are less stops.
- Vehicle emergency braking was set hard, causing even cargo to move. However, there are ways around both problems.

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H2H stop reasons

- Unnecessary emergency stops due to the lidar data filtering issue and some due to a slightly old map
- A few times loss of localization on the road segement in figure – not an easy place for environmental sensing placed positioning, due to vegetation.
- 17% of driving was manually supported. That equals operator support of 10 minutes per hour

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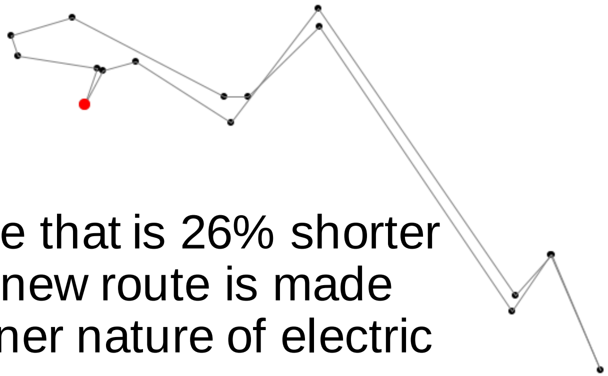
H2H simulation



- Automated electric trucks can follow a route that is 26% shorter than the route taken by diesel trucks. This new route is made possible by the inherently quieter and cleaner nature of electric vehicles.
- Human work time would be reduced by 79% in automated mode compared to fully manual operations, assuming teleoperation requirements of 5 minutes per operational hour and a part-time maintenance worker.
- Costs (just driving, not about investments) could decrease by 70% as vehicle is automated
- The case assumes a **3rd party teleoperation company** that oversees several vehicles.

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DFDS Terminal in Rotterdam

- Trailer ports are for short sea shipping, frequent sailings, quick turnaround, unstandardised cargo, different interfaces
- Automation provides an option especially for rearranging trailers, outside peak hours, for faster ship loading
- It was not yet practical to navigate an AV inside a ship, at least in mixed fleet together with several human drivers and keeping safety zones

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DFDS Rotterdam terminal, first tests

- 25 hours of driving in September 2023 (8.5 hours automated). 4 days of testing.
- The average driving speed of in automated mode 8.4 km/h versus manual driving 13.8 km/h
- The automated vehicle drove slower than normally, due to the asphalt being somewhat bumpy in practice and software starting to have difficulties to differentiate the road surface from small potential obstacles during bumps.
- Energy consumption differences between manual and automated modes were minimal, plus minus 2%.
  - AV did brake 2.5 times more often than a human, but softer.

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DFDS Rotterdam Terminal Lessons

- AV being overtaken frequently was an issue during busy hours. Automation would operate during off-peak to ensure safety. Or, it would have to drive faster.
- Connecting and disconnecting trailers automatically will have to be solved before operational use.
- Test route included one too busy intersection for an AV (might always require human teleoperator help?)
  - Safety drivers handled the intersection by forming eye contact with other drivers and occasionally <u>waving their hand about who moves first</u>
  - Infrastructure changes could be considered

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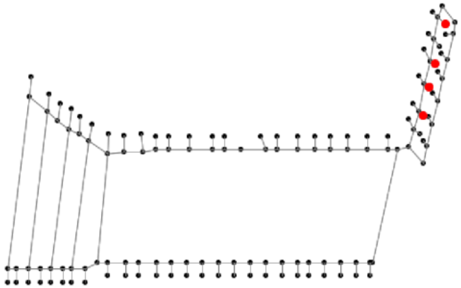

Port simulation results

- Rearranging trailers saves money: By positioning trailers closer to the oncoming ship, loading time is reduced by 15 minutes, saving around €2,500 for the port.
- When **5 human drivers** work for 3 hours and rearrange e.g. 53% of trailers into optimal positions, the projected time savings amount to €1,340 (simulated example percentage). The combined cost for their work and vehicles is €600, leading to **net savings of €740** due to expedited ship loading.
- With **5 automated vehicles** and varying degrees of human assistance, 37% of the trailers are rearranged, leading to a time-related savings of €940. After accounting for expenses, **net savings range between €540 and €840**, depending on the level of human support on the field (maintenance and attaching trailers).
- If manual labour is required especially to attach/detach trailers, it's more economical to proceed without automation. However, if this process can be automated, automation proves to be more cost-effective

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Conclusions

- Automation can offer cost savings in all the demonstrated cases, through less human work needed, as long as integration with industrial processes can be achieved
- Effective integration seems to require automating more phases than merely the driving: e.g., connecting trailers, coordinating vehicle fleet, considering automated loading
- Automated vehicles require teleoperation support of some minutes per hour. This is mostly due to interactions with human drivers and their transfer processes. Further teleoperation development will be necessary.

