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Summary

As one of the main objectives of the AEROFLEX project is to develop a road map to realize an efficiency increase in logistics of up to 33%, subtask 1.2 of working package 1 examined whether savings potentials were 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 CO_2 emission savings? Technical basis for this approach were the so called Prime Candidates 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 to 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 analysed with regard to the KPIs €/tkm, €/tour and CO_2e [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.

In order to quantify possible savings for the above mentioned KPIs, use cases were analysed 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 savings resulted 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. As expert interviews are planned to be continued, the scope of examined transports will expand and therefore the additional data are supposed to sharpen the results in respect to what efficiency effects can be expected by the use of EMS vehicles.

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 due to the fact that the three main cost categories of the TCO – fuel consumption, labour cost, invest – would rather benefit from the use of EMS vehicles. Three assumptions form the foundation for this derivation. First, load increase is expected to outgrow fuel consumption increase. Additionally, 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. As a consequence of the fleet reduction less towing vehicles for the same number of loading units would mean a decrease in cost.

Additionally to the quantification of potential savings EMS provide, emphasise 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.

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 manoeuvre and parking areas are mentioned. Intermodality is considered useful for cases that actually serve intermodal transport. But it is not required as general equipment feature. An important finding was that sustainability and CO_2 emission reduction is not yet prioritized comprehensively. This is certainly a task to be tackled by authorities, NGO etc. It was stated by a majority of participants that 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.

Another task that was addressed by the expert interviews was to select those Prime Candidates which provide most potential for future cost and CO_2 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) and route type (FTL main run, FTL pre- and onward carriage, LTL, source consolidation and milk run) combination. 24 of the available 27 Prime Candidate received at least one vote. This reflects the versatility of the transport business and the need for customized application specific vehicle concepts. Though there were six Prime Candidates that received 55% of all votes (plus additional 11% for candidate 1.3 which is actually a standard 5-axle semi-trailer combination), there are still 17 vehicle concepts 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.

Based on the explanations above, the main recommendation from this subtask 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 includes also the regulation to carry at least 25% of the GCW on driven axles (European Union, 1996). Therefore further in-depth analysis on fleet level are 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. These analysis should not only cover the long haul sector as it is stated in the project description of the AEROFLEX project but take into account 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 within the other work packages of the AEROFLEX project that impact transport efficiency (smart loading units, advanced energy management power train, optimized aerodynamics and safety improved front end design) should be taken into account, as they are supposed to provide additional savings potential.

In addition to the above explained objectives and proceedings of subtask 1.2, a further in-depth analysis of newly available data were realized to describe the current logistics market complementing the findings, already reported in deliverable 1.1. Also, first data sources providing future projections of the road freight market have been reviewed and the results are also reported in this document (subtask 1.3). All listed actions were aimed at mapping and quantifying load in road freight transport today and in the future, a first assessment of savings potential, Prime Candidates provide and subsequently at recommendations for the architecture of future towing vehicles. An overview of the structure and how the undertakings have been tackled can be seen in Figure 1-1.

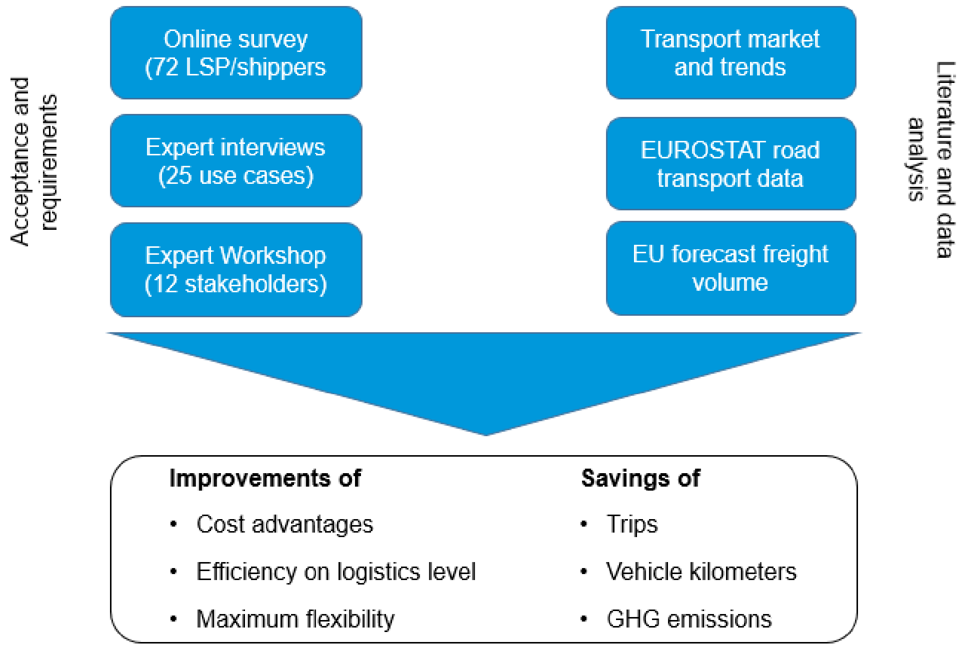

Figure 1-1 Overview and structure of the analysis and proceedings used for this document in work package 1

Amendment to D1.1 - Results from the Eurostat data analysis

The analysis of the Eurostat micro data shows the following results:

- FTL transports are of high importance within the analysed part of the European freight transport.
- The selected commodities groups with high volumes and transport distances above 150 km (see deliverable D1.1) are primarily transported on pallets. Container transports may have a high relevance for intermodal transport chains or hinterland transports.
- The share of fully loaded transports for journeys between 150 and 299 km is about 42 %. The share increases with the transport distances up to 45 %.

The monitoring of European road freight transport micro data of the year 2014 (EUROSTAT, 2011) shows the three categories (i) vehicle-kilometres, (ii) tonnes, and (iii) tonnes-kilometres by a journey based evaluation including all journeys of EU 29 road freight transport. The journey based evaluation was chosen related to the existing data base because a vehicle based evaluation was not available to describe the European long haul road freight transport. It is shown that on one side more than 75% of tonne kilometres are in the group above 150 km transport distances and on the other side 80% of the transport volume is in the transport distance class below 150 km (Figure 1-2 and Figure 1-3). The amount of vehicle kilometres (about 73%) explains the relation between these figures in the distance classes. It can be considered that high capacity vehicles should address not only higher road transport distances but also the high transport volume in shorter distances.

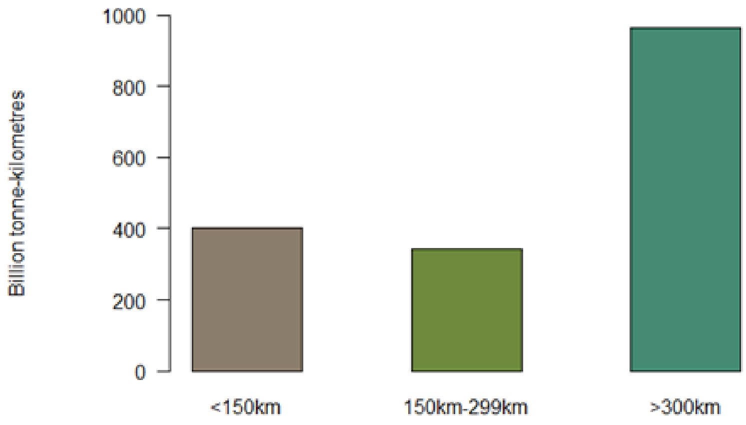

Figure 1-2 Tonne-kilometres of European road freight transport related to distance classes (EUROSTAT micro data)

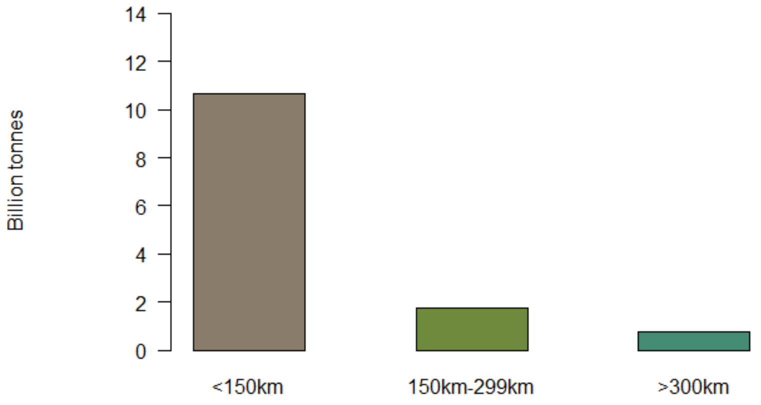

Figure 1-3 Transport volume of European road freight transport related to distance classes (EUROSTAT micro data)

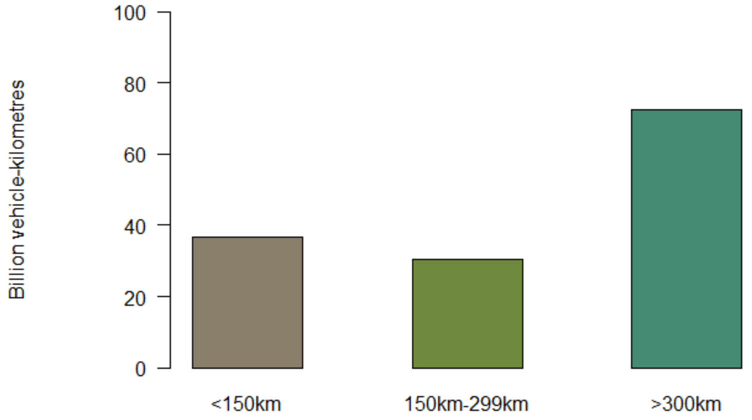

Figure 1-4 Annual Mileage (vehicle-kilometres) of European road freight transport related to distance classes (EUROSTAT micro data)

Preview of deliverable 1.3 - Results from the projections

Projections with regard to average trip distance from four Western European countries indicate that this parameter will increase slightly, with tonne kilometres growth outpacing tonnage growth.

Commodities with the strongest expected growth are grouped and miscellaneous goods, representing e.g. containers and groupage activities, which fits well within the projections of e.g. the ALICE project (more consolidation and horizontal collaboration). Metals and metal products are also projected to see increased transport volumes. Lower or negative growth is to be expected from commodity groups' coal and lignite, and petroleum products.

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Abbreviations

ACEA	European Automobile Manufacturers' Association
BTO	Basic transport operation
CEP	Courier, Express, Parcel
DC	Distribution centre
FTL	Full truck load
GA	General Assembly
GPS	Global positioning system
KPI	Key performance indicator
LHCV	Longer heaver vehicles
LSP	Logistics Service Provider
LTL	Less than truck load
NGO	Non-government organisation
NST / NSTR	Standard goods classification for transport statistics
PBS	Performance Based Standards
PI	Physical internet
ROI	Return on invest
SB	Sounding Board
SME	Small medium enterprises
TCO	Total cost of ownership
tkm	tonne kilometre
TM	Transport management
TTW	Tank-to-Wheel
vkm	Vehicle kilometre
WTW	Well-to Wheel

1 Purpose of the document

This document is the AEROFLEX D1.2 containing results of work package 1 subtasks 1.1, 1.2 and already some first information from subtask 1.3.

Task 1.2 covers the question of requirements and needs, logistics service provider (LSP) have in order to be able to use longer heavier vehicles (LHCV) as specified in the European Modular System (EMS) concept in the future, as well as barriers for the introduction of those vehicles. EMS is based on article 4 of directive EC 96/53 (European Union, 1996) and allows the combination of standard towing vehicles and loading units into vehicles that exceed the limits in weight and measurements for international transports as defined in the directive. It also identifies most promising vehicle concepts for efficiency improved transport, based on the Prime Candidates delivered by the FALCON project. These analyses are based on primary data collected during an online survey among stakeholders (shippers and LSP) that was conducted right before the start of the AEROFLEX project and a series of expert interviews that delivered use cases and deep insight in opinions and estimations of logistics market participants.

Furthermore this document contains quantitative information about the transport market in Europe on trip level (additional output of task 1.1). It also lists possible data sources concerning vehicle fleets, relevant cost components and driving times that could provide suitable information for task 1.3. Additionally it provides projections for growth rates of different market segments.

2 Introduction

One of the main AEROFLEX project's objective is to set up a roadmap to realize an efficiency increase in logistics of 18 - 33% with a focus on long haul transports. Additional to the work packages that tackle this challenge by technical innovations like an Advanced Energy Management Power Train (AEMPT), aerodynamic improvements and smart loading units, the efficiency effects of the utilization of EMS combinations is examined in work package one. This deliverable reports the results and findings of research that has been done on this specific subject in the field of logistics operations by conducting a stakeholder survey and expert interviews. The study was meant to serve as an exploratory examination to answer the essential question task 1.2 is focussed on: Can the use of EMS (in this paper referred to as Prime Candidates) generally contribute to an increase in transport efficiency in terms of transport cost and CO_2 emissions (results see chapter 4.2.2.5). Also, a first estimation of savings potentials on a best case level using a number of assumptions was achieved. The possible use of EMS presumably would be accompanied by several requirements, constraints and preconditions for infrastructure, logistics operations, legislation etc. This paper also reports first findings on these subjects (chapter 4.2.2.6) and delivers recommendations about what measures could be taken to facilitate the use of EMS in Europe (chapter 5.2).

Furthermore, this report covers the task to link the findings about the European freight transport market, that were analysed in deliverable 1.1 to the actual use of vehicles on trip level (chapter 4.1.1). The EUROSTAT micro data set (EUROSTAT, 2011) was used for this approach. For analysis and modelling tasks on later stages of the project, a broad information basis is needed that covers, among others, fleet compositions, costs and it's drivers and data about logistics operations. This paper lists and explains possible sources for these kind of information that can be used in the mentioned tasks (chapter 4.1.2).

It is important to notice that the results reported in this paper lead to the assumption that there is potential for efficiency increase by the use of EMS not only for long haul transport but for all logistics segments. Therefore, the results and recommendations chapter will report accordingly.

2.1 Transport market

The European transport and logistics market was analysed in D1.1. This section summarises some of the main findings.

2.1.1 Analysis of the current situation

The transport of goods can be performed by road, rail, water (sea and inland waterways), air or pipeline. In total about 3,516.5 billion (bn) tonne-kilometres (tkm) were performed on the territory EU28 in 2015. Annual growth rates are between 0.5 and 1.2% (European Union 2017). It is expected that commercial transport will grow further. The most important driver of this growth is the dynamics in international trade. The International Transport Forum (ITF) expects a doubling in European freight volumes by 2050. Global transport demand is even expected to triple by 2050 (International Transport Forum 2015). Improvement in all modes, including road, will be needed to cope with the rising demand for transport.

