AEROFLEX – AEROdynamic and FLEXible Trucks

HIGH-CAPACITY ROAD TRANSPORT. FOCUSSING INNOVATION ON SMARTER MOBILITY SOLUTIONS FOR SMARTER POLICIES.
Efficiency improvement up to 33% by 2030.

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1. Introduction

As stated in the abstract, paper 27, the conclusion out of phases 1 and 2 were summarized as below.
New vehicle concepts and new technologies developed within the AEROFLEX project do have a significant contribution to CO2 reduction objectives and to increase efficiency in road transport in a multi-modal context.

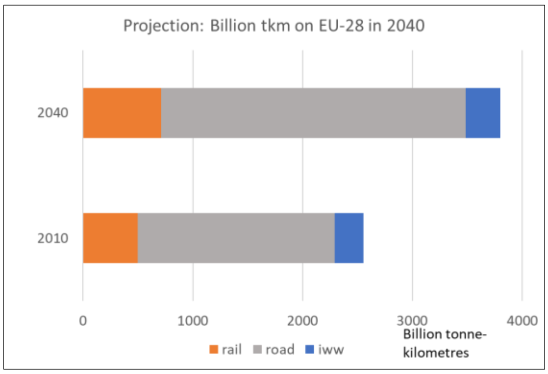
1. The new vehicle concepts allow:
   a. A wider use of HCV for efficient and cleaner road transport
   b. An enhancement of EMS concept for optimized multi-modal transport
2. The logistics operations can handle in a better way:
   a. Both low- and high-density goods as well as for long and short haulage
   b. Consolidation of freight as a pre-condition.
3. The ongoing digitalization process will transform the assets (semi-trailers, boxes, wagons) into smart devices, forcing the transport industry to change and adapt the logistics processes (horizontal and vertical collaboration) to keep competitiveness against Asia and the US.
4. Smart Infrastructure Access Policies (SIAP) are crucial for optimal matching of novel vehicle concepts, infrastructure, and operations (handling of goods, loading units and vehicles).

As outcome of the project, it can be stated that the overall AEROFLEX goal, an efficiency improvement in long haul freight road transport up to 33% is achievable under the given recommendations enabling the implementation of AEROFLEX innovations, see points 1-4, during the period 2025-2030.
Due to covid-19 restrictions, testing, demonstrations, and validation are performed till end Q3-2021.

The final evaluation and conclusions will be done in Q3-2021 and presented during the AETOFLEX final event at the ZF-WABCO Test Track Jeversen, Germany on September 28th.
An interactive one-day hybrid event for visitors and live stream for those who cannot join physically.

This paper presents high level results with focus on use cases and market implications. The results and details of the technical innovations will be demonstrated and explained at the final event as teaser to have a dialog with all participants.

2. Boundaries and constraints



In short, a summary and outline of the problem areas coming from the research and analytic phase of the project to underline the defined goals and objectives at the beginning of the project. The European transport sector contributes to about 25% of the total CO2 emissions in Europe.[1)]
The demand for transport of freight will increase by app. 45% by 2040![2)] Figure 1, projection demand of freight transport

The growth for the different modes is app. rail by about 43 %, road by about 55 % and IWW by about 19 %.

The cost for transport (2019, including external cost in ct/ton-kilometers) for road is 4.47, 2.03 for rail and 2.00 for inland navigation.[3)]

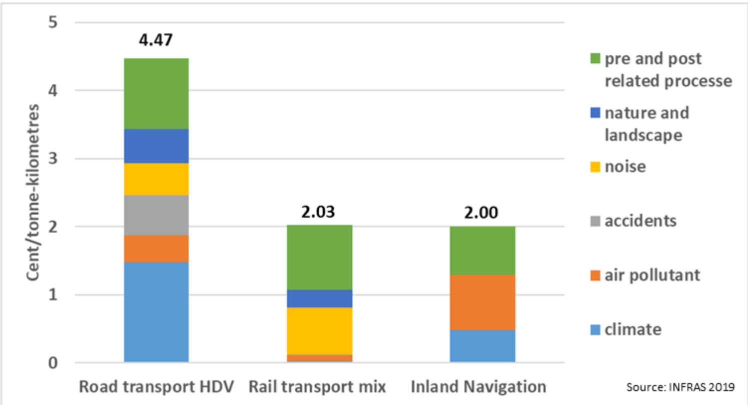


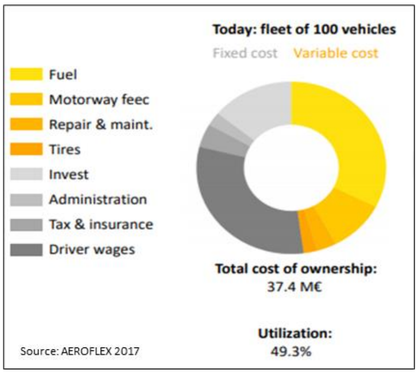
Figure 2, cost of transport INFRAS2019.

The main cost contributions for road transport are the climate impact and accidents representing with over 50%.

The pre and post related processes represent for all three transport means a significant cost level up to 1ct/ton-kilometers (20-25% for road and 50% for rail & inland navigation).

It should be stated that the cost for rail transport is only valid for an electric mix out of pure green electricity.

The cost of running trucks for road transport are expressed in the total cost of ownership (TCO).



The TCO of a typical long-haul fleet of 100 vehicles over a period of 48 months exceed the 35MEUR.