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4. Regulatory and governance frameworks

Victoire Couëlle -
International Road Transport Union (IRU)

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Automation in legislation: a brief overview

Who does what?

UN Regulation
approval of components safety (ISO standards)

EU Regulation
vehicle type-approval (EU)

National
validation & traffic

Overall, various level of regulation to ensure minimum safety requirements for ADS.

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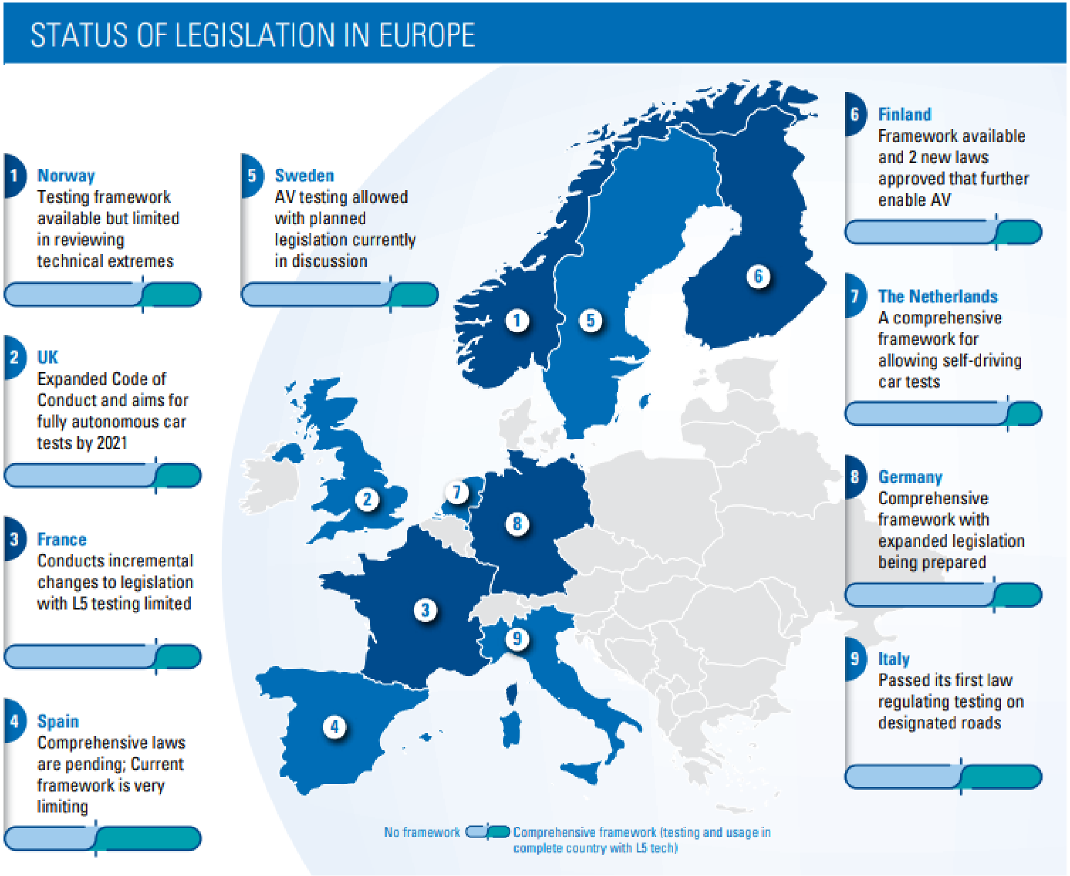
Automation across the EU: a brief overview



Source: TUV SUD

► Common EU type-approval framework

► National authorities to verify and validate AV testing and deployment

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Automation across the EU: a brief overview

Country	Testing regulation	SAE	Conditions	Approval
Germany	Verordnung zum autonomen Fahren	4-5	Human supervision and ability to take control at any time	Framework, case-by-case
France	Loi PACTE	4-5	Human supervision and ability to take control at any time	Framework, case-by-case
Austria	AutomatFahrV	4	Safety driver (in vehicle able to take control at any time, '-	Use-cases
Norway	Lov om utprøving av selvkjørende kjøretøy (exemption approval for AV)	3-4	Safety driver (in vehicle able to take control at any time,	Exemption approval, case-by-case

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Removing the driver from the vehicle: legal implications

UNECE Vienna Convention required all vehicles to have a driver:

- in the vehicle (location)
- in control of it at all times (liability).