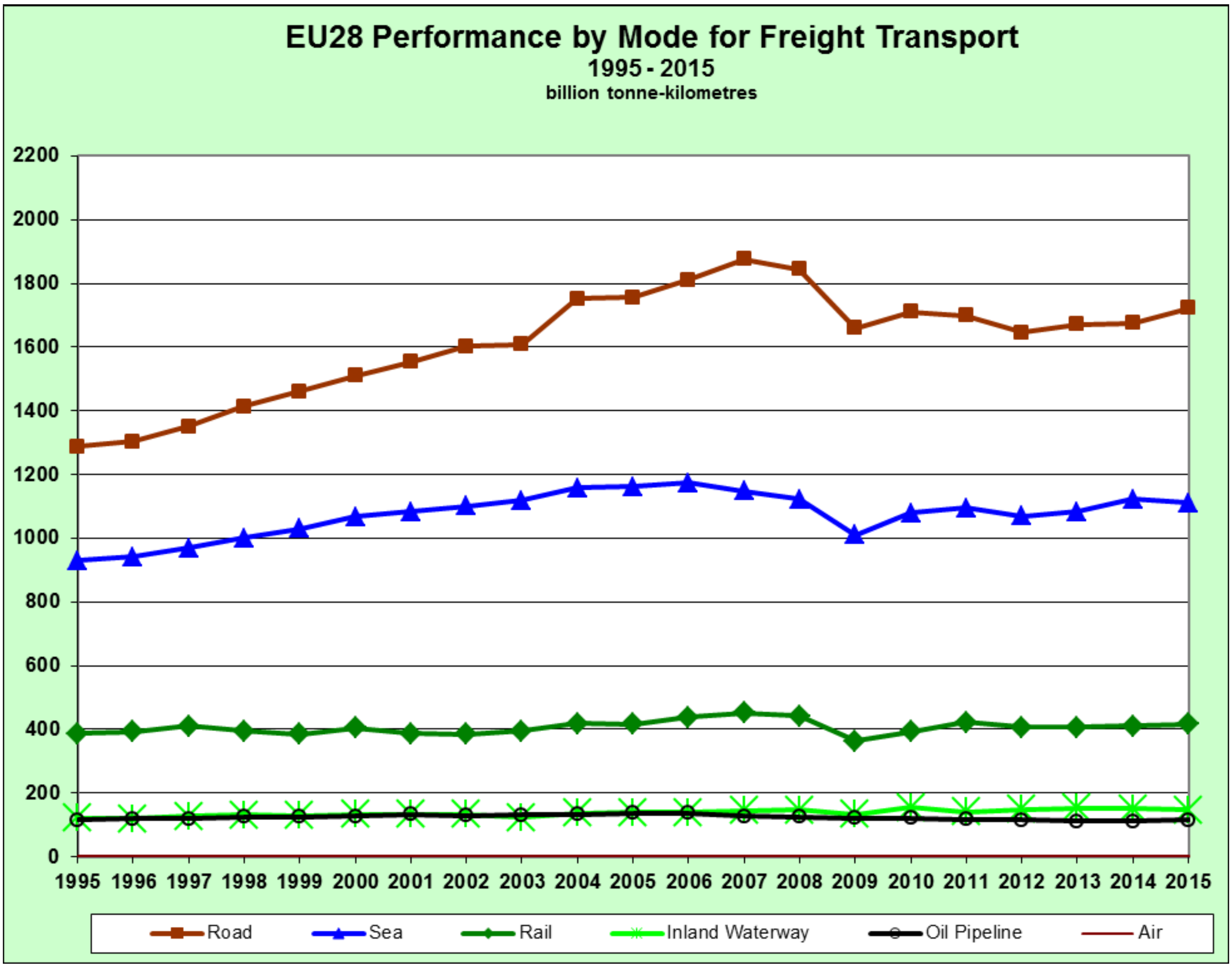


Figure 2-1 EU28 Performance by mode for freight transport (European Union 2017)

European data shows that in terms of tonne-kilometres, about 80 % of all freight transport is realised on the long haul (150 km or more). This also holds for road transport, as demonstrated by EUROSTAT table *road_go_ta_dctg*. This table identifies the different market segments which are categorized by type of goods and transport distance class (see Table 2-1 to Table 2-4). The market segments will be used as a guideline throughout this deliverable.

Table 2-1 Road transport by type of goods (NST2007) and distance class (million tkm, 2017) (source: EUROSTAT)

Million TKM	<50km	50-149km	150-299km	300-499km	500-999km	1000-1999km	2000-5999km	>6000km	**Sum**
Products of agriculture, hunting, and forestry; fish and other fis	9 798	37 249	44 461	33 008	38 730	26 254	17 766	59	207 325
Coal and lignite; crude petroleum and natural gas	939	2 324	3 980	2 630	1 640	215	73		11 801
Metal ores and other mining and quarrying products; peat; uran	45 559	45 838	26 523	14 264	9 317	3 125	1 054		145 680
Food products, beverages and tobacco	10 548	46 763	75 811	67 898	75 509	39 051	13 666		329 246
Textiles and textile products; leather and leather products	406	1 418	2 980	2 752	4 960	4 365	1 696		18 577
Wood and products of wood and cork (except furniture); article	3 731	14 842	22 687	22 698	32 057	19 021	4 399		119 435
Coke and refined petroleum products	3 553	15 934	15 559	8 704	5 888	2 051	566		52 255
Chemicals, chemical products, and man-made fibers; rubber a	3 740	12 762	23 191	25 289	33 921	26 832	6 944		132 679
Other non metallic mineral products	18 839	31 591	34 792	24 813	22 225	12 060	2 564		146 884
Basic metals; fabricated metal products, except machinery an	3 414	12 761	21 868	23 933	36 544	26 901	4 515		129 936
Machinery and equipment n.e.c.; office machinery and comput	2 164	5 443	7 747	8 003	12 938	12 426	3 971	3	52 695
Transport equipment	2 112	4 796	10 045	12 722	21 306	22 034	6 053		79 068
Furniture; other manufactured goods n.e.c.	596	2 417	4 905	6 409	10 565	10 475	2 390	32	37 789
Secondary raw materials; municipal wastes and other wastes	10 323	20 702	19 546	10 889	9 658	2 413	188		73 719
Mail, parcels	840	5 270	11 006	12 684	12 775	4 250	523		47 348
Equipment and material utilized in the transport of goods	2 777	7 774	9 631	7 942	9 067	5 636	1 338		44 165
Goods moved in the course of household and office removals; I	1 670	3 714	3 801	2 521	1 928	732	202		14 568
Grouped goods: a mixture of types of goods which are transpo	3 508	17 209	38 489	41 628	51 886	32 702	11 425		196 847
Unidentifiable goods: goods which for any reason cannot be ide	1 113	3 746	5 726	4 652	5 158	2 890	850		24 135
Other goods n.e.c.	1 419	4 706	7 629	7 392	15 614	10 692	1 931		49 383
Sum	127 049	297 259	390 377	340 831	411 686	264 125	82 114	94	**1 913 535**

Table 2-2 Road transport by type of goods (NST2007) and distance class (million vkm, 2017) (source: EUROSTAT)

Million VKM	<50km	50-149km	150-299km	300-499km	500-999km	1000-1999k	2000-5999k	>6000km	**Sum**
Products of agriculture, hunting, and forestry; fish and other fis	731	2 502	3 125	2 354	2 712	1 693	1 119	2	14 238
Coal and lignite; crude petroleum and natural gas	62	130	226	139	104	13	4		678
Metal ores and other mining and quarrying products; peat; urar	2 344	1 955	1 090	586	399	146	54		6 574
Food products, beverages and tobacco	1 084	4 862	6 748	4 960	4 868	2 332	758		25 612
Textiles and textile products; leather and leather products	81	311	506	392	526	398	130		2 344
Wood and products of wood and cork (except furniture); article	411	1 348	1 816	1 585	1 990	1 093	248		8 491
Coke and refined petroleum products	280	1 079	1 021	490	310	106	28		3 314
Chemicals, chemical products, and man-made fibers; rubber a	339	1 149	1 923	1 791	2 268	1 732	436		9 638
Other non metallic mineral products	1 432	2 029	2 123	1 465	1 356	727	150		9 282
Basic metals; fabricated metal products, except machinery an	404	1 278	1 804	1 668	2 359	1 638	249		9 400
Machinery and equipment n.e.c.; office machinery and comput	292	735	951	849	1 260	1 084	325	1	5 497
Transport equipment	253	618	1 130	1 275	2 168	1 942	472		7 858
Furniture; other manufactured goods n.e.c.	130	472	774	876	1 350	1 167	233	2	5 004
Secondary raw materials; municipal wastes and other wastes	1 289	2 039	1 543	695	493	122	9		6 190
Mail, parcels	155	818	1 304	1 178	1 177	359	42		5 033
Equipment and material utilized in the transport of goods	993	2 019	1 899	1 261	1 194	603	131		8 100
Goods moved in the course of household and office removals; I	309	606	524	287	258	106	37		2 127
Grouped goods: a mixture of types of goods which are transpo	474	2 180	3 849	3 447	4 064	2 423	713		17 150
Unidentifiable goods: goods which for any reason cannot be ide	129	343	497	392	397	210	62		2 030
Other goods n.e.c.	132	398	605	548	1 070	726	119		3 598
Sum	11 324	26 871	33 458	26 238	30 323	18 620	5 319	5	**152 158**

Table 2-3 Road transport by type of goods (NST2007) and distance class (thousand tons, 2017) (source: EUROSTAT)

Thousand Tonnes	<50km	50-149km	150-299km	300-499km	500-999km	1000-1999km	2000-5999km	>6000km	Sum
Products of agriculture, hunting, and forestry; fish and other fis	431 799	450 606	241 197	100 374	63 651	19 026	7 305	9	1 313 967
Coal and lignite; crude petroleum and natural gas	63 289	26 407	20 409	7 635	2 730	185	34		120 689
Metal ores and other mining and quarrying products; peat; urar	2 809 199	609 256	155 420	43 061	14 945	2 327	434		3 634 642
Food products, beverages and tobacco	481 462	559 625	407 540	204 809	127 814	28 955	5 660		1 815 865
Textiles and textile products; leather and leather products	24 853	16 603	15 219	8 301	7 472	3 216	704		76 368
Wood and products of wood and cork (except furniture); article	189 115	167 642	111 965	61 468	48 510	14 497	1 878		595 075
Coke and refined petroleum products	157 214	195 458	90 819	30 911	9 918	1 601	247		486 168
Chemicals, chemical products, and man-made fibers; rubber a	206 990	142 013	112 264	68 735	51 352	20 399	2 880		604 633
Other non metallic mineral products	1 055 595	379 786	177 086	69 899	34 830	9 152	1 079		1 727 427
Basic metals; fabricated metal products, except machinery an	180 761	144 110	107 991	65 207	54 765	20 950	1 938		575 722
Machinery and equipment n.e.c.; office machinery and comput	110 994	65 310	39 468	22 482	19 669	9 133	1 581	0	268 637
Transport equipment	129 025	54 974	49 545	35 532	32 200	16 109	2 583		319 968
Furniture; other manufactured goods n.e.c.	31 075	27 090	24 264	17 742	15 707	7 758	1 027	5	124 668
Secondary raw materials; municipal wastes and other wastes	602 320	286 572	112 421	31 660	15 366	1 946	82		1 050 367
Mail, parcels	34 726	62 671	58 675	37 631	21 677	3 320	217		218 917
Equipment and material utilized in the transport of goods	139 639	89 930	48 171	22 116	14 100	4 205	575		318 736
Goods moved in the course of household and office removals; I	83 480	46 549	21 057	7 431	3 164	549	86		162 316
Grouped goods: a mixture of types of goods which are transpo	179 160	209 381	207 104	128 744	89 698	24 415	4 736		843 238
Unidentifiable goods: goods which for any reason cannot be ide	65 422	42 536	28 735	13 532	8 123	2 165	360		160 873
Other goods n.e.c.	77 682	53 995	36 170	19 676	22 312	8 094	768		218 697
Sum	7 053 800	3 630 514	2 065 520	996 946	658 003	198 002	34 174	14	**14 636 973**

Table 2-4 Road transport by type of goods (NST2007) and distance class (thousand transport operations, 2017) (source: EUROSTAT)

Thousand transport operations	<50km	50-149km	150-299km	300-499km	500-999km	1000-1999k	2000-5999k	>6000km	Sum
Products of agriculture, hunting, and forestry; fish and other fis	31 188	25 412	13 645	5 590	3 514	1 017	375	0	80 741
Coal and lignite; crude petroleum and natural gas	4 353	1 269	914	340	118	8	2	:	7 004
Metal ores and other mining and quarrying products; peat; urar	157 538	24 226	5 265	1 538	595	106	22	:	189 290
Food products, beverages and tobacco	41 147	45 916	28 612	11 819	6 586	1 550	295	:	135 925
Textiles and textile products; leather and leather products	4 015	2 839	2 082	952	651	259	51	:	10 849
Wood and products of wood and cork (except furniture); article	18 044	12 654	7 510	3 678	2 654	749	101	:	45 390
Coke and refined petroleum products	10 399	10 128	4 302	1 125	412	70	11	:	26 447
Chemicals, chemical products, and man-made fibers; rubber a	16 847	10 535	7 772	4 188	2 987	1 179	171	:	43 679
Other non metallic mineral products	81 383	21 660	9 338	3 587	1 892	499	58	:	118 417
Basic metals; fabricated metal products, except machinery an	19 810	12 515	7 518	3 893	3 039	1 132	99	:	48 006
Machinery and equipment n.e.c.; office machinery and comput	14 622	7 394	4 002	2 044	1 635	724	122	0	30 543
Transport equipment	14 383	6 165	4 758	3 031	2 732	1 270	173	:	32 512
Furniture; other manufactured goods n.e.c.	5 701	3 930	2 907	1 898	1 406	643	85	0	16 570
Secondary raw materials; municipal wastes and other wastes	67 502	21 811	6 874	1 685	719	96	4	:	98 691
Mail, parcels	5 797	8 416	5 922	2 975	1 666	220	15	:	25 011
Equipment and material utilized in the transport of goods	51 902	21 313	8 264	3 059	1 637	408	52	:	86 635
Goods moved in the course of household and office removals; I	14 629	6 266	2 119	641	301	60	12	:	24 028
Grouped goods: a mixture of types of goods which are transpo	18 411	19 298	15 811	8 295	5 495	1 515	260	:	69 085
Unidentifiable goods: goods which for any reason cannot be ide	5 072	2 972	1 907	882	484	134	22	:	11 473
Other goods n.e.c.	6 961	3 968	2 442	1 226	1 372	525	47	:	16 541
Sum	589 704	268 687	141 964	62 446	39 895	12 164	1 977	0	**1 116 837**

Agricultural and food products are transported the most in Europe, along with ‘grouped goods’, mostly along distances between 150 and 1000 km. Over short distances, raw material and heavy products such as metal ores and minerals are mostly transported via roads– in many cases as the first or last leg of a multimodal chain, or between the production site and the processing facility.

2.1.2 Future projection

Several important trends will impact the demand for freight transport in the future.

First of all, the improvement of efficiency is one important measure for the European freight transport market. Co-modality and synchromodality are key concepts to improve the efficiency. The idea of these concepts is that freight transport should be organized by the consideration of the strengths and weaknesses of the transport modes that are relevant to fulfil the requirements of the shippers.

These requirements are defined by lead and transport time, weight and volume of the order/the shipment and further specific costumer and good related characteristics. Unimodal transport (by only one transport mode) could be the most efficient way provided that this transport 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 specialised equipment, sum of working time. Furthermore, it is necessary to fulfil the customer related expectations regarding transport costs.

Due to the rising amount of courier/parcel/express cargo and general cargo, hub and spoke concepts are increasingly used to consolidate the shipments and thus, to enhance transport efficiency. Therefore, a promising and growing market segment 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 manoeuvred and placed at the gateways in cross-docking stations or in warehouses, even if there are limitations concerning infrastructure. Further, the organisation of a fast transhipment of loading units between different vehicles or between transport modes is important.

The digitalization of logistics processes supporting the drivers, 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 (in particular platooning and automated driving) reduce the stress for the drivers and may contribute to a reduction of transport costs. However, they require sensors, communication technology and energy supply within the vehicle.

Further trends that will influence the transport sector and the vehicle technologies are:

- Dematerialisation, i.e. the amount of materials used in products might be reduced.
- 3D-printing technology will be developed, i.e. personalised, 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.

Among the further objectives of this WP is the task to translate these general trends in quantitative projections of the different market segments.

2.2 Logistics operations

To achieve the AEROFLEX project's goal to increase transport efficiency up to 33%, a number of current developments have to be taken into account that have major influence on transportation business and operations. In the following paragraphs the idea is laid out how EMS can contribute to this goal and what data is needed to assess the according potential.

2.2.1 Capacity, driver scarcity and efficiency

Several main topics dominate current discussions and concerns the road transportation business has to deal with. As transport volume is expected to increase over the next decades, as was reported with deliverable D1.1 of the AEROFLEX project and also in the following chapters of this report, one of the most relevant issues to solve for LSP is growing scarcity of professional truck drivers. This does not only result in higher transport costs due to higher wages, but also in a lack of transport capacity.

Also, low loading factors reduce transport efficiency and result in higher transport costs and lower margins for LSP. Even though in some logistics segment, e.g. long haulage, utilization is generally on a somewhat higher level (see chapter 3.1), there are efficiency potentials to be harvested to reduce cost pressure for LSP, e.g. in 2014 33.867 Million vehicle kilometres were empty runs in Europe (EUROSTAT, 2017b). In general the logistics and transportation business is facing a growing cost pressure which is expected to intensify.

Based on these findings working package 1 of the AEROFELX projects examines whether the use of EMS vehicles can contribute to significant efficiency improvements, both in terms of transport cost and in terms of CO_2 emissions. Additionally the question is addressed, if EMS could result in a reduced number of vehicles in use, i.e. the driver current driver scarcity could possibly be eased by the introduction of longer heavier vehicles.