Driver wages and fuel (and indirectly CO2 emissions) are representing >66%.

New technologies and innovations may increase the purchase price of the vehicles but should reduce running cost,
- by reducing number of vehicles kilometers, energy & emissions, and
- improving road safety for driver, occupants and VRU.

Figure 3, TCO of trucks representing a typical fleet of 100 units.

A paradigm shift is needed to cope with these challenges. AEROFLEX focused on the vision of "The Physical Internet"[4)], a new vision of future logistics for physical goods to achieve a sustainable logistics and transport system. This includes the optimization of multimodal transport chains by drawing on the advantages of the different modes.
From these figures, it became obvious that the focus of AEROFLEX is to reduce CO2 emissions, the impact on climate, road accidents, TCO and pre & post related processes by transporting the same freight.
To achieve this an overall goal is an efficiency improvement in long haul road transport up to 33% guided by objectives as defined in the table below.

Objective	Target	Action
Energy saving	Reduce 4-5%	Separate platforms
	Reduce 4-6%	Effective use of loading space
Energy consumption	Reduce 5-10%	Vehicle aerodynamics
Energy efficiency	Improve 5-12%	Flexible and advanced powertrains
Std interfaces and sharing components	Economy of scale	Uniform protocols, processes
Ensure survivability occupants and VRU	Crashes up to 50km/hr	Front end design

Table 1, objectives AEROFLEX

The vision of the project AEROFLEX is to support the vehicle manufacturers and logistics industry to achieve the coming challenges.

3. Research approach

All activities are divided into 2 different types of activities (see figure x below):
The "horizontal" activities relate to generic and collaborative activities that are key to developing synergies through the project. More specifically, the investigation of potentials for a configurable truck, the standards and setting the baselines for the project (WP1&7). The "vertical" type activities relate to specific innovation, development and demonstration activities, the developments on Energy management (WP2), Aerodynamics (WP3), Smart loading units (WP4), and front-end design for safety (WP5) all feeding into the demonstration and validation phase (WP6). Pert diagram, including results (Deliverables). The figure below shows the pert diagram of the project, the flow of results (deliverables) through the AEROFLEX phases and are linked to the WPs. A list of all deliverables is to find in appendix 1.

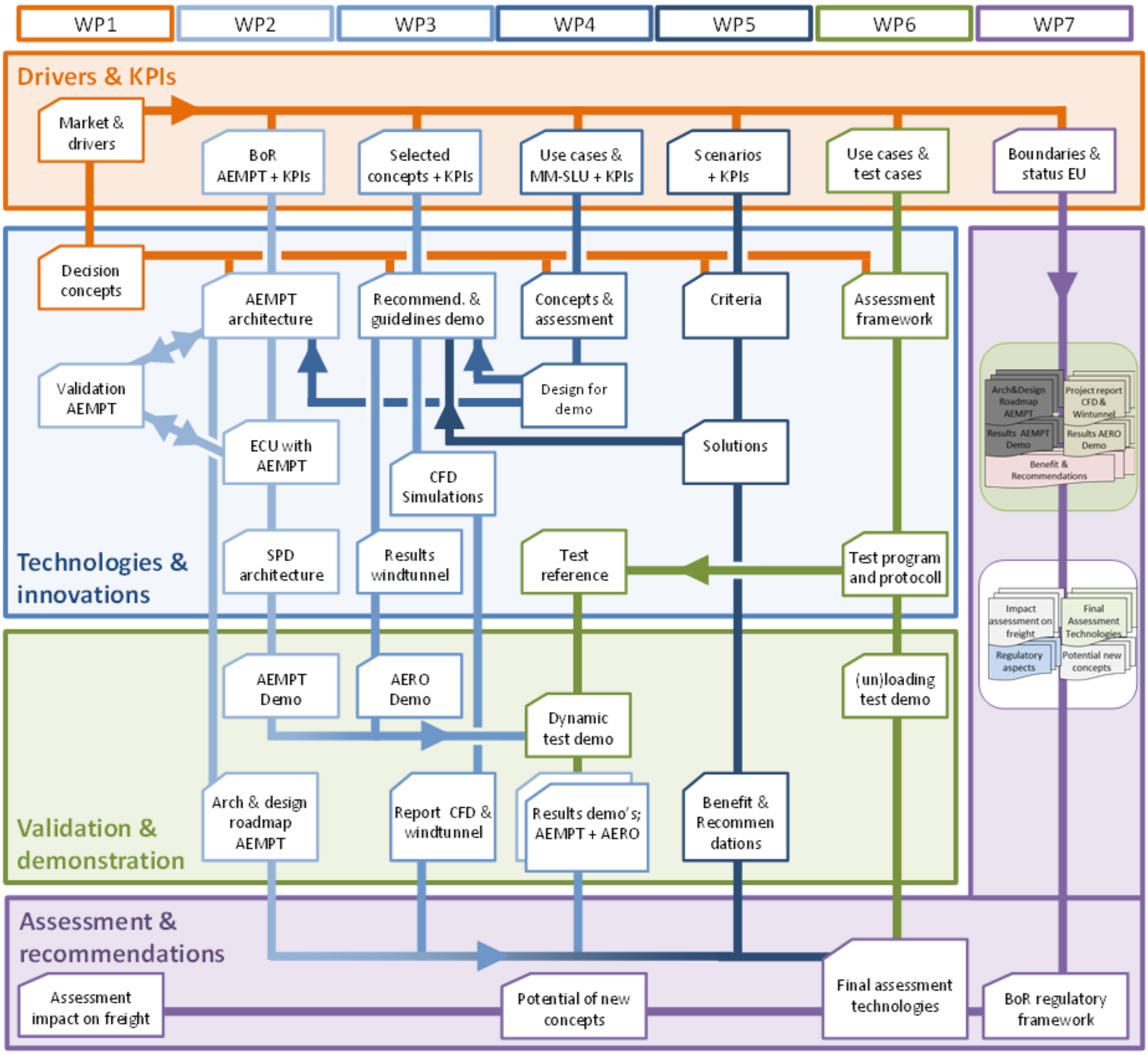


Figure 4, pert diagram (flow and deliverables)