Amendment in 2021, enabled human supervision outside of the vehicle.

Source: DB Schenker

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Source: DB Schenker

Opens the door to new questions:

- Who is responbile (in case of accidents, damaged goods, checking the vehicle, paperwork)?
- What new knowledge, training, and skills is required?

New legal, operational and social changes to take into account.

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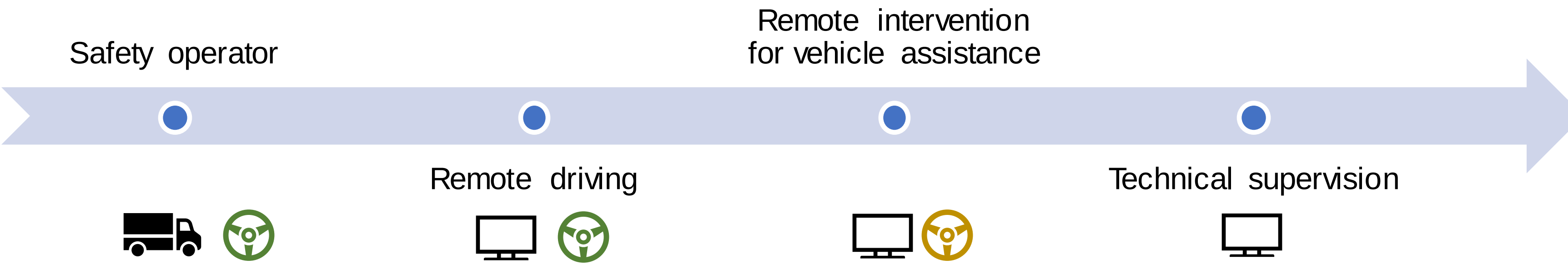
Human involvement in operation

Gradual evolution: from more active involvement to monitoring role



- Most countries still require the presence of a safety operator inside the vehicle to take over the vehicle at all times (e.g. Austria).
- EU Regulation foresees remote intervention, but not direct remote driving.

Further research on remote driving is required, to better determine the capabilities and limitations.

Clarify the characteristics different types of teleoperation, to better address the different requirements.

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Working conditions and requirements

Adapt existing EU regulation

- *Drivers: Driving and rest time rules*
- *remote safety operator*

Human AV intervention

- *Minimum requirements for remote operator work environment*
- *Limit of vehicles set remote operator can monitor*
- *What information is required by the teleoperator?*

	Driving
	Break or rest period
	Other work
	Period of availability (POA)

- ***Implement an effective staffing ratio, that ensures an adequate number of operators are available at all times to monitor the vehicle fleet.***
- ***Set teleworking conditions that ensure a safe work environment and conditions for operators (hours, max number of vehicles under their supervision).***
- ***Define the information FMS should provide to ensure the effective take over of vehicle within a short period of time.***

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New training and qualifications

- Different requirements across Member States with some more advanced than others, but commonalities.

- **What should be required?**

Knowledge on the vehicle	Knowledge on remote operation	Knowledge on the specific operation
• Driving Licence in line with the AV being operated (e.g car, truck, minibus) • Knowledge on the AV specificities and capabilities	• Safety procedures when intervening and taking over the vehicle manually, specific to each system	• Characteristics of routes or zones (e.g. restricted area, mixed traffic) • Use-case manoeuvres (e.g. loading, braking)

Define common EU minimum training requirements for people involved in AV operation, to ensure safety.

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Liability – under normal circumstances

Involvement in driving

1. Drivers

Deployment of automation

Involvement in driving

1. Automated vehicle
2. Remote human operator
3. Fleet Management System

- Clearly define division of tasks and hand-over responsibilities between drivers (ADS and human operator).
- Monitor hand-over --> identify at all time the entities in control of the vehicle times (ADS, human operator), to identify liability.
- Liabilities regime are national competences, each Member State slightly different approach.
- ***Liability should be clearly determined, communicated and monitored among all stakeholder involved in AV operation.***