2.2.2 Future vehicle concepts – Prime Candidates

One of the outcomes of the Project FALCON (Freight and Logistics in a Multimodal Context) funded by the Conference of European Directors of Road (CEDR) was a list of vehicle concepts complying with the EMS approach that were supposed to be useable in road transportation (CEDR - Conference of European Directors of Road, 2018). These vehicle concepts were named Prime Candidates as they provide highest potential for efficient road haulage according to the results of the project. These vehicle concepts form the technical basis form the analysis of working package 1 of the AEROFLEX project and thus for this report. The research focussed on the examination of possible potential for efficiency improvements as explained in the introduction. Furthermore, it is explored if and what specific Prime Candidates provide biggest potential. A graphical overview of the vehicle's layout and composition can be seen Appendix D

2.2.3 Required data for assessment of Prime Candidates

In order to answer the above mentioned research questions, dedicated information is necessary. Public statistics and previous research yield a lot of information, e.g. the EUROSTAT data that is also used for this report. However, none of the available statistics provide information on the needed level of granularity.

Therefore, the project partners decided to do own field research to gather exactly the kind and level of information that is needed. To gather these kind of information a stakeholder survey and a series of expert interviews were conducted. The analysis is focussed on transport cost in €/tkm, €/km and €/tour to assess economic efficiency and kgCO_2e/tour to assess emission efficiency. Please see chapter 3.2 for explanation of the collected and analysed data.

3 Methods

3.1 Transport market

3.1.1 Analysis on journey level

The objective of WP1 is to characterize the European freight transport market. Previous work in WP1 was based on publicly available data and therefore mainly focused on the transport sector as a whole. Commodity group-specific analyses concerning transport volume, distances or specific revenues of logistic segments were conducted (see Deliverable D1.1). A more detailed analysis of the vehicle use on a journey level including distances, load factors and commodities was not possible, as the previous data base didn't provide such detailed information. For the development of new vehicle concepts within the AEROFLEX project, the analysis of the current vehicle usage in Europe is necessary. Therefore, the DLR used the European Road Freight Transport Survey (EUROSTAT micro data) from EUROSTAT, to close the gap between typical trips and the transport segment.

EUROSTAT aggregates country-specific data on vehicles, journeys and transported goods in the freight transport on a quarterly basis and compiles an anonymized micro data set for scientific purposes. The analyzed data set contains microdata collected from the 28 EU countries (except Malta) and EFTA countries (except Iceland). Each country uses an individual sample strategy for sampling in space, over time and over domains. The usual period for data acquisition is one week. The data is from the reference period 2014. Further information on the survey methodology can be found in the methodological manuals published by EUROSTAT(2011, 2014, 2016).

The EUROSTAT micro data consists of three linked data sets A1, A2 and A3. The data set A1 contains vehicle-specific variables, while data set A2 includes journey-specific variables and data set A3 contains goods-specific variables (see Table 3-1). The data set includes identifiers. They enable to link every journey within data set A2 with transported goods in A3 or the vehicle in A1. Several goods may be transported within the same journey and different trips may be conducted by only one vehicle. Conversely, each transported good belongs to only one trip and each trip to only one vehicle. The following table provides an overview of the variables included in the three data sets:

Table 3-1 Variables in the European Road Freight Transport Survey (EUROSTAT micro data)

A1 Vehicle-specific variables	A2 Journey-specific variables	A3 Goods-specific variables
• Year of data set • Quarter of data set • Questionnaire identifier	• Year of data set • Quarter of data set • Questionnaire identifier • Journey identifier	• Year of dataset • Quarter of the dataset • Questionnaire identifier • Journey identifier

• Age of the road motor vehicle (lorry or road tractor). Years from first registration • Total vehicle-kilometres during the survey period – loaded • Total vehicle-kilometres during the survey period – empty • Vehicle weighting. Grossing-up factor. • Number of linked A2 records.	• Type of journey • Maximum permissible laden weight (per 100kg) • Load capacity (per 100kg) • Type of transport. May change for each journey • Weight of goods; gross weight per 100kg • Place of loading (NUTS 2). • Place of unloading (NUTS 2). • Distance travelled (km). • Tkm during journey • Countries crossed in transit. Suppressed for very small countries. • Degree of loading of vehicle – in terms of max. volume of space used during journey (Unladen, Less than 90%, More than 90%) • Number of linked A3 records	• Goods operation identifier • Type of goods • Weight of goods (per 100kg) • Classification of dangerous goods • Type of cargo • Place of loading (NUTS 2). • Place of unloading (NUTS 2). • Distance travelled (km). Excluding the distance covered with the goods road motor vehicle while being transported by another means of transport

The following variables are in general vehicle-specific variables:

- Maximum permissible laden weight (100kg)
- Load capacity (100kg)
- Type of transport

They are included by EUROSTAT in the journey-specific data set, as they actually change for specific trips (e.g. by using a trailer).

The EUROSTAT micro data set contains data of approx. 419,000 vehicles (A1), approx. 4,908,000 journeys (A2) with approx. 3,488,000 transported goods (A3). At a first step, the three data sets were merged. The merged data set consists of transported goods which are connected to journeys and vehicles. As the data were collected within the countries on the basis of different sampling strategies (stratification), EUROSTAT provides a vehicle weighting factor which has to be taken into account to avoid bias. The weighting factor weights various vehicles and their journeys and transported goods differently. The second step defines the amounts of cases to be considered in the analysis.

3.1.2 Other quantitative information

The purpose of the next tasks of this work package is to develop a model that will allow to assess the impact of EMS vehicles on fuel consumptions and emissions in Europe. The data requirements of such a model are significant. Apart from transport demand and emission factors, information is required on the vehicle fleet composition (trucks, tractors and trailers) and the practical market conditions (like costs, its components and drivers, transport times). This section discusses the data sources to be used for the collection of this information.

3.1.2.1 Vehicle fleet

The heavy duty vehicle fleet is reported by a number of sources.

- ACEA, the organisation representing European Automobile Manufacturers, publishes an annual report about the vehicles in use (ACEA, 2017), which includes the category « medium and heavy commercial vehicles ». It also publishes monthly data on the amount of new vehicles registered.
- The European project TRACCS (Emisia, 2013) collected data on fleet composition for the years 2005-2010, for all EU28 countries. For heavy commercial vehicles, following categories are distinguished:
    - Rigid <=7.5 t
    - Rigid 7.5 - 12 t
    - Rigid 12 - 14 t
    - Rigid 14 - 20 t
    - Rigid 20 - 26 t
    - Rigid 26 - 28 t
    - Rigid 28 - 32 t
    - Rigid >32 t
    - Articulated 14 - 20 t
    - Articulated 20 - 28 t
    - Articulated 28 - 34 t
    - Articulated 34 - 40 t
    - Articulated 40 - 50 t
    - Articulated 50 - 60 t
- EUROSTAT has the following relevant categories:
    - Lorries and road tractors, by age (road_eqs_lorroa)
    - Lorries (excluding light goods road vehicles), by permissible maximum gross weight (road_eqs_lornum)
    - Lorries, by type of motor energy (road_eqs_lormot)
    - Road tractors by type of motor energy (road_eqs_roaene)
    - Semi-trailers, by permissible maximum gross weight (road_eqs_semit)
    - Trailers, by permissible maximum gross weight (road_eqs_trail)
- For some countries, national statistics are more detailed, e.g. additional weight categories or also including the type of trailer. However, the above EU level statistics are likely sufficient for the analysis required.

3.1.2.2 Costs: components and drivers

Transport cost indicators are generally not a part of regular government initiated data collection, but are mostly gathered for specific case studies or by private institutions, and in those cases only available for purchase. We will rely on the following sources from research:

- « Kostenbarometer » (« cost barometer », Panteia, 2016): a regular publication by the Dutch research institution containing cost components for all transport modes. For road specifically, the following distinctions are made:
  - Markets : small (1.5t van, out of scope), medium (12t rigid truck), large (27t tractor-semitrailer combination) vehicles - piece goods, containers, tankers
  - Components:
    - Fixed costs (depreciation & amortisation, fixed taxes, insurance)
    - Variable costs (repair & maintenance, tyres, fuel)
    - Wages
    - Specific costs (licences, inspection,…)
    - Other costs (overhead & support)
- The DG MOVE sponsored study "Case study analysis of the burden of taxation and charges on transport" (Schroten et al., 2017) used the same numbers but recalculated them to represent EU average figures.

3.1.2.3 Driving times

Driving times and distances play an important role in the attribution of costs to certain routes. The ETISplus database (Panteia et al., 2012) contains a table with transport « impedances », i.e. transport distances and times between any two NUTS3 regions in Europe, also allowing for the calculation of an average travel speed.

3.1.3 Market projections

The purpose of the market projections is to estimate growth factors for the different market segments. For the purpose of this study, we considered existing projections only; creating a dedicated projection for the AEROFLEX project would be beyond the scope of this work. The main potential sources for projections of this nature are transport models, logistics and freight projects, the TEN-T corridor studies and planning agencies (usually at the national level).

However, transport models at the European level were unable to provide recent projections with a sufficient amount of detail. The reason is mainly that the models focus on transport directly, and while some reveal all calculations, the data level that is relevant for AEROFLEX is not necessarily available in the outputs of the model. The TEN-T corridor studies did not deliver any directly useful information either, as projections were rarely made at the level of detail required for AEROFLEX.

Following potential sources of model data were checked:

- OECD/ITF: Transport Outlook Project (OECD/ITF, 2017)
- EC Transport Reference scenario 2016 (European Commission, 2016)
- TransTools v3 (DTU et al., 2018)
- CLUSTERS 2.0 (PTV et al., 2018)
- HIGH-TOOL (KIT et al., 2016)

Furthermore, national projections were found for these countries:

- Belgium (Federaal Planbureau, 2015)
- The Netherlands (Romijn, Verstraten, Hilbers, & Brouwers, 2016)
- France (Pochez, Wagner, & Cabanne, 2016)
- Germany (BVU, Intraplan, IVV, & Planco, 2014)

Other countries that were checked but for which no suitable projections were found:

- Sweden
- Denmark
- Finland
- United Kingdom
- Hungary

3.2 Logistics operations

This section describes the methods used to assess the nominal potential of Prime Candidates in every day transportation operations as substitute for current vehicles according to directive EC96/53 (European Union, 1996) and the amendment EC2015/719 (European Union, 2015). Two different approaches were used to evaluate a) the technical applicability of prime candidates in common logistics applications, i.e. the question if those vehicle concepts fulfil features needed and comply with existing prerequisites and constraints, and b) possible benefits of the use of prime candidates in terms of transport costs, fuel consumption and CO_2 emissions in comparison to current vehicle concepts.

3.2.1 Stakeholder Survey

In WP1, an online survey was conducted to gain information about the demands of stakeholders (logistics service providers, fleet managers and shippers) concerning the market potential for new vehicle concepts in road freight transport. The survey was divided into the following sections.

- Details of company/branch: to provide some basic details about the companies
- Freight and cargo: to provide details about the goods and cargo which are carried within the context of selected logistics segments (Full truck load shipping, Consolidated cargo / Less-

than-truck-load, Bulk goods / Silo, Special haulage[1], Heavy haulage[2], Courier / Express / Parcel and type of transport routes (Full-truck-load ‘main run’, Full-truck-load ‘pre-carriage or onward-carriage’, Less-than-truck-load, Source consolidation, Milk run).

- Times: to get details about the trips in the context of selected logistics segments and types of transport route.
- Trip data: to get details about the trips for selected logistics segments and type of transport route.
- Future prospects: to ask questions concerning future prospects for new vehicle concepts (>18.75 m / >44 tonnes) to rate their importance. For the purpose of answering these questions, no legal restrictions apply to the use of new vehicle concepts.

The online survey was published via the platform of LimeSurvey (2012). A mix of different types of questions has been used including multiple choice questions, questions to rank the stakeholder’s interests and open-ended questions where stakeholders are encouraged to give a full, meaningful answer (see appendix B).

The collections of responses was realised in two steps. First, the online survey was prepared and tested and has gone online for a limited stakeholder group in 2017. Second, the online survey was rolled out as part of the AEROFLEX project between February and June 2018. It addressed European stakeholders (LSP, fleet managers and shippers) with the help of the members of the sounding board and the AEROFLEX project partners. An invitation letter was prepared that has been published on the AEROFLEX website. The stakeholders were also contacted by direct e-mailing. The aim was to get a sample including data of stakeholders in all EU countries and in Turkey.
A communication possibility was arranged for the case that the participants have additional requests concerning the questionnaire or practical issues. AEROFLEX project partner DLR as a neutral research institute has responded to all requests by special support and to increase the number of participants.

3.2.2 Expert Interviews

Though the stakeholder survey delivered valuable information about logistics operations and freight flows in Europe, the data gathered were not sufficient to provide a solid base for future tasks in the project due to the low number of respondents. Therefore the project partners decided to collect and analyse use cases to account for these needs. A constitutive workshop was held in Dortmund on March 7th 2018 at the premises of Fraunhofer IML to present and evaluate a concept for the

[1] Special Haulage: All types of shipping that cannot be handled with a standard vehicle or with a standard body, e.g. shipping of refrigerated and frozen goods, livestock transport, textile transport, tipper trucks, cement mixers.

[2] Heavy haulage: All types of shipping involving non-standard dimensions and weights.

application of use cases. Members of the project consortium, of the Sounding Board and LSPs took part in this event. During the workshop the approach of conducting expert interviews to gather use cases was approved as valid to deliver the needed input for all involved WPs. The concept for the data collection was also tweaked to optimize the output. Additionally the first exemplary use cases were set up as a reference.

In a second step the improved study concept was presented and discussed during the General Assembly (GA) of the AEROFLEX project in Berlin end of May 2018. The GA also approved the approach, so that WP1 was able to kick-off the fieldwork phase.

As a next step, the expert interviews were conducted by project consortium partners in the period between June and September 2018. The general objective of this undertaking was to gain insight into the daily operations of LSPs as well as shippers. A general understanding of the logistics processes and needs were supposed to be generated. Therefore the use cases were planned to cover a representative share of the total European transport volume. This was achieved by the following two-step approach.

First, relevant market sectors based on the EUROSTAT data table [road_go_ta_dctg] (2017a) in terms of transport volume (tkm, vehicle km, ton and BTO), journey distance and goods type according to NST2007 (European Union, 2007), were identified (see Table 2-1 to Table 2-4). Aim for this approach was to cover market sectors with at least one use case that represent a share of ca. 50% of the overall transport volume. This was done by selecting the sectors with biggest shares each KPI (vkm, ton and tkm). There was no specific threshold for sector share size set, instead a compromise was aimed for between overall covered market share (ca. 50%) for all chosen sectors and the number of chosen sectors. This was necessary, as the number of chosen sectors directly influence the number of needed use cases and thus resources. The market sectors as illustrated in table 3-2 were selected and use cases aimed to target these market sectors. WP1 aimed for collecting use cases across Europe in order to be able to derive conclusions that differentiate between specific national and / or regional market situations.

Table 3-2 Selected market segments to target the use cases on

No.	NST Category	Distance [km]	VKM [%]	Ton [%]	TKM [%]	BTO [%]
1	Products of agriculture, hunting, and forestry; fish and other fishing products	< 50	0.47	2.89	0.50	2.77
		50 - 149	1.69	3.08	1.99	2.32
		150 - 299	2.00	1.61	2.30	1.18
		500 - 999	1.78	0.42	1.98	0.31
3	Metal ores and other mining and quarrying products; peat; uranium and thorium	< 50	1.56	18.5	2.37	14.12
		50 - 149	1.27	4.22	2.46	2.11
4	Food products, beverages and tobacco	< 50	0.74	3.32	0.57	3.78
		50 - 149	3.27	3.87	2.51	4.16
		150 - 299	4.43	2.78	4.00	2.54
		300 - 499	3.30	1.46	3.69	1.07
		500 - 999	3.04	0.83	3.84	0.56
		1.000 – 1.999	1.55	0.20	2.07	0.14
8	Chemicals, chemical products, and man-made fibers; rubber and plastic products ; nuclear fuel	500 - 999	1.51	0.36	1.84	0.27
9	Other non-metallic mineral products	< 50	0.97	7.38	1.02	7.56
		50 - 149	1.31	2.53	1.62	1.88
14	Secondary raw materials; municipal wastes and other wastes	< 50	0.85	4.50	0.57	6.17
		50 - 149	1.32	2.16	1.19	1.88
16	Equipment and material utilized in the transport of goods	< 50	0.63	0.93	0.14	4.47
18	Grouped goods: a mixture of types of goods which are transported together	150 - 299	2.51	1.43	2.01	1.39
		300 - 499	2.27	0.87	2.13	0.74
		500 - 999	2.53	0.58	2.56	0.46
	Targeted coverage per KPI		**38.99**	**63.97**	**41.36**	**59.87**

Additionally to this market volume driven process, the participating LSPs and shippers had the opportunity to evaluate the usability of Prime Candidates independently from statistical figures. As market segments with lower transport volumes can add up to a significant potential level, this may add relevant information to the study.