4. Results

4.1 Freight market in EU and potential for configurable truck.

Increase of efficiency for freight transport.
First, the improvement of efficiency is one important driver of European freight transport market. Co-modality and synchromodality are key elements to improve the efficiency. Freight transport should be organized by the consideration of the strength and weaknesses of the transport modes that are relevant to fulfil the requirements of the shipper that are defined by lead and transport time, weight and volume of the order /the shipment and further specific costumer and good related characteristics. The transport by only one transport mode could be the most efficient way in case the strength of this mode fulfils the given constraints, e.g., to carry goods due to time constraints, direct link between origin and destination without detours, availability of infrastructure and specialized equipment, sum of working time. Furthermore, it is necessary to fulfil the costumer related expectations regarding transport costs. About 80 % of all freight transport is realized on long haul[4)]. Freight transport services up to 150 km are also relevant for new vehicle concepts in combination with smart loading units to support more efficient transport services at the interface between long and short distance transports e.g., in terminals and hubs. From the perspective of tonne-kilometres, new vehicle concepts could address all goods classes and not only selected ones due to the objective to develop a configurable and cost-efficient vehicle concept that is not dedicated for only some commodities.

Vehicle concepts should be developed for low density goods, long transport distances and high revenue logistics segments.
New vehicle concepts should address good classes with high transport performance measured in tonne-kilometres (e.g., food products, beverages and tobacco, agricultural products) in combination with long transport distances. Furthermore, the potential revenues in logistics segments (e.g., Contract Logistics, full and less than truck load with palletized goods and Courier/Express/Parcel) should be considered. These segments should be addressed, because the balance between market size, expected revenues and small order sizes expect a high demand for advanced vehicle concepts using modular loading units. Finally, it is recommended to realize an optimum trade-off between payloads and transport volumes to maximize the use of the loading capacities.

Fast and frequent road transport between hubs and industrial sites become important.
Due to the increasing amount of courier/parcel/express cargo and general cargo, hub and spoke concepts are increasingly used to consolidate the shipments and thus, to increase transport efficiency. Therefore, a promising and growing segment for new truck concepts can be identified in transports between hubs (e.g. terminals, ports, huge warehouses) as well as between industrial sites and hubs. Here, it is essential that loading units can be optimally maneuvered and placed at the gateways in cross-docking stations or in warehouses, even if there is a limited infrastructure condition. Further, the organization of a fast exchange of loading units between different vehicles or between transport modes is important.

New vehicle concepts must be compatible with the existing infrastructure.
Infrastructure conditions and constraints of the existing road infrastructure – road, bridges, yards, driveways, roundabouts, parking areas and docks – are key issues for new vehicle concepts. Currently, most parking areas and docks are not suitable for long commercial vehicles. The new vehicle concepts should be compatible with the existing road infrastructure to avoid an extensive enhancement of the European road infrastructure or sophisticated technical solutions supporting maneuvering in confined spaces on motorways and inter-urban roads.

Platooning, autonomous driving and the digitalization of logistics processes are relevant trends.
The digitalization of logistics processes supporting the driver, simplifying vehicle routing and route planning, and enabling the monitoring (e.g., smart loading units) of the whole transport chain is ongoing. Based on these digital opportunities, new transport services and processes are expected to emerge. Further approaches (platooning and automated driving) reduce the stress for the driver and may contribute to a reduction of transport costs. However, they require sensors, communication technology and energy supply within the vehicle.

Further trends with an effect on the transport and the vehicle are seen in:
- Dematerialization, i.e., the number of materials used in products might be reduced.
- 3D-printing technology will be developed, i.e., personalized, small scale local production in regional production sizes or for spare parts retailing.
- Postponement of final product assembly, i.e., local assembly close to the consumer, leading to the transport of intermediate products (parts and components) rather than final products, with the potential to reduce the amount of space required for transport.
- Transport of Intermediary goods instead of final products is increasing and may enable a higher packaging efficiency and higher density of goods in the loading unit. This may help to meet volume restrictions.

Use Cases should represent the European transport market.
The AEROFLEX project develops innovative vehicle concepts for a major percentage of the European transport market, which shall simultaneously contribute to an efficient overall freight transport system. The use cases considered in the AEROFLEX (and in future R&I projects) should meet the requirements of significant sub-markets in the current transport market in Europe. Based on the analyses we conducted, the uses cases should:
- include own account transports as well as transports conducted by own company and conducted by third parties (e.g., by logistics service providers)
- offer the possibility to use intermodal transport chains in cases of long transport distances
- address preferably logistics segments with high expected demand for advanced vehicle concepts like Contract Logistics, full and less than truck load with palletized goods and Courier/Express/Parcel, food products, beverages and tobacco
- address transports that are mainly conducted on motorway and inter-urban roads today.