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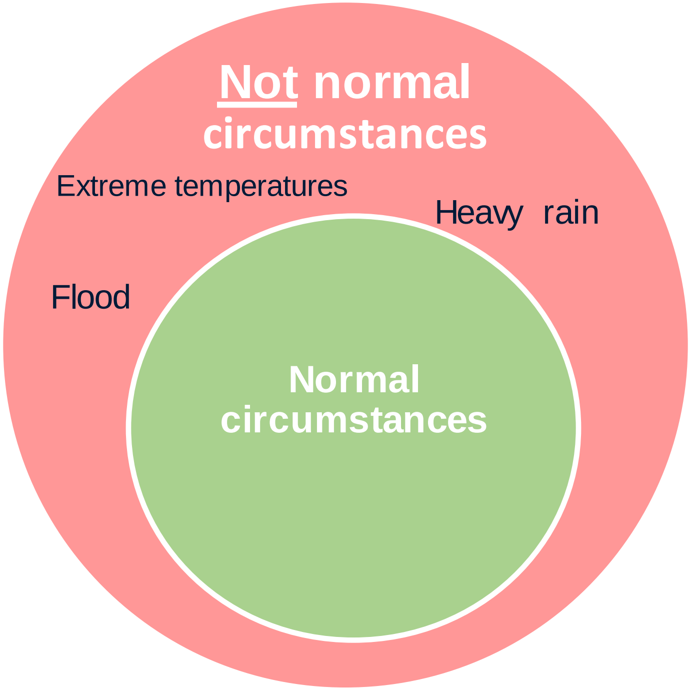
Liability – under not normal circumstances

In real-life, conditions for deployment of vehicles may vary (e.g. harsh weather conditions).

Scenario 1: Inside ODD (but not ideal)
- Mitigation measures (e.g. lower speed, bigger safety areas)

Scenario 2: Outside of ODD
- Deactivation of ADS



More data sources and information available to the ADS and FMS, will allow more accurate monitoring of the environment and.

Set minimum requirements of data and information (e.g. weather sensors) to be gathered to monitor the AV's environment, to ensure safe deployment conditions.

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Obtaining a permit

Common elements in obtaining a testing permit:

Requirements to obtain permit	Safety assessment and potential mitigation measures
	Operator (safety driver or teleoperator)
	Information on route or area

However, differences in documentation, steps and timings

- AWARD Hub-to-Hub use case
  - Documentation and process: based on Austrian regulation
  - Timing: Application on November 2022, certification in June 2023

- ***More clarity on the permitting process at national level is required, to avoid for EU fragmentation.***

- ***Enable mutual recognition of safety assessment by Member State (through bilateral agreement or EU).***

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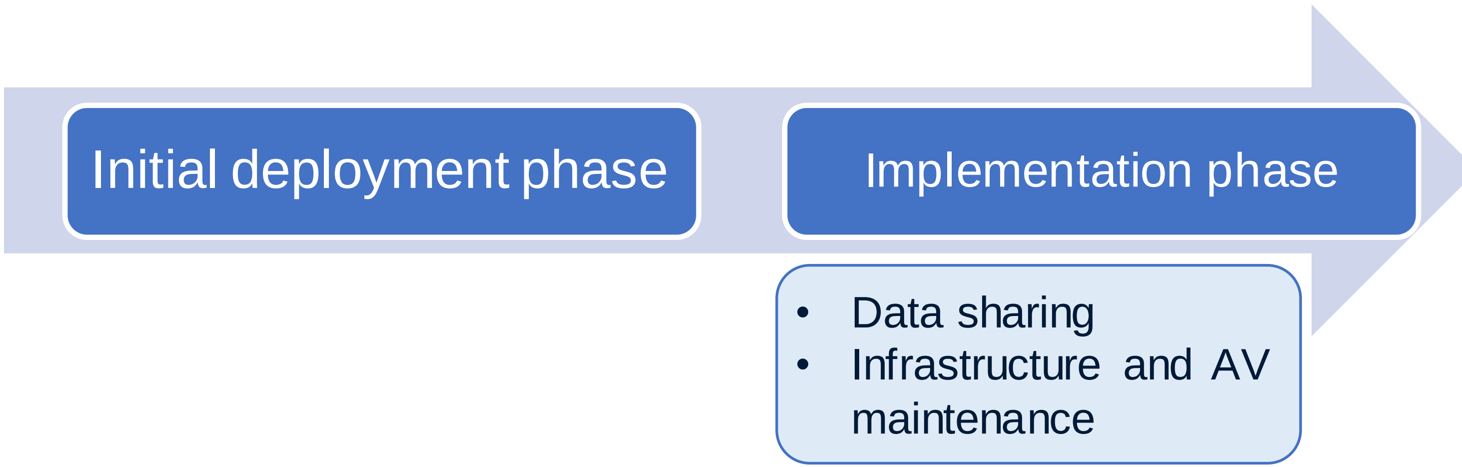
Monitoring of AV operation