3.2.2.1 Data collection

The interviews were conducted by several consortium partners either with a combination of personal visits at the participants' premises and telephone calls, or by several telephone calls. All approaches included an extensive briefing of the participants about the project, its purpose and general objectives as well as the specific role of the use cases within the project. This enabled the participant to select appropriate use cases as well as to give qualified judgements about the use of EMS vehicles. The interviews were based on a Microsoft Excel template with predefined fields and partly with predefined answer options, e.g. for the logistics sectors and route types.

3.2.2.2 Data protection

Data handling and measurements that were taken by the interviewers and work package 1 partners to maintain data protection have been explained to the interviewees in advance to the actual interview.

To ensure maximum level of privacy, no company related data were collected, e.g. company name, addresses, name of the contact etc. Additionally in the Excel template file it was possible to state only anonymous information for the defined tours, e.g. by only stating cities without actual addresses. The anonymized filled in files were forwarded only to MAN Truck & Bus, so that no other interviewer or project partner had access to the information. The analysis were done entirely by MAN Truck & Bus and only aggregated data were published.

3.2.2.3 Sampling

To acquire relevant experts for the interviews, those participants of the online survey were contacted who agreed in taking part in further steps of the study. Additionally, further direct contacts of the consortium partners were approached. Members of the Sounding Board supported the study by promoting the survey in their according networks. As with the stakeholder survey, the acquisition of participants turned out to be rather difficult. This is probably due to the rather large scope of the gathered information and the related time effort to process the questionnaire. Obviously it was not possible to approach potential participants specifically with regard to a certain market sector, thus a convenience sampling process was chosen.

3.2.2.4 Collected data and KPIs

The interviewees were asked to define use cases that represent typical transport applications in their according business (shipper and/or LSP). A use case was defined by the following categories of information

- General classification, e.g. logistics sector, route type, commodity type and selected prime candidate, number of tours per day etc.
- General setting, e.g. number of stops and depots, backhauls etc.
- Detailed tour including addresses of all served depots and stops during the tour, payload, volume and loading meter, as well as share of secondary loading units used, service times and transport mode.

- Technical description of the vehicles(s) that are currently used to serve the tour, e.g. type of vehicle, engine characteristics, transport units and their related characteristics.
- Qualitative judgements of the prerequisites and constraints that have to be met by future vehicle concepts or that can be crucial to their usability. These needed data were segmented to structure the questionnaire logically and thus ease the judgement of the participants. Covered aspects are for example costs, operational needs, infrastructure, loading, unloading and load.

Based on these data the total cost of ownership (TCO) per year and over the entire holding period (4 years used in this study) and as a consequence the transport cost per tonne-kilometre (€/tkm), per driven vehicle km (€/km) and per tour (€/tour) were calculated as key KPI. The cost per tour resulted from multiplication of €/km and driven distance per tour. For the comparison of the reference vehicles with maximum load of the Prime Candidate these values were multiplied by the consolidation factor to match regarded transport volume between reference vehicle and Prime Candidate (consolidation factor is defined as quotient of maximum load of a Prime Candidate and standard average load of the according reference vehicle, i.e. potential for load consolidation). For an overview of the variables that were used for the TCO calculation, please see Appendix C.
To be able to evaluate and compare costs between currently used vehicles and future EMS vehicles, MAN Truck & Bus simulated fuel consumptions with a proprietary tool. The tours specified in the template have been rebuilt as GPS files with trackpoints and have subsequently been processed into speed-, topology- and slope-profiles as input for the fuel consumption simulation. An example of these profiles is displayed in Figure 3-1.

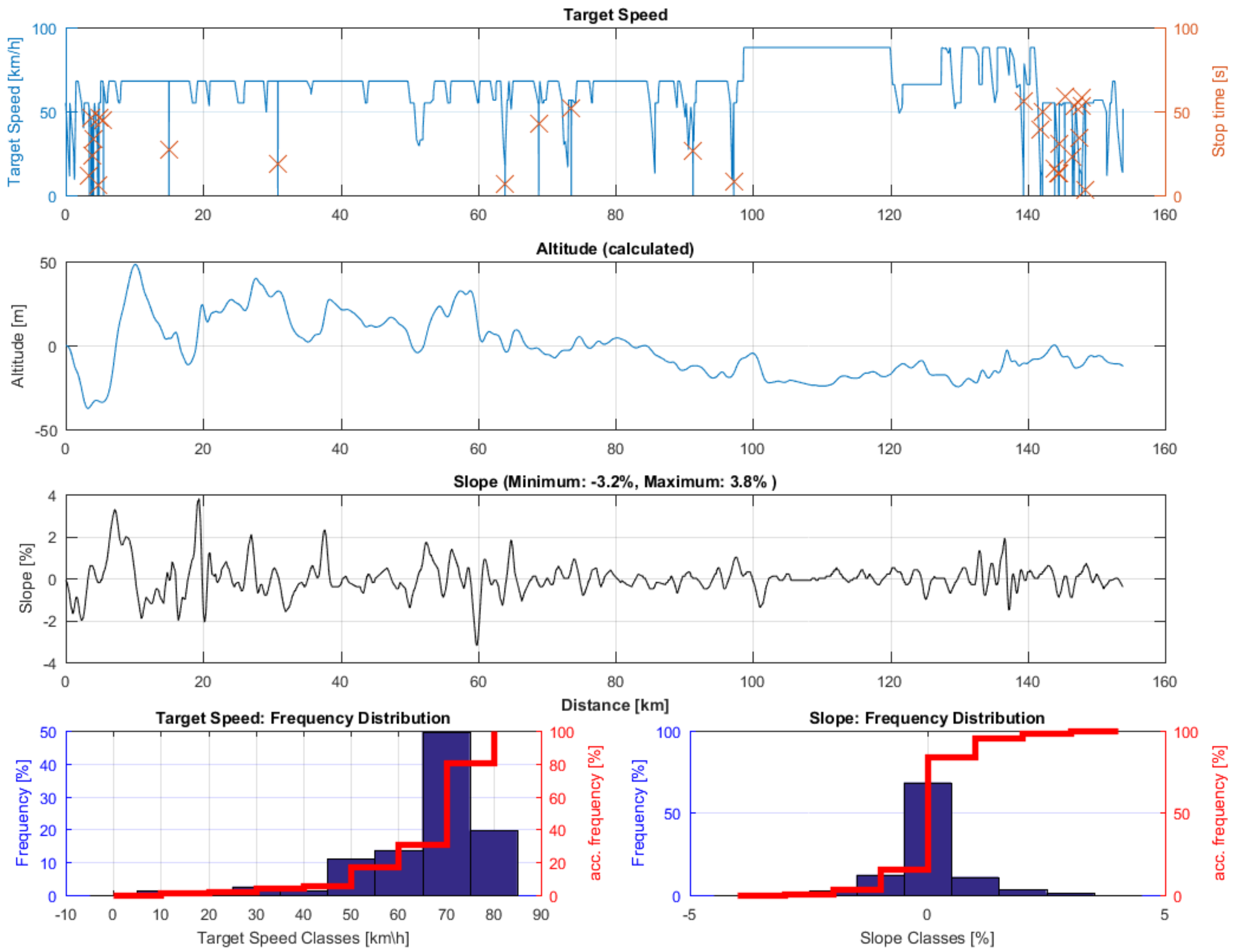


Figure 3-1 Exemplary display of speed-, topology- and slope profile with according distributions

The TCO and transport cost calculations are based on a full cost approach. If vehicle specifications for the currently used vehicles and amounts for the calculation were stated in the use cases they were used. Otherwise standard specifications for the vehicles and standard values for the cost categories were defined and used for similar vehicles. Where available cost on European level were used, to provide optimum comparability between use cases, e.g. for labour and non-labour cost (EUROSTAT, 2002, 2017c) or diesel fuel prices (European Commission, 2018). For cost categories which underlie an ongoing evolution, e.g. fuel and labour cost, a constant value was used without anticipating future developments. As these costs are main drivers for TCO and transport costs and due to the fact that an increase would rather support improved efficiency of EMS vehicles, this approach can be considered a worst case scenario, suggesting that cost evolution would strengthen the positive effect of EMS.

As it was not foreseeable how vehicles are being used apart from the described use cases, it was assumed that they were only used for the tours specified in the cases to get an annual mileage as basis for depreciation and fuel consumption. An overview of the regarded cost categories is displayed in Appendix B.

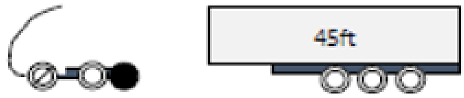
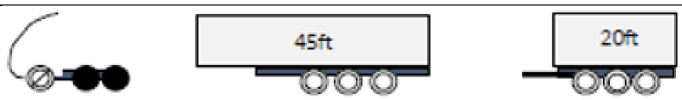
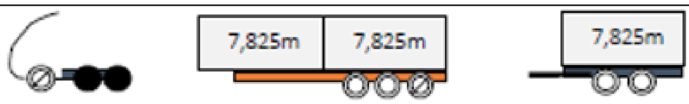
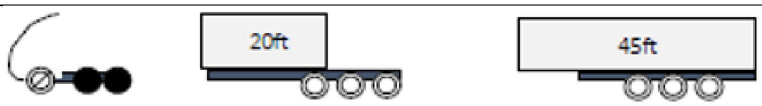
For the calculation of the CO_2 emissions, the CO_2 equivalent factors according to EN16258 for Diesel D7 with 7 Vol-% Biodiesel were used (Deutsches Institut für Normung, 2013). For Tank-to-Wheel calculations this was a factor of 2,48 kgCO_2e/l and for Well-to-Wheel a factor of 3,15 kgCO_2e/l. This deliverable reports the CO2 emissions per tour per vehicle. The reported CO_2 emissions resulted from simple multiplication of fuel consumption for a given tour and the above mentioned CO_2 equivalent factors. For the reference vehicles the values were multiplied by the consolidation factor to match the transport volumes of compared Prime Candidates.

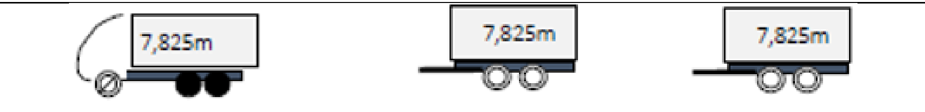
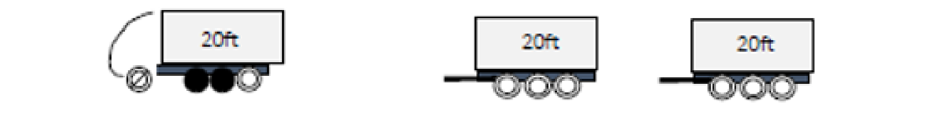
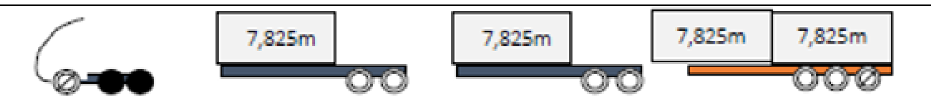
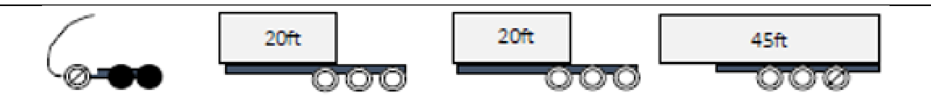
As fuel consumption simulation and TCO calculation were processed with MAN Truck & Bus proprietary algorithms, absolute figures cannot be stated in the results section of this report due to confidentiality and compliance reasons. Savings and efficiency increase potentials are expressed in percentages. Further explanations are given in the results section below.

3.2.2.5 Definition of Gross Combination Weight (GCW) and Payload

The Prime Candidates are, as mentioned above, entirely composed of standard loading units and towing vehicles as they are in use today. The majority of them contain more loading units as current legislation provides. As a consequence the GCW limits set in directive EC96/53 (European Union, 1996) and EC2015/719 (European Union, 2015) have to be adjusted to enable the use of EMS according to the suggested vehicle concepts. Furthermore, some participants of the study requested to revoke the tonnage limit for current vehicle combinations to allow efficiency improvements. Therefore adjusted GCW for all listed Prime Candidates have been calculated, that are meant as recommendations to be used in further analysis and studies. As the GCW depends on the number and kind of loading units and towing vehicles it was assumed to be variable. The axle loads in turn have been fixed to the permissible axle loads, as defined in the above mentioned directives, independent from the existing GCW limits, so that the adjusted GMC resulted simply in the sum of the single vehicle component's GVW, e.g. Prime Candidate 2.1 is composed out of a 6x2 rigid (GVW 26 t) and a 2-axle centre-axle-trailer with wheel-base >1,80m (GVW 20 t), which results in an adjusted GCW of 46 t. This procedure is supposed to avoid the danger of increased wear and tear of infrastructure, i.e. roads, bridges etc. The constraint of 25% of the GCW of a combination has to be carried by the loading axle(s) as defined in EC96/53 (European Union, 1996) has not been regarded in this procedure as it would pose a limit to GCW and with this to a potential efficiency increase. Furthermore the Hybrid Distributed Powertrain which is also part of the AEROFELX project, is seen as a potential solution for the subject, as it adds additional driven axles to the combinations. In Table 3-2 an overview of the resulting GCW is displayed. In some cases where participants requested specific tonnages that exceed current as well as adjusted limits, the GCW was calculated using the technical permissible weights defined by the manufactures, e.g. 39 to for semi-trailers and 29 to for 3 axle truck tractors.

Table 3-2 Prime Candidates and adjusted GCW based on permissible axle loads

Prime Candidate	Combination	GCW
1.1		50.000 t
1.2		50.000 t
1.3		42.000 t
1.4		42.000 t
2.1		46.000 t
2.2		46.000 t
2.3		40.000 t
3.1		74.000 t
3.2		70.000 t
3.3		68.000 t
3.4		71.500 t
4.1		68.000 t
4.2		68.000 t

4.3		68.000 t
4.4		68.000 t
4.5		66.000 t
4.6		80.000 t
4.7		74.000 t
5.1		86.000 t
5.2		86.000 t
5.3		86.000 t
5.4		92.000 t
5.5		98.000 t
6.1		92.000 t
6.2		92.000 t
6.3		93.000 t
6.4		93.000 t

4 Results

4.1 Transport Market

4.1.1 Analysis on trip level

The objective of WP1 is to characterize the European freight transport market. The deliverable D1.1 described the European freight transport market, trends and market drivers and variables which influence actor's modal choice in freight transport based on literature analysis, publicly available data evaluation and stakeholder discussions. Nevertheless the following questions remained unanswered:

- Description of the route type according to the variable 'type of journey'
- Description of typical trips (distance, load factor, vehicle kilometres, type of cargo) per commodity group

In the following, the EUROSTAT micro data are used to build a more quantitative knowledge base on road freight transport in general as well as on journeys and vehicle use in particular.

Important parameters used for the analysis

The EUROSTAT micro data consists of three linked data sets and contains 24 variables describing the vehicle, the journey and the goods (see chapter 3.1.1). For the conducted analysis it is sufficient to select a smaller amount of variables. They are described in Table 4-1. It should be noted that the given definitions are recommendations from EUROSTAT for the implementation of the questionnaires. Since various countries interpret these recommendations differently, several definitions are obtained. It is up to EUROSTAT to ensure consistency. For detailed explanations, in particular regarding different national specifics, please refer to the manuals (EUROSTAT, 2011, 2014, 2016).