Additionally, it is necessary to get more information in direct contact with stakeholders and potential users of new vehicle concepts.

4.2 Saving potentials for high-capacity vehicles (configurable trucks)

Are savings potentials to be expected if high-capacity vehicles according to the European Modular System (EMS) as currently permitted would be useable in European logistics, i.e., can new vehicle concepts contribute to yielding transport cost and CO2 emission savings?

Technical basis for this approach were the so-called Prime Candidates (see appendix 1) coming from the FALCON project (CEDR - Conference of European Directors of Road, 2018). These vehicle concepts are composed of standard towing vehicles and loading units as they are in use today. In accordance with the European Modular System (EMS) these components are combined to form new vehicle combinations with up to 4 loading units. For each Prime Candidate, a new Gross Combination Weight (GCW) is proposed which exceeds the limitations set in the relevant directives (European Union, 1996, 2015) while complying to the maximum permissible axle weights. This was done to optimize the opportunity to consolidate load on the one hand and restricting road wear and tear and strain on bridges to the current level on the other hand. **The Prime Candidates were analyzed about the KPIs €/tkm, €/tour and CO2e [kg] emissions Tank-to-Wheel (TTW) and Well-to-Wheel (WTW)**. The analyses were based on primary data that were collected during an online stakeholder survey and by in-depth expert interviews amongst logistics service providers (LSP) and shippers.

The approach to use EMS vehicles to improve efficiency is based on load consolidation as crucial factor to realize the expected benefits. This can be done either within logistics companies if the according transport volume is big enough. There are certainly several big market leaders complying with this requirement. On the other hand, there is significant number of carriers, LSP and shippers that would lack an according transport volume. For those companies, the concept of horizontal collaboration would provide an opportunity for load consolidation and thus benefit from optimized logistics operations. The answers to the online survey's question, if participants would rate horizontal collaboration either as risk or as opportunity showed slight tendency towards collaboration providing an opportunity (Median 4 on a scale from 1-6). This also shows that there is also a need to communicate the benefits of horizontal collaboration and to explain possible ways to implement such a business model in compliance with the already existing EC directive (European Union, 2011).

The finding that high-capacity vehicles are a promising concept on the way to optimizing logistics operations is supported by the fact that 62% of the survey's participants stated that they already engaged with high-capacity vehicles. 46% expect to benefit from the use of longer vehicles and 39% expect to benefit from heavier vehicles as currently permitted by law.

To quantify possible savings for the above mentioned KPIs, use cases were analyzed that were collected during expert interviews. The calculations were based on real world tours that were specified by logistics companies, including descriptions of currently used vehicles. This information was combined with characteristics of Prime Candidates the experts selected to be potentially useful in the according use cases and fuel consumption simulations as well as total cost of ownership (TCO) and transport cost calculations.

The results suggest best case scenario potential savings in
- Transport cost (€/tkm and cost/tour) of 23% on average.
- CO_2 emissions at 13% (range -7% to +42%) respectively 16% (range -7% to +71%) on average on TTW and WTW level.

This rather large range of values reflects the variability of logistics applications and is probably influenced by the compilation of the sample.

Biggest influence on these results for all reported KPIs was exerted by **the consolidation factor**, the quotient of maximum load of a Prime Candidate and the standard average load of the according reference vehicle that was specified in a use case, i.e., potential for load consolidation. The ratio between weight and volume utilization of a transport, i.e., the classification as tonnage or volume transport, on the other hand did not show any impact on the results.
Of course, **fuel consumption** has also major influence on savings potentials. However, the factors fuel consumption depends on are highly variable and specific to a certain route. These are mainly the actual GCW, the vehicle layout and the route profile, e.g., number of stops and route topography.

Though the analyses were conducted on vehicle level per use case, it can be concluded that savings potentials would probably increase on fleet level. This is since the three main cost categories of the TCO – fuel consumption, labor cost, invest – would rather benefit from the use of EMS vehicles.

Three assumptions form the foundation for this derivation.
1) Load increase is expected to outgrow fuel consumption increase.
2) The introduction of EMS would result in a reduction of the rolling fleet, due to load consolidation, therefore, fewer drivers would be necessary to operate the vehicles. Because of the fleet reduction fewer towing vehicles for the same number of loading units would mean a decrease in cost.
3) The quantification of potential savings, EMS provide, emphasis was put on the requirements and constraints these vehicle concepts are supposed to meet.

Therefore, the expert interviews also addressed this subject. These questions yielded a wealth of information about requirements, expectations, and concerns of the participants. In summary,
- Investment costs are not expected to increase significantly as standard components are used to compose EMS concepts.
- Transport costs are in turn expected to decrease by about 20-30%, which matched the results of the quantitative analyses quite well.
- Loading and unloading time is seen as crucial factor as well is road accessibility and compatibility with infrastructure. Especially maneuver and parking areas are mentioned.
- Intermodality is considered useful for cases that serve intermodal transport. But it is not required as general equipment feature.
- Sustainability and CO_2 emission reduction is not yet prioritized comprehensively. This is certainly a task to be tackled by authorities, NGO etc.
- The increase in GCW and volume between current vehicle concepts and EMS concepts need a certain extend to provide savings potentials, which also matches the results of the analyses concern the consolidation factor. The stated requirements however were very versatile.