- ***Clearly set and communicate the respective responsibilities between stakeholders, to ensure safe deployment conditions.***
  - ***- Maintenance of ADS***
  - ***- Maintenance of vehicles***
  - ***- Maintenance of infrastructure***

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5. Emerging business models

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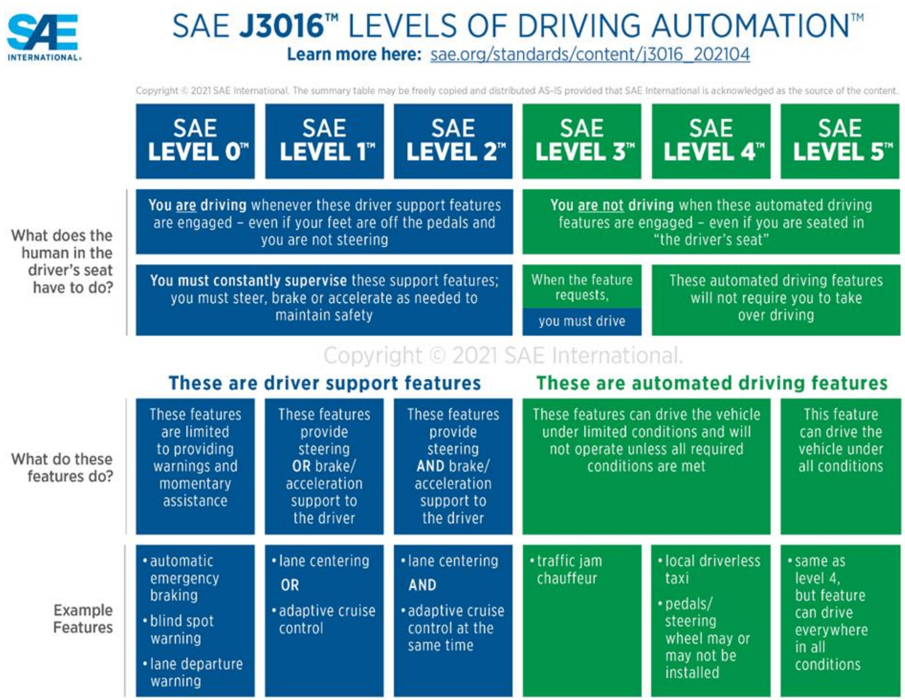
4.1 Market analysis of autonomous heavy-duty vehicles in logistics operations

- 5.1.1 Market segmentation
  - **By level of autonomy**



Society of Automotive Engineers (SAE) levels of automation:

- Levels 0-2: already in the market
- Levels 3-5: 2020 - 2030

ERTRAC CCAM Roadmap:

- Low-speed automated vehicles for transporting goods in restricted areas by 2040
- Level 4 projected to be driven by logistics business use-cases.

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5.1.1 Market segmentation

- **By vehicle type**

Weight Class	Light duty				Light Medium Duty	Medium Duty		Heavy-Duty
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
From (lbs.)	--	6,001	10,001	14,001	16,001	19,501	26,001	33,001
To (lbs.)	6,000	10,000	14,000	16,000	19,500	26,000	33,000	--

- **By geographical areas**

- Europe, North America, and China: lead in the development of AV
- EU: regulatory frameworks not harmonized yet
- *Most* advanced countries in real operations: Singapore (buses), the Netherlands, and Norway

- **By application**

- AWARD's use-cases: main applications of AVs in the logistics sector
- Key dimensions: geographic areas (indoor/outdoor), type of road (public/confined), traffic conditions, weather conditions and incidents (obstacles)

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5.2 Market analysis of Fleet Management Systems

- 5.2.1 Market segmentation
  - **By region**

- North America: 27%. Second largest market.
- Europe: 20%
- Asia-Pacific: 42%. Investments in smart cities. Sensors, data generation.
- Rest of the World: 11 %

- **By component**

- Operations management
- Fleet maintenance and diagnostics
- Performance management
- Compliance management
- Fleet analytics and reporting

- **By deployment**

- On-premises
- Cloud-based

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5.2.2 Market drivers

1. Political/Legal drivers: EU Green Deal, European Strategy on Cooperative Intelligent Transport Systems, supply chain law, safer vehicles. Non-emissions economy. Pressure on drivers' working conditions.
2. Economic drivers: increasing costs of trucking, truck crashes, human errors.
3. Social drivers: growth of e-commerce, few HDV licenses., consumers' behaviors (green solutions)
4. Technological drivers: technology advancement, AI, teleoperation, 5G, real-life traffic monitoring, R+D projects
5. Environmental drivers: need to reduce environmental impacts of transportation. Electric vehicles. Optimization of routes, performance improvement.