Table 4-1 Important parameters for the analyses. Source: (EUROSTAT 2011, 2016)

Variables	Values	Explanation
Type of journey	• Laden journeys, involving one single basic transport operation. • Laden journeys, involving several transport operations but not considered as a collection or distribution round. • Laden journeys of the collection or distribution round type. • Unladen journeys.	EUROSTAT defines trips with more than four stops as a collection or distribution round type journey. For a loading journey, the place where the goods are loaded onto a previously empty vehicle (or where a road tractor is coupled up to a loaded semi-trailer) is the place of loading. For the analysis below, the following terms are defined as **route types**: **Full Truck Load (FTL):** Laden journeys, involving one single basic transport operation **Less than Truck Load (LTL)**: Laden journeys with several transport operations but not considered as collection of distribution round **Consolidation and milk-run tours:** Laden journeys of the collection or distribution round type
Degree of loading of vehicle (optional)	• Unladen journey • Not fully loaded (less than 90%) • Fully loaded (at least 90%) • Unknown	This variable provides an indication of the degree of loading of the vehicle in volumetric terms, and thus a measure of spare capacity on vehicle journeys. If the weight of goods carried is less than the load capacity of a vehicle, this does not necessarily mean that the vehicle is not fully loaded in the sense that it is not possible to put more goods into the vehicle. In many cases vehicles will be fully loaded with light goods where the weight of the goods is well below the load capacity of the vehicle.

Variables	Values	Explanation
Type of cargo[3]	• Liquid bulk goods (no cargo unit) • Solid bulk goods (no cargo unit) • Large freight containers • Other freight containers • Palletized goods • Pre-slung goods • Mobile, self-propelled units • Other mobile units • (Reserved) • Other cargo types	This variable describes the type of packaging of the cargo. Please note: With regard to the project-specific analyses, the values are clustered into the following groups: **Freight Containers:** include 'Large freight containers' and 'Other freight containers' **Palletized goods:** include 'palletized goods' **Bulk goods:** include 'Solid bulk goods (no cargo unit)' **Other goods:** include 'Pre-slung', 'Liquid bulk goods without cargo unit', 'mobile, self-propelled units', 'other mobile units', 'reserved' and 'other'
Type of goods	• 20 group classes according to NST 2007 Classification	
Classification of dangerous goods	• Good is not classified as dangerous • Good is classified as dangerous	
Journey-specific distance travelled	km	The actual distance travelled on roads excluding the distance covered by the goods road motor vehicle while being transported by another means of transport. Note: this variable describes the distances driven during the whole trip.

[3] Classification according to Regulation 70/2012, Annex VI.

Variables	Values	Explanation
Good-specific distance travelled	km	The actual distance travelled on roads excluding the distance covered by the goods road motor vehicle while being transported by another means of transport. Note: this variable describes the distances driven by the good during a trip. The distance can be less than the journey-specific distance, if several goods are transported and loaded or unloaded during the trip.
Maximum permissible weight	• Multiples of 100 kg	This variable describes the total weight of the vehicle (or vehicle combination) when stationary and ready for the road and of the weight of the load declared permissible by the competent authority of the country of registration of the vehicle. This may change from journey to journey.
Load Capacity	• Multiples of 100 kg	This variable describes the maximum weight of goods declared permissible by the competent authority of the country of registration of the vehicle. This may change from journey to journey.
Weight of goods	• Gross weight in 100kg	This variable includes the total weight of the goods and all packaging, but excluding the tare-weight of any container, swap-body and pallets containing goods.

The main scope of the previous work in WP1 was to identify suitable segments of the European road freight transport market for EMS vehicles, where the best chances for applications are expected. The results are summarized in deliverable D1.1. For this purpose a general description (see chapter 4.1.1.1) as well as a commodity specific description (see chapter 4.1.1.2) for potential commodity groups, distances and vehicle sizes is made. The deliverable D1.1 suggested to focus on specific goods classes (NST 2007 Classification: 01, 03, 04, 06, 08, 09, 10, 18 – classification see Annex D in this D1.2), General Cargo, Heavy Commercial Vehicles and medium journey specific distances over 150 km as well as long distances of at least 300 km. Nevertheless, focusing on the mentioned type of goods and transport distances does not implicate that there is no other market potential for the new vehicle concepts (see Chapter 4.1.1.3). As a result, several analyses were made with different data bases, which are summarized in the following Table 4-2.

Table 4-2 Overview about conducted analyses with the EUROSTAT micro data set and their respective data base

	Analyses conducted with the EUROSTAT micro data		
	General description of the data set regarding journeys Chapter 4.1.1.1	Commodity specific description of the data set Chapter 4.1.1.2	Special case: container and solid bulk transports Chapter 4.1.1.3
Excluded features from the data set	• Empty trips • Journeys with load capacity smaller than 23 tons • Journey specific travelled distances shorter than 150 km • NST 2007 category 02, 05, 07, 11, 12, 13, 14, 15, 16, 17, 19, 20	• Empty trips • Journeys with load capacity smaller than 23 tons • Journey specific travelled distances shorter than 150 km • NST 2007 category 02, 05, 07, 11, 12, 13, 14, 15, 16, 17, 19, 20	• Empty trips • Journeys with load capacity smaller than 23 tons
Remaining data set	n = 373,365 journeys(7.6%)	n = 438,236 transported goods (12.7%) $n_{150\text{-}299\ km}$ = 217,446 journeys (49.6%) $n_{\geq 300\ km}$ = 220,790 journeys (50.4%)	n = 1,783,144 transported goods (51,7%)

The remaining data set for commodity-specific analysis consists of n= 438,236 transported goods. Nevertheless, it is possible to conduct journey-specific analyses with this data set, because the identification of journeys is possible by the identifier. The journey-specific n decreases to avoid that multiple goods per journey are counted several times (n= 373,365). Furthermore, the data set is divided into journeys with a distance between 150 and 299 km and journeys with a distance of at least 300 km. Both groups have a comparable amount of journeys. With regard to the analysis of container and solid bulk transports, all types of goods and distance classes are included. Here, n = 1,783,144 data of transported goods are available for the analysis.

For simplification reasons, the different types of cargo are clustered as follows (see also Table 4-1):

- Freight containers: consist of ‘Large freight containers’ and ‘Other freight containers’
- Palletized goods: include the value ‘palletized goods’
- Solid bulk goods: include ‘Solid bulk goods (no cargo unit)’
- Other goods: consist of ‘Pre-slung’, ‘Liquid bulk goods without cargo unit’, ‘mobile, self-propelled units’, ‘other mobile units’, ‘reserved’ and ‘other’

4.1.1.1 General description of the data set regarding journeys

The European transport is shaped by different **route types**. The micro data show that the FTL operations dominate the regarded transport market with distances over 150 km with a market share of 76.5%. Around 11% of the transported goods are transported by LTL operations and 12 % by consolidation and milk-run tours (see Figure 4-1).

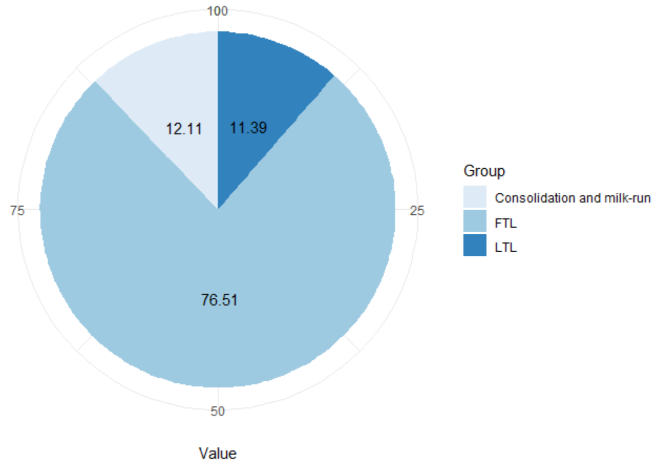


Figure 4-1: Percentage share of the journey type within the European Road freight transport. Source: EUROSTAT micro data, n= 373,365

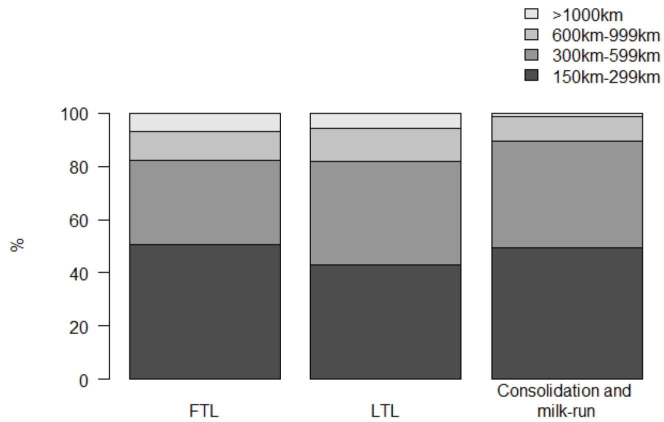


Figure 4-2: Percentage share of transport volume (tons) separated by distance classes and route type. Source: EUROSTAT micro data, n= 373,365

Figure 4-2 shows the **distance distribution** (weighted in tons) regarding different route types. Around 80 % of the transport volume of FTL and LTL is made by short and medium distance transports between 150 and 599 km. Consolidation and milk-run tours achieve a slightly higher share of around 90% in this distance range. On the contrary, the share of transport volume of FTL and LTL made by long distance transports over 600 km amounts to around 20 % and is slightly higher than at consolidation and milk-run-tours (10%).

The type of **loading unit** and loading device is a crucial information for the development of new vehicle concepts. It can be stated that 49 – 63% of the ton kilometres of the analyzed type of goods are based on pallets – namely in all three logistic sectors (see Figure 4-3). The transport with containers plays a minor role in the selected type of goods. The reason may be that the goods transported in containers are normally statistically not determined. For this reason, they are rarely included in the selected type of goods. Another reason could be that the selected type of goods are rarely transported in continental combined transport or in hinterland transports, where containers are a common loading unit. Simultaneously, it can be stated that containers are transported on rail, inland vessel and feeder transports in a very efficient and eco-friendly way. To take further types of goods into account, a special analysis for container transports and solid bulk transport is made in chapter 4.1.1.3.

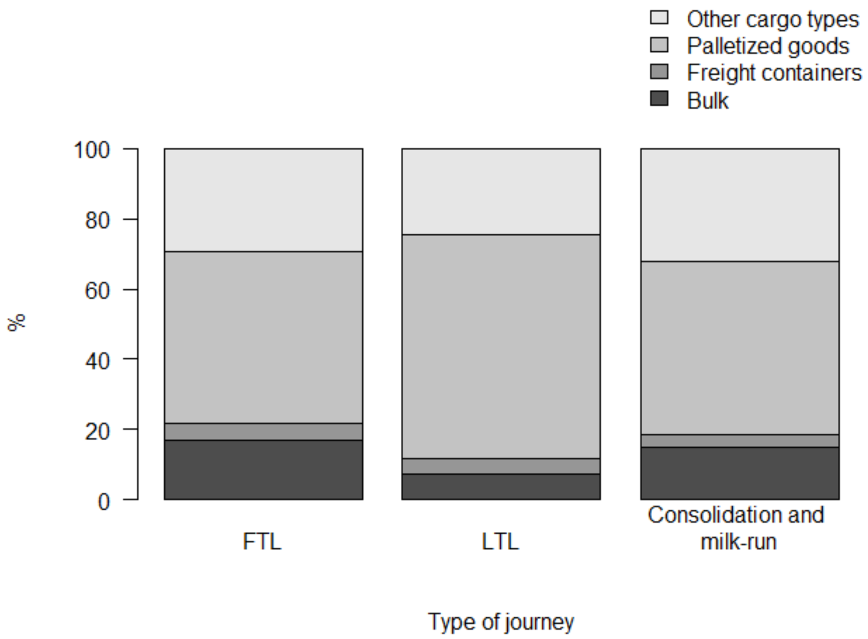
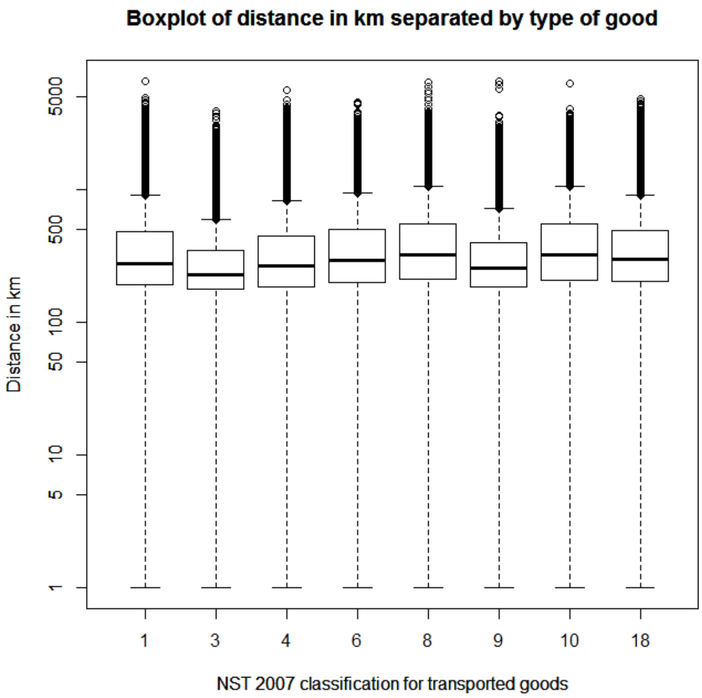


Figure 4-3: Percentage share of tkm transported in different loading units and loading devices. Source: EUROSTAT, n= 373,365

4.1.1.2 Commodity specific description of the data set

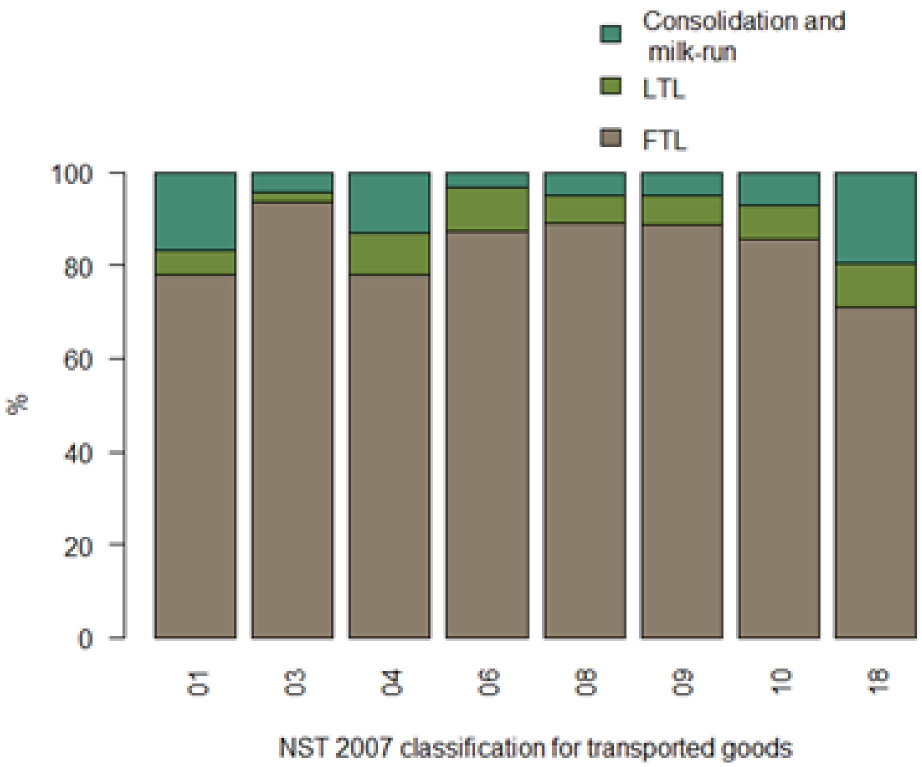
The EUROSTAT micro data enable a commodity-specific analysis. In Figure 4-4, the driven **distances** per transported good is depicted. The focus of the distances per transported goods is by round about 285 km, which is the overall median. Though, within the analyzed data set there are some individual cases, where the distances per transported good are much higher or lower. They can even be less than 150 km, since goods that have been transported less than 150 km remain in the data set if only the entire journey-specific distance was longer than 150 km (i.e. LTL, consolidation, milk-run). Approximately 6.9% of the values were marked as extreme values. The maximum travelled distance accounts for 6,628 km. The distribution of the distance is relatively similar between the different type of goods with commodity group 3 (metal ores and other mining and quarrying products) having the smallest distances and commodity group 8 (chemicals) having the longest.