4.3 Use cases to identify feasible vehicle configurations (configurable trucks)

Expert interviews were held to select those Prime Candidates which could be used in their daily business providing biggest potential for economical and logistical benefits (future cost and CO2 emissions savings). The experts were asked to select a maximum of three vehicle concepts per
- market sector (FTL, consolidated cargo/LTL, bulk/silo, CEP, special haulage, and heavy haulage)
- route type (FTL main run, FTL pre- and onward carriage, LTL, source consolidation and milk run)
- combination.

32 different use cases have been created. The regarding tours involved 19 countries, either as origin, destination, or transit country (EU countries as well as Serbia and Turkey). Combined, 171 different combinations of tour, vehicle and load variants have been analyzed.
The 257 votes were spread over 24 of the available 27 Prime Candidates. About 53% of the votes were given to 6 Prime Candidates in descending order of vote share: 6.1, 2.1, 3.1, 1.4, 2.2 and 4.7 (see also figure xx). The shares ranged from 11,7% to 6,2%. An additional 10,1% was achieved by Prime Candidate 1.3, which is a standard 4x2 tractor unit with a 13,62m semi-trailer. Three candidates did not get any vote (4.6, 5.4, 5.5). The remaining 14 candidates achieved shares between 0,4% and 5,8%, still considered as useful as, or even more useful than those focus concepts for some applications. This suggests a necessity for flexible, adjustable, and smart vehicle concepts.

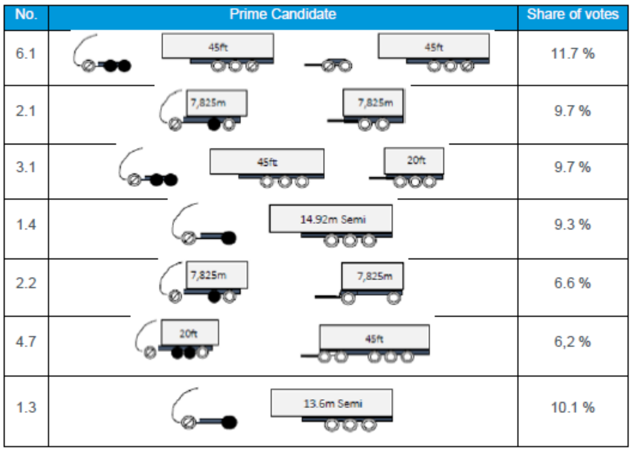


Figure 5, overview most chosen prime candidates. n=254 votes.

In addition, standard average loads by reference vehicles are compared to the maximum load for Prime Candidates to calculate the average main values and standard deviations of each KPIs as on pages 5. These main savings potentials in percentage values for different KPIs for the overall sample are displayed in table below.

KPI	€/tkm	Cost/tour	CO2e TTW	Co2e WTW
Standard average load	18.7 (10.9)	19.0 (11.2)	28.8 (17.0)	20.9 (11.3)
Maximum load for Prime Candidate	-28.2 (16.4)	-28.1 (16.5)	-16.9 (14.4)	-25.8 (33.7)

Table 2, overview savings of chosen prime candidates in analyzed use cases. n=32 votes.

On fleet level up to 30 % of tractors and drivers in suitable use cases could be saved by using these prime candidates! The next chapter shows a typical use case, demonstrating the in dept analysis of the real-world conditions, the methodology of assessing new configurable trucks, and the simulation results.

Example

Customer use case – NL-FIN multi-modal An international Logistics Service Provider does daily transport from Northern Europe to Scandinavia and the Baltic states. Their home base in southern part of the Netherlands. The use case represents the daily route Katwijk, Netherlands to Tampere, Finland. They have access to warehouses and cross-docking facilities and run a fleet of 70 trailers, consisting of tautliners, cooling trailers and box trailers. The operation of vehicles 277 days/yr and drivers 200 days/yr. See figure 6.

figure 6, fleet of 70 semi-trailers

The characteristics of use case, see figure 7:
Milk run to outward journey, 3,5 – 15,2t cargo
Delivery on outward journey, 15,2-3,5t cargo
Full truck load on return journey, 22t cargo

Freight

Product	Amount	loading unit	Weight [tonne]	Height [m]	length [m]	Width [m]	Load location	Unload location	Load time	Unload time
Tires	500	piece goods	3.5	3	3	3	Almelo	Janakkala	00:30	00:30
Laptops	6	euro	0.1	0.2	3	3	Bijsterhuizen	Loimaa	00:45	00:30
Chemical X	10	IBC	11	1.1	4	3	Maasvlakte Rotterdam	Tampere	03:00	02:15
Beer	50	crates	0.4	1.8	1.5	3	Zwolle	Orivesi	00:45	00:30
Pillows	4	euro	0.2	1.8	2	3	Assen	Lahti	00:15	00:15
Wood	52	m3	22	1.8	13	3	Hyvinkää	Klazinaveen	00:45	00:30

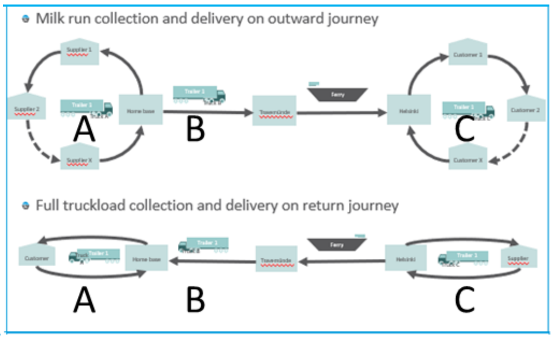
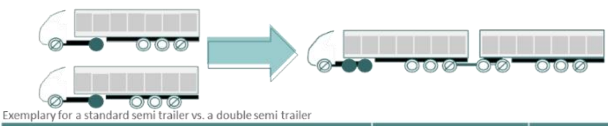


Figure 7, characteristics use case

The challenge of the planner is to cope with, see figure 7:
the daily milk run must function not to miss Truck B. Truck B must meet the time slot loading the ship in Travemünde, Germany. The return trip of truck B depends on truck C meeting the time slot loading the ship in Helsinki, Finland. See scheme below. Finally, the short sea´s weather conditions and traffic must meet the time slots.