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5.2 Barriers and Opportunities

Barries:

- **Safety:** opportunity when technology matures
- **Cyber-security:** main barrier for FM
- Technological barriers: only protected environments
- Regulatory and legislation: in the EU, a driver is responsible for a vehicle on public roads (Treaty of Rome)
- Licensing: lack of criteria. British Standards Institution
- Liability: responsibility in case of accident?
- Ethics and social: judgments in case of accident may be challenged

Opportunities:

- Decreased transportation costs
- Safety: human-related mistakes
- Efficient use of resources: fuel
- Efficiency: reduction of bottlenecks (resting time, accidents)
- Better road utilization

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5.3 Market Size

5.3.1. Total addressable market (Global)

- Increasing CAGR from $59.70 billion in 2021 to $191.83 billion in 2028.
- Global sales: €196.97 billion in 2030.
- Uncertainties: uptake rates and technology costs.
- Commercial freight vehicles: limited share of the market in 2035.
  - Vans: 20% of all CAVs
  - HGVs: 3.1%.
- **Fleet management:** market size is estimated to double in 10 years, from 24.95 USD Billion in 2022.
  - Driver shortages
  - High fuel prices
- **Fleet type:**
  - Commercial fleets: 14 USD Billion in 2020
  - Passenger cars: 5 USD Billion.
  - Type of vehicle: growth for heavy commercial vehicles not as strong as the other types, but significant

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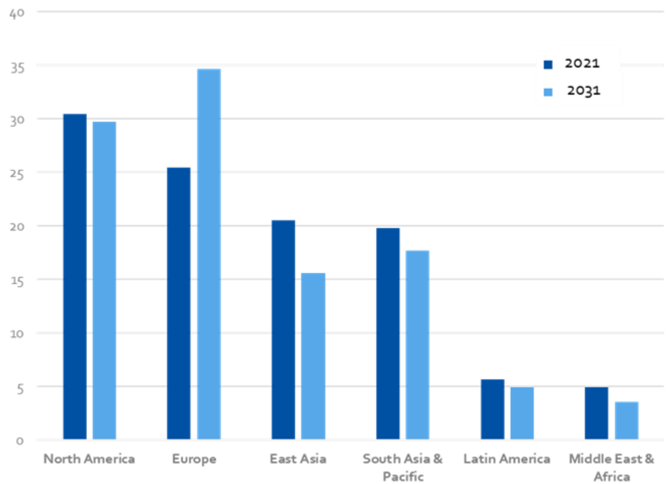
5.3 Market Size

5.3.2. Total addressable market (Europe)

- Forefront of CAV adoption -> market uptake rate surpassing the global average
- Up to 58% of the global market by 2035
- Vehicle manufacturers, premium offerings, component suppliers, early regulatory frameworks
- **Fleet management:** top 3 in market share in 2021:
  - North America
  - Europe
  - East Asia.
- 2031: Europe will have the largest share (34%). Drivers: cloud-based solutions



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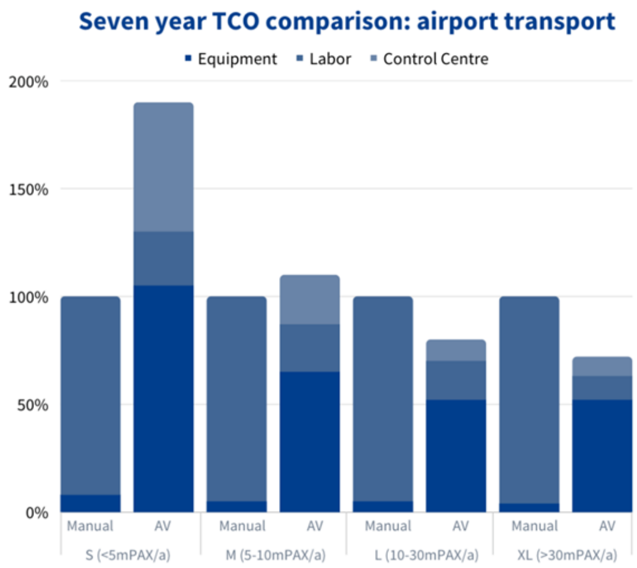
5.4 Market Size

5.4.3.2 Airports

- Baggage tractors for cargo transportation: baggage handling
- January 2022-September 2022: 615 million passengers
- 2021: 15 million tons of freight
- Most important airports: Paris Charles de Gaulle, Amsterdam Schiphol, and Frankfurt-am-Main
- EU: 298 airports, 15,000 passengers/year
- Total Cost of Ownership (TCO)



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5.3 Market Size

5.3.3 Serviceable Addressable Market

- AWARD’s use-cases:
  - Hub-to-hub (first-mile delivery)
  - Ports
  - Airport trucks
  - Forklift operations
- European market
- Assumption: all the sites using AV use an FMS
- Interviews with industry stakeholders.