No.	NST 2007 commodity group	No.	NST 2007 commodity group
01	Agriculture products	08	chemical products
03	Metal Ores	09	Other non-metallic mineral products
04	Food products	10	Basic metals; fabricated metal products
06	Wood and cork products	18	Grouped goods

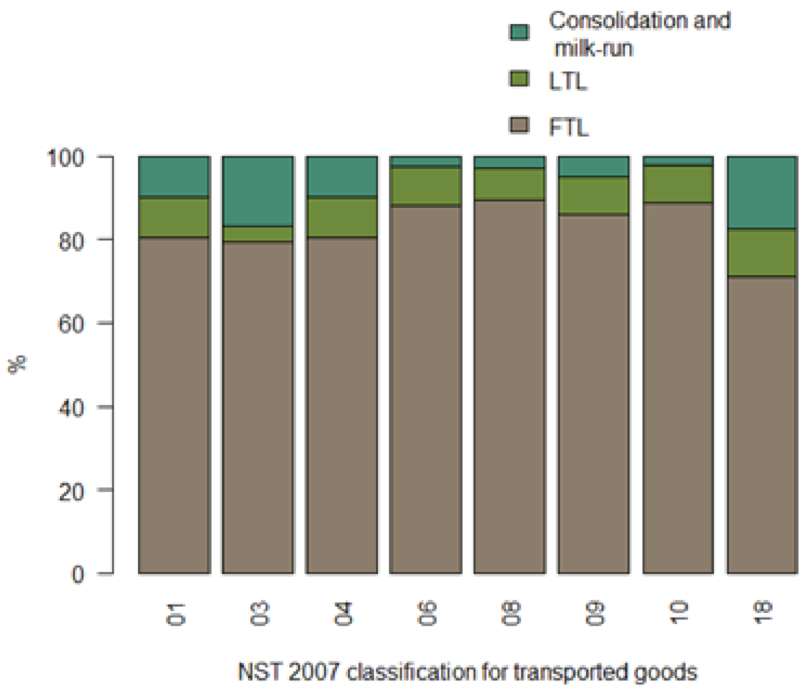
Figure 4-4: Boxplot of distances per transported good in km in the selected type of goods; source: EUROSTAT, n= 438,236

Another characteristic of the European Transport is the **distribution of the logistics segments** in the selected type of goods. The Figure 4-5 and figure 4-6 show that the FTL transports dominate in both distance classes and all commodity groups: Around 71 to 90 % of the transports by tonne-kilometres (tkm) in each commodity group are hauled by FTL transports in both distance classes. An exception is the commodity group 3 (metal ores) with a percentage share of FTL transports up to 94 %, because solid bulk goods are in particular suitable for FTL transports. LTL and consolidation and milk run tours are specifically used within the commodity groups 01 (agricultural products), 04 (food products) and 18 (grouped goods). Here, the percentage share lies between 20 and 29 % in both distance classes. The importance of LTL and consolidation and milk run tours can be judged as lower compared to FTL transports. It has to be noted, that the share of multi-stop trips analyzed at good group level is higher than indicated here, since there are some countries that do not report all good types for multi-stop trips. Germany codes the type of goods with the uppermost weight, if several different types of goods are transported.



No.	NST 2007 commodity group	No.	NST 2007 commodity group
01	Agriculture products	08	chemical products
03	Metal Ores	09	Other non-metallic mineral products
04	Food products	10	Basic metals; fabricated metal products
06	Wood and cork products	18	Grouped goods

Figure 4-5: Percentage share (tkm) of type of journey for the selected commodity groups between 150 and 299 km distance, source: EUROSTAT, n= 217,446



No.	NST 2007 commodity group	No.	NST 2007 commodity group

01	Agriculture products	08	chemical products
03	Metal Ores	09	Other non-metallic mineral products
04	Food products	10	Basic metals; fabricated metal products
06	Wood and cork products	18	Grouped goods

Figure 4-6: Percentage share (tkm) of type of journey for the selected commodity groups with 300 km distance and more, source: EUROSTAT, n= 220,790

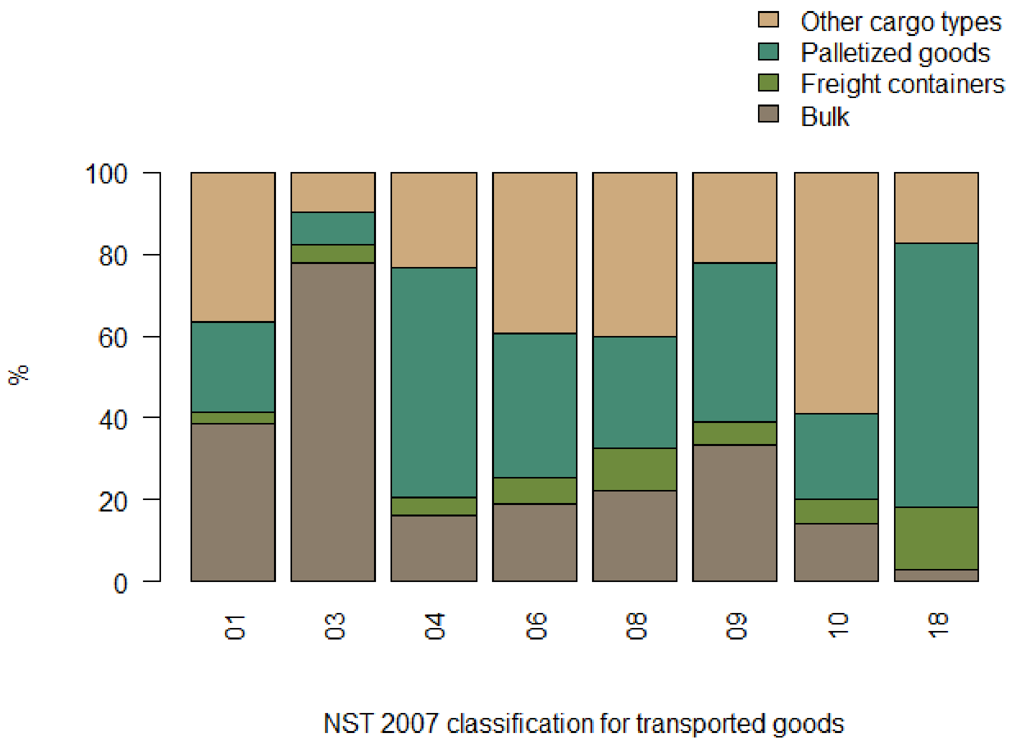
The total **vehicle kilometres** are calculated, as well. It is analyzed, how they differ between the selected types of goods. For journeys with a distance between 150 km and 299 km, the vehicle kilometres (vkm) of the groups 01 (agriculture), 04 (food products) and 18 (grouped goods) are between 2,800 Million and 6,100 Million vkm in 2014. The other groups have vehicle kilometres between 1,700 Million and 1,900 Million vkm in 2014 with an exception for group 3 (metal ores) with 797 Million vkm. For journeys with a distance of at least 300 km, the vehicle kilometres of the groups 01, 04 and 18 are between 7,000 Million vkm and 11,000 Million vkm. The other type of goods show an amount of vehicle kilometres between 2,000 and 6,000 Million vkm with an exception for group 3 (metal ores) with round about 1,000 Million vkm.

Table 4-3 Overview Million vehicle-kilometres selected NST groups (EUROSTAT 2014)

No.	NST 2007 commodity group	total Million vehicle-kilometres year 2014	
		150-299km	300 km and more
01	Agriculture products	2,592	7,075
03	Metal Ores	797	667
04	Food products	6,072	11,254
06	Wood and cork products	1,757	4,695
08	chemical products	1,137	5,856
09	Other non-metallic mineral products	1,911	3,398
10	Basic metals; fabricated metal products	1,195	5,583
18	Grouped goods	2,164	9,344
	Total selected NST groups	17,655 (58%)	47,872 (66%)
	Total all NST groups	30,439	72,439

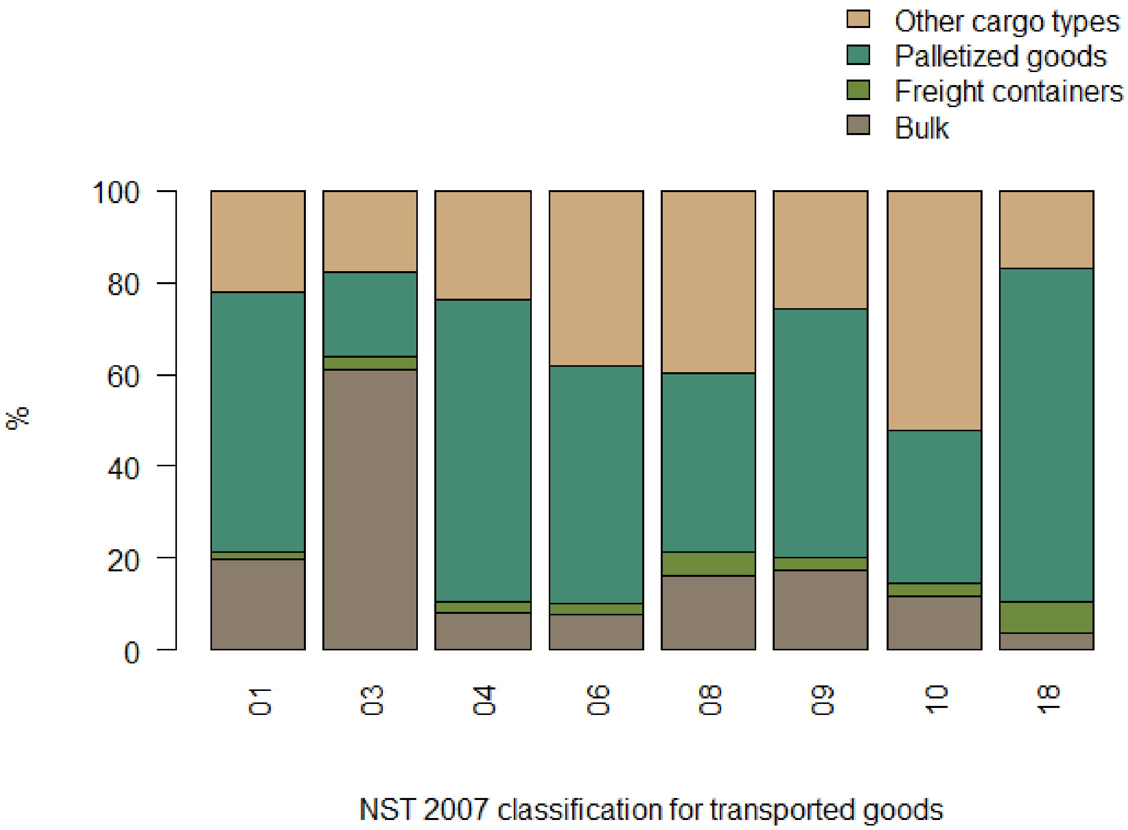
Within the European freight transport several **loading units** are used.

The Figure 4-7 and Figure 4-8 show the distribution of the loading units used per type of goods and distance classes in terms of the transport by ton-kilometres. On long distances of at least 300 km, the transports by ton-kilometres in nearly all of the analyzed type of goods are predominantly performed with palletized goods – which are transported in semitrailers. Commodity group 03 (Metal ores) is a classic solid bulk good and therefore primarily transported in solid bulk trailers. Although, on distances between 150 km and 299 km other cargo types have a higher percentage share compared to other commodity groups, because agriculture products (commodity group 01) and paper (commodity group 6) are often not suitable for pallets, if they are still raw products and not processed, yet. The commodity group 10 (Metals and pre-products) constitutes an exception: In this case, around 59% of the transport performance for journeys with distances between 150 and 299 km are performed by other cargo types. The reason is that this type of cargo doesn't usually fit for pallets. Commodity groups 08 (Chemicals) and 18 (Grouped goods) have the highest share of container usage on distances between 150 km and 299 km: 10-15% of the transport performance is performed in containers. However it can be stated for all type of goods and both distance classes that the importance of container transports is low in the selected commodity groups (see Chapter 4.1.1.3).



No.	NST 2007 commodity group	No.	NST 2007 commodity group
01	Agriculture products	08	chemical products
03	Metal Ores	09	Other non-metallic mineral products
04	Food products	10	Basic metals; fabricated metal products
06	Wood and cork products	18	Grouped goods

Figure 4-7: Percentage share of tkm for type of cargo, separated for the selected commodity groups and for journeys between 150 and 299 km; source: EUROSTAT, n= 217,446



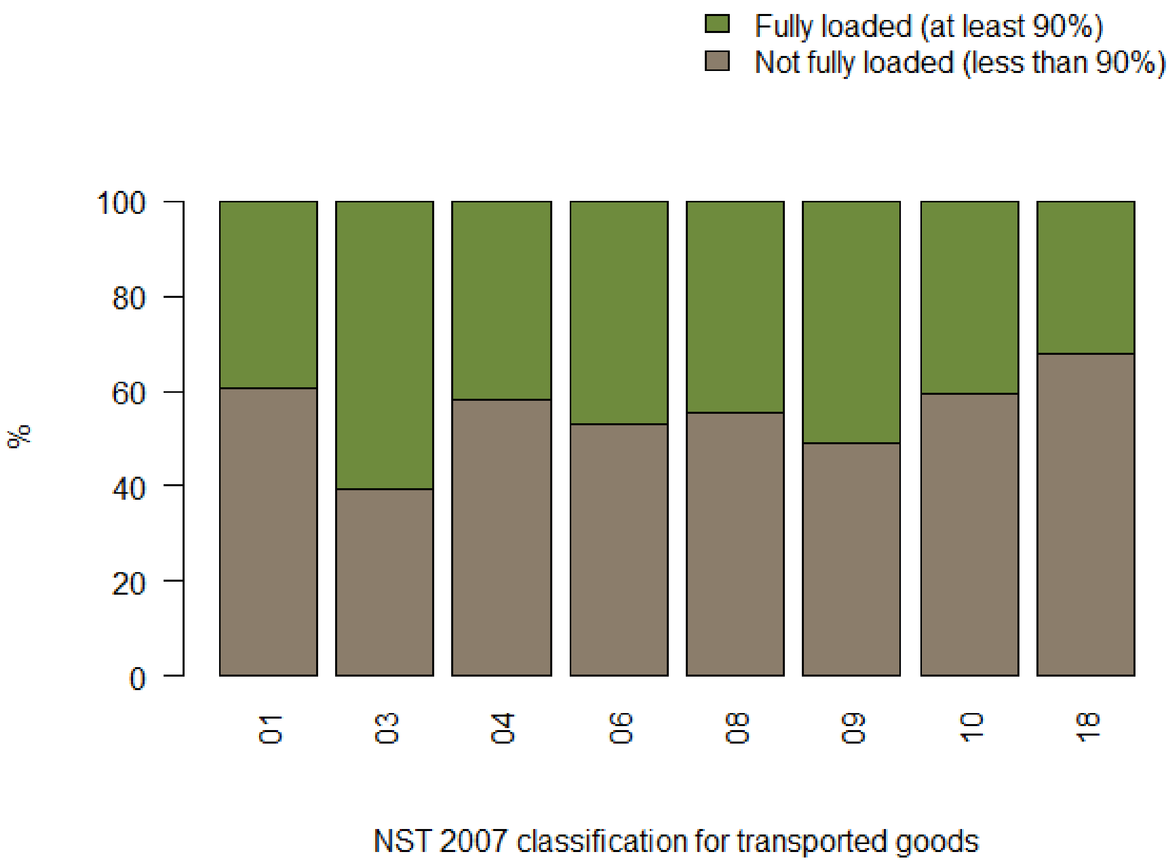
No.	NST 2007 commodity group	No.	NST 2007 commodity group
01	Agriculture products	08	chemical products
03	Metal Ores	09	Other non-metallic mineral products
04	Food products	10	Basic metals; fabricated metal products
06	Wood and cork products	18	Grouped goods

Figure 4-8: Percentage share of tkm for type of cargo, separated for the selected commodity groups and for journeys with 300 km distance and more; source: EUROSTAT, n=220,790

For the AEROFLEX project the **utilization of the vehicles** is of high importance. Transports with a high degree of loading are equivalent to a potential for new vehicle concepts. The Figure 4-9 and Figure 4-10 show the percentage share of journeys with a loading degree in terms of maximum volume of space with less than 90 % and of at least 90 % for the two different distance classes.