Leg	Vehicle	mo	tu	we	th	fr	sa	so	mo	tu	we	th	fr	sa	so
Milkrun	Truck A	10													
Hub to Port	Truck B		10												
Short sea				10	10	10									
Port to Delivery	Truck C						10								
Return to Port	Truck C								10						
Short sea										10	10	10			
Port to Delivery	Truck B			10										10	

The focus of the research was to analyze with the operator the impact of consolidation of semi-trailers by using one of the prime candidates (pc) out of the “FALCON” list. The best choice was the use of pc 6.1.
At fleet level, a reduction of tractor units and drivers by ca. 45% and clear efficiency improvements by > 30% and emissions by > 18%. The average savings potential by consolidation by the usage of EMS2 vehicle combinations is seen in the graph below (fig. 8).



	€/m3km	€/tkm	Cost/tour	CO_2e TTW	Co_2e WTW
Average savings potential (%)	-32,4	-32,4	-31,7	-18,4	-23,0

Figure 8, efficiency improvements within use case

Technical innovations, e.g., a hybrid distributed powertrain and active aerodynamic features will bring further savings up to 10% and 12% depending on driving conditions. The final impact of these technologies will be available and presented at the AEROFLEX final event, End September 2021.

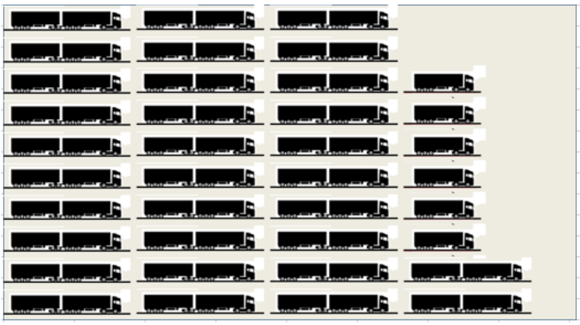


Figure 9, reduced fleet

Figure 10, e-dolly able to move trailers at yards

Another important advantage is the space used on the road infrastructure, reduced by 35%. This also has a positive effect at parking places since the e-dolly developed within AEROFLEX enables splitting of the vehicle when looking for parking bays. See figure 8-11

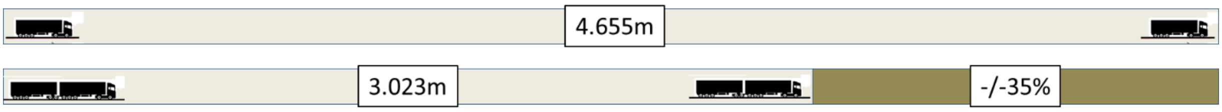


Figure 11, reduced space on road infrastructure

5. Conclusions and recommendations

Based on the explanations above, the **main recommendation is to further investigate a possible revokement of the current GCW and measurement limitations for heavy commercial vehicles (European Union, 1996, 2015) to enable the use of EMS vehicles and load consolidation and foster their savings potentials. This also includes the regulation to carry at least 25% of the GCW on driven axles (European Union, 1996).** Therefore, further in-depth analysis on fleet level is necessary. Allowing field tests in actual transportation businesses on public roads would provide real world data to prove or disprove the results of the simulations mentioned above. This analysis should not only cover the long-haul sector as it is stated in the project description of the AEROFLEX project but consider the entire transport market without limitations, e.g., in trip distances, commodity groups etc.

As LSP are free to use vehicles as they suite their business needs, all possible applications should be regarded to facilitate a proper and comprehensive assessment of the impact EMS will have on the European logistics business. The further developments that impact transport efficiency (smart loading units, advanced energy management power train, optimized aerodynamics and safety improved front end design) should be considered, as they are supposed to provide additional savings potential.

Summary other activities within AEROFLEX project

WP2 Advanced Energy Management Powertrain

One main objective is to reduce fuel consumption of EMS vehicles by advanced powertrain technology. A key idea is to combine the combustion engine of the pulling vehicle with electric drives in different vehicle units, thereby creating a distributed hybrid drive. In turn AEROFLEX vehicles would allow a flexible combination of vehicle units which bring their own driveline into the combination. A sophisticated energy and torque management system will allow an efficient operation of this distributed powertrain. This type of powertrain architecture including at least one electric drive in a trailer unit, the sophisticated energy and torque management and a suitable communication interface is referred to as Advanced Energy Management Powertrain (AEMPT). Fuel savings (up to 15%) can be achieved with this new global approach.

Furthermore, the global approach enables a supervisor safety controller, which ensures driving stability for the vehicle combination, demonstrated by the demo.

On top the e-dolly enables automation at terminals through autonomous operation for increased efficiency and safety.