5.3.3.1 Ports

- 1,200 commercial seaports
- The Netherlands leads the ranking
- In 2021: 3.5 billion tons of freight handled annually
- Yard trucks: 1,300 vehicles/year
- Container terminals more propitious for automation
- Different levels of automation. No specific characteristics to determine what terminals can be automated

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5.3 Market Size

5.3.3.3 Hub-to-hub (first mile logistics)

- Transportation of goods from factories to distribution centres/warehouses
- Main European corridors:
  - Blue banana: from the United Kingdom to Northern Italy
  - Irish corridor: between the ports of Cork and Dublin in Ireland and the ports of Zeebrugge and Antwerp in Belgium
  - Baltic corridor: depending on the construction of TEN-T road and rail networks

5.3.3.4 Forklift operations

- Different use cases
- Global warehouse automation market size: USD 12.85 billion in 2020, expected to reach USD 30.69 billion in 2028
- 20,000 -50,000 warehouses in Europe
- Advanced automation systems: less than 10% of the existing warehouses
- Electric forklift market in Europe: USD 15.30 billion in 2021

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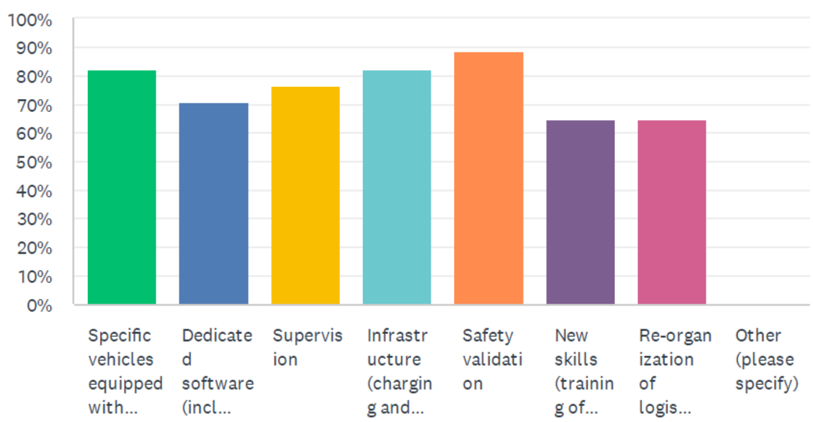
5.4 Emerging Business Models: preliminary findings

AV added values in comparison with human-driven vehicles

1. Reduced human-personnel costs
2. Safety
3. Improved efficiency
4. Marketing (innovative image)
5. Improved working conditions

Q7 In your opinion, which additional resources are required for the shift from a conventional vehicle to an automated one, within the hub-to-hub use-case?

Answered: 17 Skipped: 0



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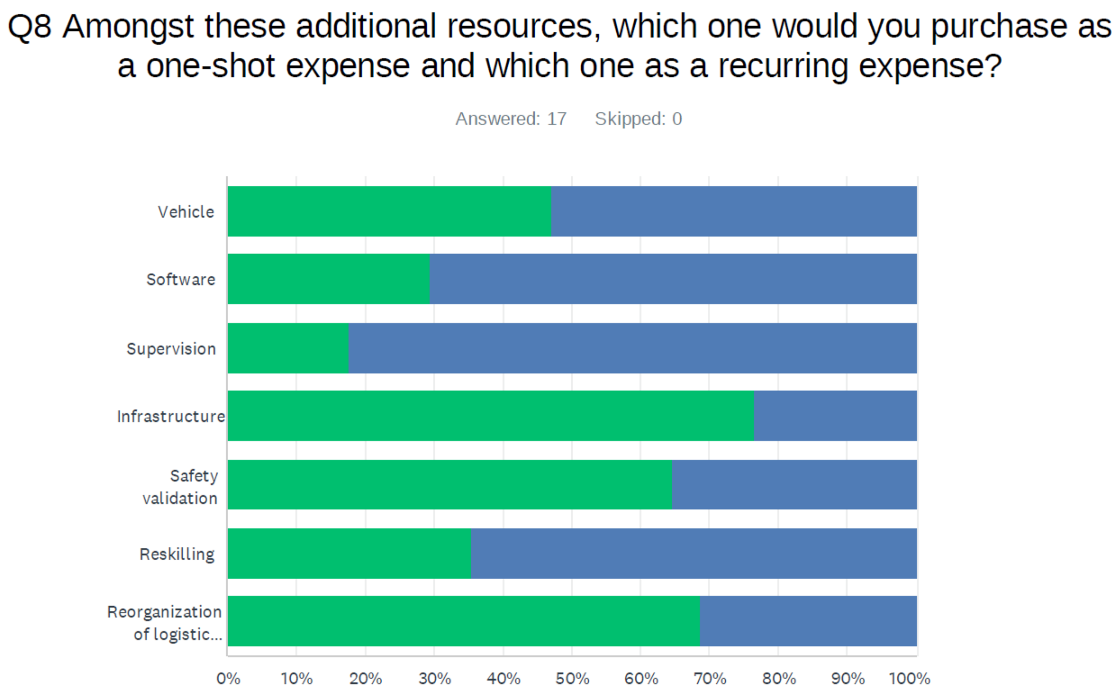
5.4 Emerging Business Models: preliminary findings