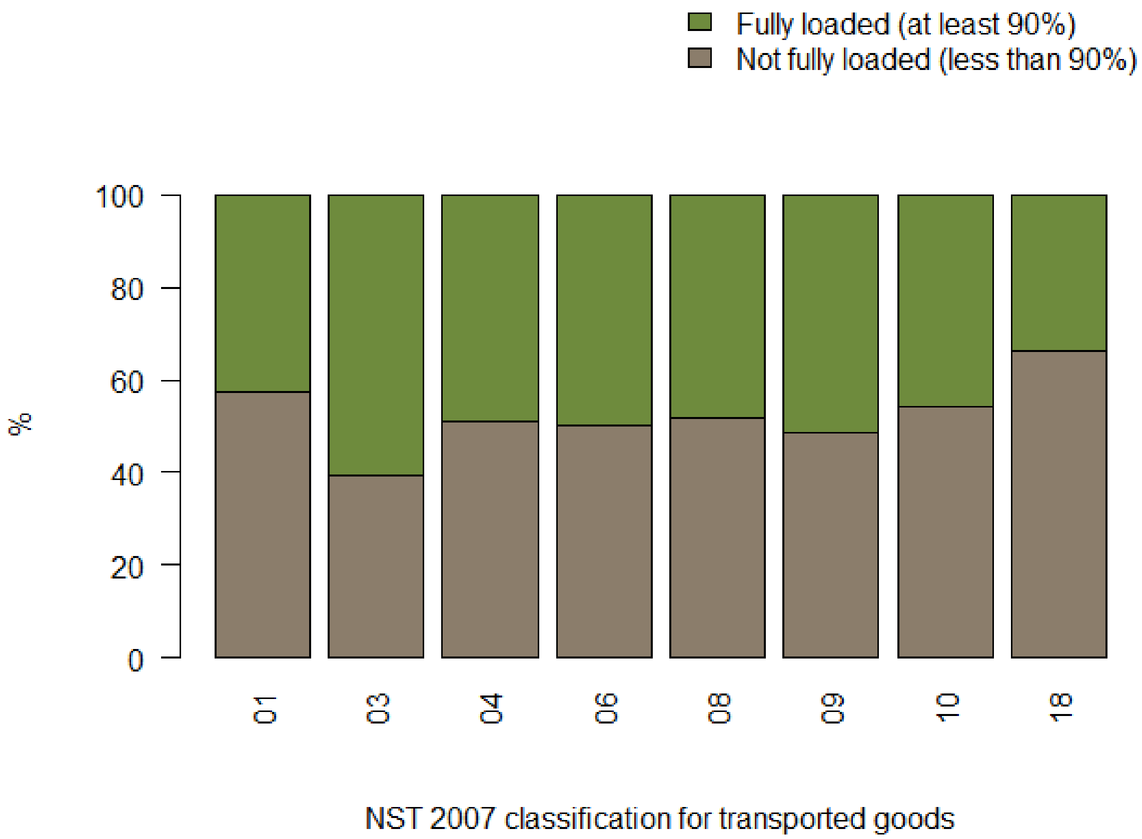
For distances between 150 and 299 km, the commodity groups 01 (agricultural products), 04 (food products), 06 (wood products), 08 (chemical products), 09 (other non-metallic mineral products) and 10 (Basic metals) show a percentage share of fully loaded journeys of 40-51% (Figure 4-9). Within commodity group 18 (grouped goods), the percentage share is slightly lower (Figure 4-104-10). Only commodity group 03 (metal ores) has a higher share of fully loaded journeys of 61 %, due to the solid bulk characteristic. With increasing transport distance, the percentage share of journeys performed by fully loaded vehicles increases in the selected commodity group up to 50 % (Figure 4-10). For all selected commodity groups, it can be stated that 42 % of the transports by ton-kilometres on distances between 150 and 299 km is hauled by vehicles with a degree of loading of at least 90 %. The percentage share even increases up to 45 % when distances of at least 300 km are considered.

On the contrary, a lot of journeys are performed with vehicles which are not fully loaded (less than 90 %). However, a more efficient consolidation and the usage of a smart loading unit may help to increase the utilization of the vehicles.



No.	NST 2007 commodity group	No.	NST 2007 commodity group
01	Agriculture products	08	chemical products
03	Metal Ores	09	Other non-metallic mineral products
04	Food products	10	Basic metals; fabricated metal products
06	Wood and cork products	18	Grouped goods

Figure 4-9: Percentage share of journeys with different degree of loading, separated by the selected type of goods between 150 and 299 km, Source: EUROSTAT; n= 217,446



No.	NST 2007 commodity group	No.	NST 2007 commodity group
01	Agriculture products	08	chemical products
03	Metal Ores	09	Other non-metallic mineral products
04	Food products	10	Basic metals; fabricated metal products
06	Wood and cork products	18	Grouped goods

Figure 4-10: Percentage share of journeys with different degree of loading, separated by the selected type of goods with 300 km distance and more; source: EUROSTAT, n= 220,790

4.1.1.3 Special case: container and solid bulk transports

The following analysis focuses on the question whether the small amount of containers in the prior figures is a general phenomenon in the data set or reasoned by the selection of different commodity groups. The Figure 4-11 shows the distribution of the loading units used including all commodity groups (NST 2007 01 to 20) and even journey-specific distances below 150 km.

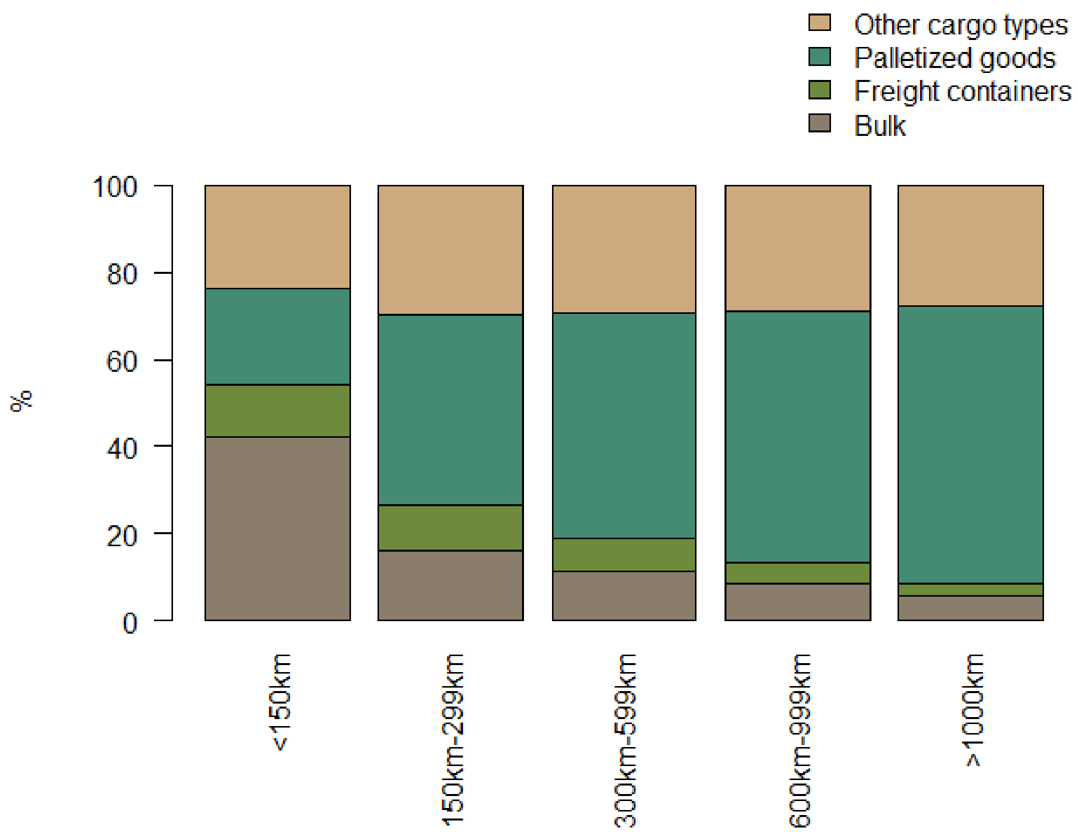


Figure 4-11: percentage share of loading units for all commodity groups and all distances. Source: EUROSTAT, n= 1,783,144

On distances below 150 km, the share of containers is about 12 %, which decreases with increasing distances. Most containers are globally used in the maritime transport with large container vessels. In European transport, containers are transported either in the direct hinterland transport coming from the ports as short-distance road transports or as pre- or onward carriage to the maritime combined transport on longer distances. The bigger amount of the European transports consists of continental transport relations, which are more focused on palletized goods and trailer usage.

Solid Bulk goods play a more important role in road freight transport on short distances up to 150 km. Building materials are often skimmed and transported by trucks to a destination (e.g. a factory) in the same region. On longer distances, solid bulk transports are often transported more efficiently and environmentally friendly by rail or by inland navigation. In this case, the transport by road is conducted as pre- or onward carriage to complement other modes. Conclusion

The analysis of the EUROSTAT micro data shows the following results:

- FTL transports are of high importance within the analysed part of the European freight transport.

- The selected commodities – which are most interesting for the new vehicle concepts – are primarily transported on pallets within trailers. Container transports may have a high relevance for intermodal transport chains or hinterland transports.
- The share of fully loaded transports for journeys between 150 and 299 km is about 42 %. The share increases with the transport distances up to 45 %.

The target market of new vehicle concepts are fully loaded transports. In this context, the potential use of high capacity vehicles is high and the highest effect of the reduction of green-house gas emission is expected. At present, only 42 % of transports with distances between 150 and 299 km and 45 % of the transports with distances of at least 300 km are fully loaded.

4.1.2 Other quantitative information

This section contains an overview of the available and relevant quantitative data on the current road freight transport market. Covered are:

- Vehicle fleet
- Transport costs and components
- Driving times

4.1.2.1 Vehicle fleet

4.1.2.1.1 ACEA

The European Automobile Manufacturers' Association (ACEA) publishes data on the current vehicle stocks on an annual basis. The most recent version of the report (ACEA, 2017) covers the time frame until 2015.

It distinguishes following categories:

- Passenger cars
- Light commercial vehicles (up to 3.5 tonnes)
- Medium and heavy commercial vehicles (over 3.5 tonnes)
- Buses

Vehicles are split by country, age (based on year of first registration) and fuel type.

For AEROFLEX, only the "EU medium and heavy commercial vehicle fleet" category is relevant Table 4-4.

Table 4-4 EU medium and heavy commercial vehicle fleet 2011-2015 (source: ACEA)

	2011	2012	2013	2014	2015	%change 15/14
Austria	71,076	70,138	69,538	69,229	68,860	-0.5
Belgium	149,444	147,545	145,694	144,370	143,697	-0.5
Croatia	34,648	37,564	39,925	44,506	45,757	2.8
Czech Republic	187,161	183,704	189,939	192,165	196,816	2.4
Denmark	43,577	42,461	41,654	41,424	41,457	0.1
Estonia	33,562	33,906	34,766	35,389	35,455	0.2
Finland	96,864	96,714	96,733	95,176	95,233	0.1
France	564,000	555,000	547,000	554,000	567,000	2.3
Germany	894,462	889,520	890,410	892,695	902,718	1.1
Greece	231,959	232,065	232,334	232,692	233,159	0.2
Hungary	88,334	86,723	86,780	87,488	86,831	-0.8
Ireland	29,725	28,097	30,262	31,084	30,932	-0.5
Italy	992,173	968,846	936,675	922,824	918,258	-0.5
Latvia	33,748	36,017	38,285	37,414	32,908	-12.0
Lithuania	81,879	83,431	84,866	48,222	50,089	3.9
Luxembourg	11,498	11,462	11,456	11,331	11,384	0.5
Netherlands	159,000	155,000	153,000	149,383	149,588	0.1
Poland	841,112	874,572	908,069	941,293	980,201	4.1
Portugal	129,500	125,000	121,400	119,000	119,000	0.0
Romania	166,964	179,409	194,974	197,382	218,728	10.8
Slovakia	91,914	92,513	93,413	93,109	94,611	1.6
Slovenia	27,806	28,946	30,165	31,068	32,445	4.4
Spain	559,853	535,624	520,098	517,268	526,559	1.8
Sweden	80,739	79,727	79,130	79,544	80,046	0.6
United Kingdom	563,872	557,128	568,993	569,921	581,645	2.1
EUROPEAN UNION	**6,164,871**	**6,131,113**	**6,145,559**	**6,137,977**	**6,243,377**	**1.7**
Norway	101,736	101,335	100,898	100,602	100,095	-0.5
Switzerland	60,241	60,335	59,950	60,602	60,076	-0.9
EFTA	**161,977**	**161,670**	**160,848**	**161,204**	**160,171**	**-0.6**
Russia	4,308,314	4,269,514	4,184,944	4,283,455	4,107,344	-4.1
Turkey	728,458	751,650	755,950	773,728	804,319	4.0
Ukraine	1,885,932	1,844,549	1,816,272	1,735,572	1,733,506	-0.1
EUROPE	**13,249,553**	**13,158,496**	**13,063,573**	**13,091,936**	**13,048,717**	**-0.3**

The total EU fleet consisted of 6.2 million medium and heavy duty vehicles in 2015. After a market stagnation since at least 2011, the market grew by 1.7%, mainly in Eastern European countries. The largest markets are Poland, Italy and Germany.

As for the age of the vehicles, we find that more than half of the fleet is older than 10 years, with an average age of 11.7 years (Table 4-5). Of the larger fleets, France has the youngest fleet, while Poland has the oldest. The impact of the 2008 financial crisis is clearly visible in the table.

Table 4-5 : EU medium and heavy commercial vehicle fleet (including buses) by year of first registration 2011-2015 (source: ACEA)

Year of first registration	*2015*	*2014*	*2013*	*2012*	*2011*	*2010*	*2009*	*2008*	*2007*	*2006*	*>10 years*	*Total*	*Average age (in years)*
Austria	8,412	8,126	7,856	7,415	7,934	6,289	5,468	7,624	6,532	5,720	7,162	78,539	8.4
Belgium	9,597	9,105	8,342	8,700	9,418	8,153	8,256	10,312	9,387	8,506	69,845	159,623	9.8
Croatia	911	1,103	874	835	1,330	1,062	1,474	3,666	3,594	2,566	28,342	45,757	14.3
Czech Republic	12,212	11,023	10,685	8,101	8,606	6,110	5,351	10,867	10,679	8,616	124,532	216,782	13.9
Denmark	4,508	3,734	4,098	3,732	3,020	2,569	3,072	4,776	4,085	3,010	13,685	50,289	7.7
Estonia	1,039	1,032	1,181	1,026	997	617	494	1,798	2,472	2,033	27,553	40,242	16.3
Finland	3,180	3,377	4,023	3,841	3,906	3,367	3,890	6,263	6,324	6,383	63,134	107,688	12.4
France	49,069	43,591	50,448	49,625	53,657	38,757	39,584	56,386	48,518	44,990	182,375	657,000	7.5
Germany	91,383	86,122	81,458	74,889	73,867	57,585	48,050	59,695	52,414	43,223	312,378	981,063	8.0
Greece	611	559	458	333	646	1,797	3,055	3,295	3,168	3,112	241,135	258,166	18.7
Hungary	5,526	5,159	6,106	4,120	3,840	2,368	2,406	5,501	5,743	4,992	58,324	104,085	12.8
Ireland	2,026	1,865	1,538	1,781	1,583	1,488	1,642	4,419	5,086	5,491	22,099	49,018	9.8
Italy	19,638	18,555	24,026	23,461	30,354	32,442	28,479	44,419	45,926	47,186	701,762	1,016,249	13.2
Latvia	1,626	1,170	1,534	1,317	1,319	630	492	1,908	2,618	1,992	18,302	32,908	13.5
Lithuania	3,731	2,406	4,013	2,785	2,386	1,061	796	2,854	3,882	3,162	30,161	57,236	12.7
Luxembourg	1,498	1,278	1,260	1,133	1,327	810	729	1,018	747	489	2,873	13,162	6.6
Netherlands	12,971	9,977	12,287	11,821	11,560	9,476	11,138	15,018	11,137	9,972	43,616	158,973	7.9
Poland	23,611	20,655	25,179	20,881	27,271	20,535	13,082	43,380	48,696	37,281	809,475	1,090,045	16.7
Portugal	2,826	2,487	1,894	1,462	2,327	2,661	2,694	4,572	5,247	5,205	102,324	133,700	13.7
Romania	7,624	5,740	7,494	6,114	6,038	4,508	3,935	10,816	14,745	16,263	156,574	239,851	13.8
Slovakia	5,950	5,568	5,528	4,107	4,078	2,986	2,529	5,328	5,287	4,512	48,738	94,611	12.7
Slovenia	2,126	1,832	1,556	1,490	2,109	1,641	1,265	3,078	2,756	1,872	12,720	32,445	10.4
Spain	29,489	20,094	15,131	14,660	18,400	15,442	13,999	30,340	40,115	36,750	352,391	586,811	12.6
Sweden	7,511	7,184	6,555	7,127	7,425	6,024	5,725	6,564	5,729	5,042	29,273	94,160	8.5
United Kingdom	55,744	44,641	60,268	48,431	43,946	33,878	33,644	49,554	42,692	39,596	217,437	669,831	8.8
EUROPEAN UNION	***362,819***	***316,384***	***343,791***	***309,186***	***327,343***	***262,257***	***241,250***	***393,451***	***387,579***	***347,965***	***3,676,209***	***6,968,234***	***11.7***

Diesel powers 95.5% of all medium and heavy commercial vehicles.