Figure 12, AEMPT demonstrator with e-dolly and e-trailer

WP3 Aerodynamic concepts for the complete vehicle

Aerodynamic drag is a major contributor to the fuel consumption needs of trucks, especially at cruise speeds for long-haul transportation. Any improvement in aerodynamic characteristics to reduce drag pays off in lower fuel consumption and less emissions. The approaches applied for aerodynamic drag reduction, however, should be balanced in the sense that cost and robustness of the implemented concepts are in line with the actual benefits achieved. Successful concepts improve the overall air flow along the entire vehicle, avoiding the adverse effects of selecting a suboptimal combination of tractor and trailer.

Figure 13, AEROLOAD demonstrator 14 active & passive devices

Therefore, we need to consider developing aerodynamic features and devices for the complete vehicle to reduce drag that are adaptable to their logistics task and circumstances. A demonstrator will feature several active and passive devices. Parallel windtunnel tests and CFD analyses will support and enable the development of devices as on the demo and beyond today's praxis, e.g., Plasma materials.

WP4 Smart Loading Units Smart

Loading Units for overall efficiency gains by separate platforms for volume and weight and by more effective loading space utilization. Three use cases are agreed in close collaboration with the stakeholders to demonstrate the potential savings and efficiency improvements.

1. Use case for combined transports performed within AEROFLEX and CFL Luxemburg, the rail connection Bettembourg - Le Boulou, to prove the aerodynamic devices on semi-trailers at high speed (< 200 km/h).

Figure 14, CFL train from Bettembourg (LU) to Le Bolou (FR)

2. Use case at Procter & Gamble to prove milk run deliveries, the improved loading efficiency as well as horizontal and future automatic (un)-loading for goods in combination with double floor, flexible and smart loading units, new trailer concepts.

PUZZLE®

3. Use case in co-operation with Clusters 2.0 using a new Puzzle Software for loading optimization and a new Cargo-Volume-Dectection to enable monitoring of loaded goods to enhance the filling factor. Both systems are developed within the AEROFLEX Consortium.

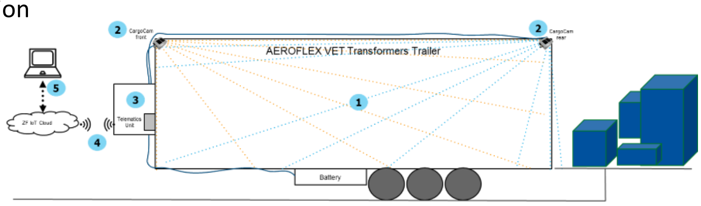
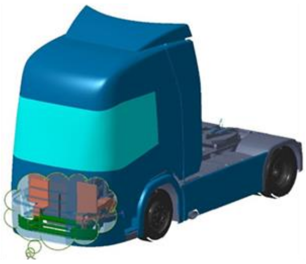


Figure 15, Cargo Volume Detection & PUZZLE[R]

WP5 Front-end design to improve survivability in crashes



The increased front extension as designed in AEROFLEX allows an improved field of vision and combined with Active Safety systems e.g., AEB, enables a drastic reduction of accidents. Further the fitment of crash absorbers connected to a crossbar ensure less damage to the occupants in case of a car collision.
The rounded design, the softer outer skin and the greater distance between the contact surface and the chassis hard points make the frontend less aggressive and reduce the level of injury on the VRU in the event of an impact.

Figure 16, New Front End Design

WP6 Demonstration and testing program

The demonstration program is ended June 2021 and the validation is ongoing, analyzing the feasibility of the AEROFLEX innovations,

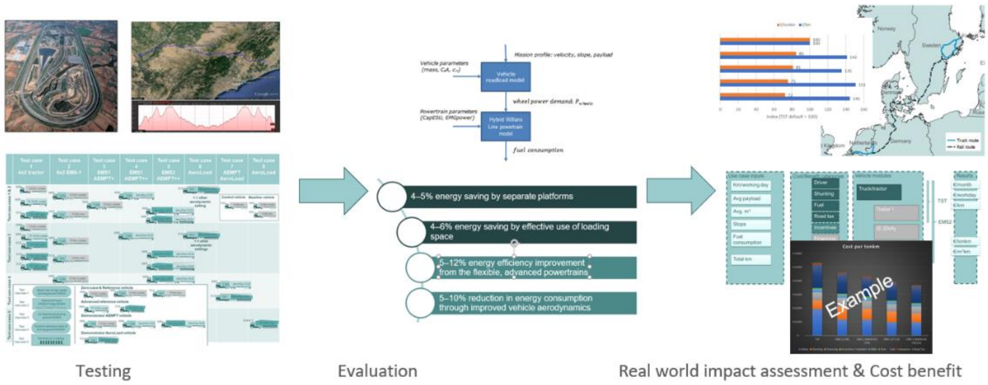


Figure 17, Testing, evaluation, and Cost Benefit Analysis

A Cost Benefit Analysis tool is developed in close collaboration with logistics operators to ensure all elements being valid for a day-to-day operation are included. The objective is to offer this tool to the market, giving the end users a tool to judge themselves which new vehicle concept and or features are best for their operations.

WP7 Recommendations for implementation of AEROFLEX innovations

The recommendations are split in 2 sections.

1. Requirements and recommendations to policymakers, authorities and industry for the **standardization, legislation and implementation of the vehicle concepts** developed within the project.

Figure 18, Book of Recommendations

The most relevant barriers are the implementation of the aerodynamic devices, the e-dolly, access to infrastructure and integration in multimodality context for the logistics partners daily activities.