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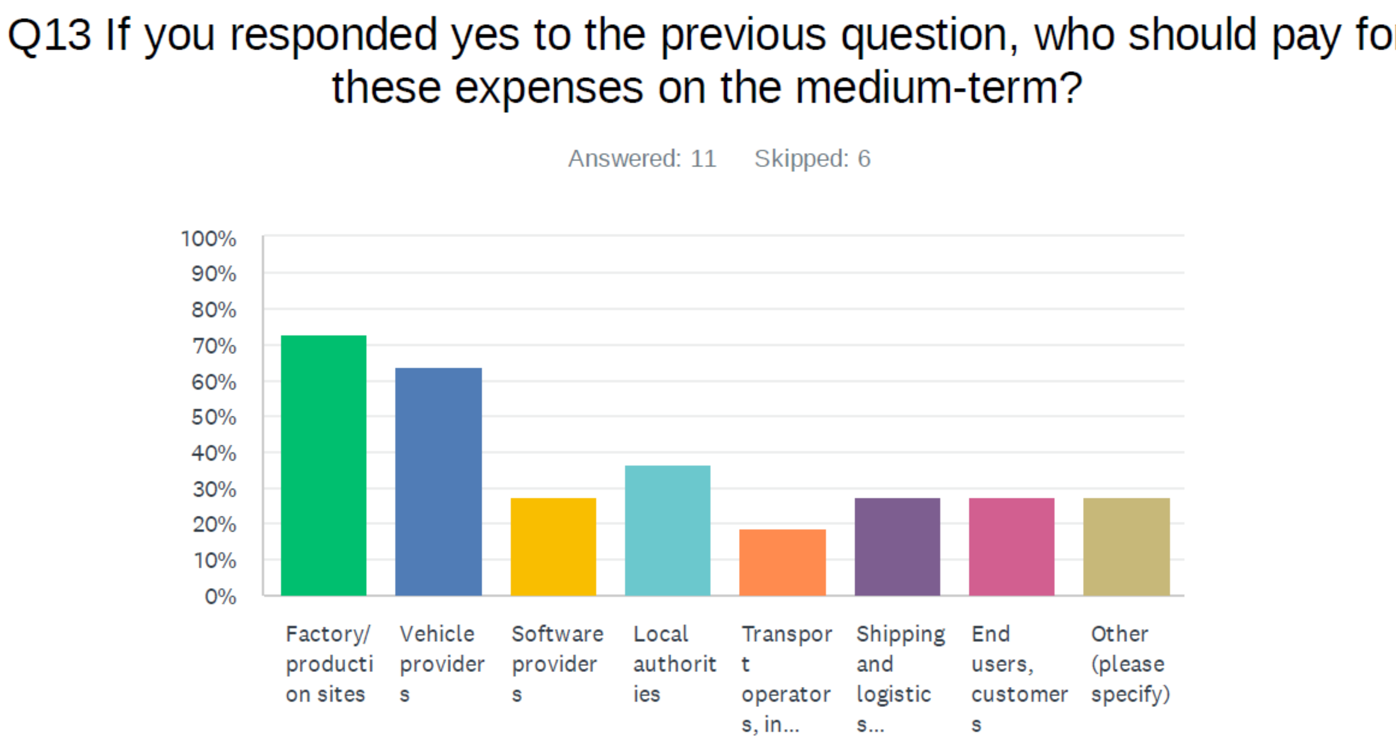
5.4 Emerging Business Models: preliminary findings



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22/11/2023

Thank you!

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