2. Recommendation **to create appropriate Access Policies for High-Capacity Freight Transport**, an opportunity to take away the burdens through management of access, the right truck with the right cargo at the right time at the right cost and regaining the control on the logistics and transport operation. The project AEROFLEX sees an urgent need to develop “the Pathway to Intelligent Access Policies through Europe to safeguard freight transport in a healthy, safe and environmentally friendly context”. A specific paper on this topic *“HVTT16: Intelligent Access for a robust and sustainable freight transport system. International research into the potential of intelligent road access policies for a robust and sustainable freight transport system”* gives full insides of the research work done including a vision beyond AEROFLEX

References

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   - 2018b. “Road Transport of Containers, 2009-2015.”
   - 2018c. “Annual Road Freight Transport by Distance Class with Breakdown by Type of Goods.”
   - 2018d. “Annual Road Freight Transport by Maximum Permissible Laden Weight of Vehicle (Mio Tkm, Mio Veh-Km, 1 000 Jrnys) "
   - 2018e. “Evolution of EU-28 Road Transport by Load Capacity.”
3) The cost for transport (2019, including external cost in ct/ton-kilometers) for road is 4.47, 2.03 for rail and 2.00 for inland navigation. INFRAS2019
4) See the website of the European Technology Platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe) http://www.etp-logistics.eu/ for a detail explanation about (roadmaps towards) the Physical Internet.

Figures

Tables

Appendix 1

Overview of AEROFLEX deliverables. See also https://aeroflex-project.eu/downloads-2/

Deliverable number	Deliverable title	WP no.
D1.1	Transport market and its drivers with respect to new vehicle concepts (Task 1.1)	1
D1.2	Decision maker survey on new vehicle concepts (Task 1.2)	1
D2.1	Book of Requirements AEMPT and KPIs	2
D2.2	Architecture and design of the AEMPT, approved by core team	2
D2.3	Validation report AEMPT and ECU with AEMPT for truck, dolly, (semi)trailer	2
D2.4	Architecture and design of the SPD	2
D2.5	Complete vehicle prepared for hand over to WP6	2
D2.6	Result validation and roadmap of AEMPT	2
D3.1	Report on selection of concepts	3
D3.2	CFD simulations (results + methodology).	3
D3.3	Recommendations and guidelines for demonstrator	3
D3.4	Results from wind tunnel test	3
D3.5	Build-up of demonstrator, integration and handover to WP6.	3
D3.6	Project report with conclusions and recommendations based on the CFD simulations and wind tunnel tests.	3
D4.1	Use cases and requirements defined for smart loading units in a multi-modal context and KPIs	4
D4.2	Description of concepts and assessment of potential efficiency improvements.	4
D4.3	Design specifications of smart and flexible loading units for demonstrator specifications	4
D5.1	Safety Issues for Safety System Development	5
D5.2	Background and Test Scenarios with inherent targets	5
D5.3	Virtual demonstrator. A virtual simulation will be done to validate the results of task 5.3, based on the test scenarios and target establishments done in Task 5.2	5
D5.4	Predicted benefits and regulatory recommendations for future safety systems	5
D6.1	Definition of use cases	6
D6.2	Assessment framework	6
D6.3	Test program and protocol	6
D6.4	Reference testing results	6
D6.5	Demonstration testing results	6
D6.6	Final technical assessment results	6
D7.1	Definition of the boundary conditions and current state of EU legislation	7
D7.2	Book or Recommendation. Models validation and future regulatory framework proposals	7
D8.1	Project Website.	8
D8.2	Initial Dissemination Plan.	8
D8.3	Intermediate Dissemination and Exploitation Plan.	8
D8.4	Final Exploitation Plan.	8
D8.5	Newsletter 1/3, 2/3 and 3/3 (M10, M22, M36).	8
D9.1	Project Handbook.	9
D9.2	Initial Risk Management plan.	9
D9.3	Final Risk Management plan.	9

Appendix 2

Prime Candidates coming from the FALCON project (CEDR - Conference of European Directors of Road, 2018)

Prime Candidate	Combination	GCW
1.1	45ft	50.000 t
1.2	7,825m 7,825m	50.000 t
1.3	13.6m Semi	42.000 t
1.4	14.92m Semi	42.000 t
2.1	7,825m 7,825m	46.000 t
2.2	7,825m 7,825m	46.000 t
2.3	20ft 20ft	40.000 t
3.1	45ft 20ft	74.000 t
3.2	7,825m 7,825m 7,825m	70.000 t
3.3	7,825m 7,825m 7,825m	68.000 t
3.4	20ft 45ft	71.500 t
4.1	7,825m 7,825m 7,825m	68.000 t
4.2	7,825m 7,825m 7,825m	68.000 t
4.3	20ft 45ft	68.000 t
4.4	20ft 45ft	68.000 t
4.5	7,825m 7,825m 7,825m	66.000 t
4.6	20ft 20ft 20ft	80.000 t
4.7	20ft 45ft	74.000 t
5.1	7,825m 7,825m 7,825m 7,825m	86.000 t
5.2	20ft 20ft 45ft	86.000 t
5.3	7,825m 7,825m 7,825m 7,825m	86.000 t
5.4	7.825m 7,825m 7,825m 7,825m	92.000 t
5.5	20ft 20ft 45ft	98.000 t
6.1	45ft 45ft	92.000 t
6.2	45ft 45ft	92.000 t
6.3	7,825m 7,825m 7,825m 7,825m	93.000 t
6.4	20ft 20ft 45ft	93.000 t