4.1.2.1.2 TRACCS project

The TRACCS project (Emisia, 2013) collected transport data for the period 2005-2010. Although outdated, the information can nonetheless serve as an indicator for more detailed splits not available in other datasets.

Table 4-6 EU heavy duty fleet: split by type and weight (source: TRACCS)

Vehicle	**Type**	**Propulsion**	**Number of Registered Vehicles**					
			2005	2006	2007	2008	2009	2010
Heavy Duty Trucks	>3.5 t	Gasoline	158 294	161 624	166 711	159 681	160 188	167 671
Heavy Duty Trucks	Rigid <=7.5 t	Diesel	1 588 469	1 472 104	1 464 413	1 459 296	1 422 056	1 469 155
Heavy Duty Trucks	Rigid 7.5 - 12 t	Diesel	841 969	861 810	866 848	884 041	864 942	893 762
Heavy Duty Trucks	Rigid 12 - 14 t	Diesel	247 064	251 231	249 179	251 312	248 327	247 765
Heavy Duty Trucks	Rigid 14 - 20 t	Diesel	784 218	792 606	806 044	800 931	785 681	773 592
Heavy Duty Trucks	Rigid 20 - 26 t	Diesel	634 977	648 681	668 050	636 259	618 343	616 731
Heavy Duty Trucks	Rigid 26 - 28 t	Diesel	145 469	154 832	165 434	166 386	167 217	164 025
Heavy Duty Trucks	Rigid 28 - 32 t	Diesel	140 844	147 989	162 177	163 850	165 204	168 691

Heavy Duty Trucks	Rigid >32 t	Diesel	74 532	78 221	81 677	83 987	82 989	82 405
Heavy Duty Trucks	*Rigid*	*All*	*4 457 542*	*4 407 474*	*4 463 822*	*4 446 062*	*4 354 759*	*4 416 126*
Heavy Duty Trucks	Articulated 14 - 20 t	Diesel	139 801	145 828	154 401	180 312	182 825	184 126
Heavy Duty Trucks	Articulated 20 - 28 t	Diesel	101 172	100 608	108 295	110 308	107 377	109 800
Heavy Duty Trucks	Articulated 28 - 34 t	Diesel	89 519	86 254	90 592	81 569	74 986	76 064
Heavy Duty Trucks	Articulated 34 - 40 t	Diesel	506 691	511 635	543 220	485 493	436 014	421 456
Heavy Duty Trucks	Articulated 40 - 50 t	Diesel	792 321	809 740	848 416	884 716	919 268	860 833
Heavy Duty Trucks	Articulated 50 - 60 t	Diesel	30 642	32 008	35 220	36 313	37 710	38 369
Heavy Duty Trucks	*Articulated*	*All*	*1 660 147*	*1 686 074*	*1 780 144*	*1 778 713*	*1 758 181*	*1 690 648*
Heavy Duty Trucks		**Total**	**6 275 983**	**6 255 171**	**6 410 676**	**6 384 456**	**6 273 128**	**6 274 445**

The data reveals that 70% of the European heavy duty vehicle fleet consists of rigid trucks, over half of which are below 12 tonnes. Of the heavier rigid vehicles, only 9% weigh over 26 tonnes.

Of the articulated vehicles on the other hand, over 75% weigh at least 34 tonnes.

These splits clearly indicate that rigid and articulated vehicles are used in different markets and on different mission profiles.

Table 4-7 EU heavy duty fleet: average annual mileage (source: TRACCS)

Vehicle	**Type**	**Propulsion**	**Total distance (km) travelled by average vehicle**					
			2005	2006	2007	2008	2009	2010
Heavy Duty Trucks	>3,5 t	Gasoline	19 247	19 876	19 381	20 535	19 899	19 162
Heavy Duty Trucks	Rigid <=7,5 t	Diesel	35 662	36 955	37 667	39 665	38 980	39 892
Heavy Duty Trucks	Rigid 7,5 - 12 t	Diesel	42 048	42 055	43 039	43 952	43 119	43 489
Heavy Duty Trucks	Rigid 12 - 14 t	Diesel	38 061	37 644	36 895	37 345	35 929	35 951
Heavy Duty Trucks	Rigid 14 - 20 t	Diesel	47 356	48 013	48 226	48 183	45 991	45 901
Heavy Duty Trucks	Rigid 20 - 26 t	Diesel	47 238	47 102	46 176	46 590	45 980	45 132
Heavy Duty Trucks	Rigid 26 - 28 t	Diesel	58 447	59 042	58 068	58 530	55 274	55 613
Heavy Duty Trucks	Rigid 28 - 32 t	Diesel	50 646	55 833	54 460	53 505	51 039	50 833

Heavy Duty Trucks	Rigid >32 t	Diesel	55 535	57 783	57 227	57 072	55 496	54 867
Heavy Duty Trucks	*Rigid*	*All*	*42 257*	*43 253*	*43 571*	*44 457*	*43 285*	*43 465*
Heavy Duty Trucks	Articulated 14 - 20 t	Diesel	39 349	39 298	37 934	40 259	38 197	37 899
Heavy Duty Trucks	Articulated 20 - 28 t	Diesel	63 603	64 945	62 765	62 815	58 396	59 085
Heavy Duty Trucks	Articulated 28 - 34 t	Diesel	62 624	63 881	62 545	62 705	57 389	57 239
Heavy Duty Trucks	Articulated 34 - 40 t	Diesel	89 333	93 573	93 355	100 360	98 750	102 998
Heavy Duty Trucks	Articulated 40 - 50 t	Diesel	67 674	69 626	69 720	69 314	67 602	69 050
Heavy Duty Trucks	Articulated 50 - 60 t	Diesel	38 390	39 657	41 575	41 695	41 391	42 180
Heavy Duty Trucks	*Articulated*	*All*	*70 838*	*73 127*	*72 830*	*73 573*	*70 709*	*72 332*
Heavy Duty Trucks		**Total**	**49 237**	**50 701**	**51 067**	**51 970**	**50 374**	**50 594**

Table 4-7 confirms the assertion that rigid and articulated vehicles are used in different ways: rigid vehicles have a similar annual mileage of around 45 000 km, whereas the mileage of heavy articulated vehicles is double.

4.1.2.1.3 EUROSTAT

EUROSTAT datasets on the road freight vehicle fleet are in line with the other sources (as is to be expected), but seem to be less comprehensive (missing countries, missing categories) and are not necessarily validated (totals versus subcategories). The data will be therefore included in Appendix G of this report, but is not retained for further analysis at this point.

4.1.2.2 Transport cost components

Gaining an insight into current freight transport cost components and linking these insights to the changes resulting from the implementation of AEROFLEX improvements, is a step towards assessing the expected impact of AEROFLEX on Total Cost of Ownership (TCO) for road freight transport operators.

4.1.2.2.1 "Kostenbarometer" (Panteia)

Panteia updates its "Kostenbarometer" (Panteia, 2016) annually, assessing evolutions in factor costs contribution to the total costs of freight transport (covering all transport modes – only road is discussed here). While mostly for internal use only, in 2016 a public version has been made available by the Dutch ministry of transport (Rijkswaterstaat), with cost levels for 2015. While the cost levels in principle only apply for the Netherlands, they can serve as a proxy for other countries as well, mutatis mutandis.

The different components include:

- Fixed costs: depreciation & amortisation, fixed taxes, insurance
- Variable costs: repair & maintenance, tyres, fuel
- Wages
- Specific costs: licences, inspection,...
- Other costs: overhead & support

The cost levels as illustrated in Table 4-8 and Table 4-9 were calculated:

Table 4-8 Annual road freight operational costs 2015 NL (source: Kostenbarometer Panteia)

Total costs/year	Medium (12 tonne rigid)		Heavy (27 tonne articulated)		
	Piece goods	Container	Tanker/bulk	Piece goods	Container
Fixed costs	€ 16 503	€ 18 077	€ 36 506	€ 28 998	€ 28 998
Variable costs	€ 23 403	€ 28 581	€ 61 487	€ 58 492	€ 60 743
Personnel costs	€ 60 569	€ 69 098	€ 81 569	€ 81 569	€ 81 569
Specific transport costs	€ 569	€ 569	€ 1 149	€ 887	€ 887
Other costs	€ 14 836	€ 10 993	€ 23 672	€ 22 740	€ 16 113
Total	**€ 115 880**	**€ 127 319**	**€ 204 383**	**€ 192 686**	**€ 188 310**

Table 4-9 Annual road freight operational costs per vkm 2015 NL (source: Kostenbarometer Panteia)

Cost/vkm	Medium (12 tonne rigid)		Heavy (27 tonne articulated)		
	Piece goods	Container	Tanker/bulk	Piece goods	Container
Annual mileage	*85000*	*105000*	*125000*	*130000*	*135000*
Fixed costs	€ 0.19	€ 0.17	€ 0.29	€ 0.22	€ 0.21
Variable costs	€ 0.28	€ 0.27	€ 0.49	€ 0.45	€ 0.45
Personnel costs	€ 0.71	€ 0.66	€ 0.65	€ 0.63	€ 0.60
Specific transport costs	€ 0.01	€ 0.01	€ 0.01	€ 0.01	€ 0.01
Other costs	€ 0.17	€ 0.10	€ 0.19	€ 0.17	€ 0.12
Total	**€ 1.36**	**€ 1.21**	**€ 1.64**	**€ 1.48**	**€ 1.39**

Cost components which are likely to be the most affected by AEROFLEX modifications are fixed costs (purchase) and variable costs (fuel).

4.1.2.2.2 DG MOVE study

The DG MOVE study "Case study analysis of the burden of taxation and charges on transport" (Schroten et al., 2017) covers in its appendix E the internal costs of transport in Europe. Specifically for road freight (only long distance transport is covered), it builds on Panteia's Kostenbarometer, but adds the international dimension by correcting the figures for the difference between the Dutch situation and the European average, largely based on economic indicators (price levels, wage scales) provided by EUROSTAT. Transport taxes (the Eurovignette) were removed compared to the figures above, but those only represent 0.6% of total costs.

Table 4-10 Annual road freight operational costs per vkm 2015 EU

Cost/vkm	Heavy (27 tonnes articulated)	
	Tanker/bulk	Container
Annual mileage	*125000*	*135000*
Fixed costs	€ 0.28	€ 0.21
Variable costs	€ 0.50	€ 0.45
Personnel costs	€ 0.51	€ 0.47
Specific transport costs	€ 0.01	€ 0.01
Other costs	€ 0.17	€ 0.08
Total	**€ 1.47**	**€ 1.22**

4.1.2.3 Driving times & speeds

Driving times are not expected to be affected by the AEROFLEX project output, but overall transport times can be reduced, e.g. through the use of automated electric dollies that diminish loading and unloading times.

Furthermore, trends in freight transport such as modal shift to rail for long distances, and reshoring production facilities can affect the average distances, average trip speeds and thus the overall costs of freight transport.

The ETISplus database (Panteia et al., 2012) collected information on distances and travel times between regions (NUTS3 level). While this data is too disaggregated for the purpose of this report, an overview of average travel speeds between European countries provides some useful insight (

Table 4-11).

Table 4-11: Road freight travel speeds between European countries (source: ETISplus + own calculations)

km/h	AT	BE	BG	CH	CY	CZ	DE	EE	ES	FI	FR	GR	HR	HU	IE	IT	LI	LT	LU	LV	MT	NL	NO	PL	PT	RO	SK	TR	UK
AT	53.3	33.7	31.7	37.0	27.2	48.1	36.0	29.3	31.9	26.8	34.1	26.2	25.9	39.4	25.9	38.0	41.7	29.6	32.7	28.9	23.6	33.1	27.3	32.5	30.2	32.1	40.4	28.6	29.6
BE	33.7	60.3	29.9	46.3	27.1	32.8	40.0	28.0	33.1	27.1	40.9	29.0	27.8	31.0	23.5	36.2	38.2	29.4	61.3	29.9	25.4	57.0	27.8	31.8	31.2	30.8	33.9	28.7	32.1
BG	31.7	29.9	60.2	30.9	27.6	32.0	30.8	28.8	30.2	27.1	30.8	31.9	27.4	32.7	26.5	27.9	31.3	30.0	30.3	29.3	17.3	29.3	27.0	30.4	29.2	47.5	34.1	30.2	28.9
CH	37.0	46.3	30.9	62.7	27.8	33.4	39.2	28.0	32.9	26.7	41.6	24.4	27.5	34.1	26.8	43.4	62.6	29.7	57.5	28.6	23.7	33.2	28.6	30.4	31.0	31.2	33.9	28.7	32.0
CY	27.2	27.1	27.6	27.8		27.9	27.2	26.1	27.9	25.5	27.7	22.6	25.3	26.4	25.3	25.4	27.3	26.0	28.4	26.8	20.6	26.8	25.8	26.5	27.8	26.4	26.6	21.7	27.0
CZ	48.1	32.8	32.0	33.4	27.9	59.0	39.8	28.3	31.4	26.7	33.6	29.2	25.5	45.5	25.6	33.3	36.7	31.4	33.5	30.3	23.9	31.7	26.8	37.2	30.1	34.0	53.9	28.9	29.5
DE	36.0	40.0	30.8	39.2	27.2	39.8	45.9	29.3	31.7	26.7	34.9	28.4	26.5	33.1	25.1	34.9	40.0	28.9	44.7	28.9	25.1	40.8	27.8	32.4	30.0	31.0	34.2	28.5	30.1
EE	29.2	28.1	28.8	27.8	26.1	28.2	29.2	63.4	29.0	29.2	28.9	28.3	26.3	30.0	25.5	29.7	27.2	50.7	28.0	60.5	24.4	30.0	21.3	31.7	28.7	29.8	28.7	27.4	27.9
ES	32.0	33.2	30.3	33.0	28.0	31.4	31.8	29.1	38.1	27.8	34.0	26.0	29.2	31.3	24.6	33.9	33.0	29.3	33.3	29.1	26.3	32.3	28.6	30.2	31.3	30.5	31.1	29.1	29.3
FI	26.8	27.1	27.1	26.7	25.5	26.7	26.6	29.2	27.7	41.8	27.4	26.7	25.2	26.9	25.0	27.8	26.6	27.8	26.8	27.6	24.5	27.1	25.2	26.8	27.3	26.9	27.1	26.3	26.6
FR	34.1	40.9	30.8	41.6	27.7	33.6	34.9	29.0	33.9	27.4	45.5	26.0	29.5	32.5	24.5	37.8	39.2	29.5	41.2	29.1	25.9	37.5	28.4	30.9	30.6	31.2	32.7	29.0	30.4
GR	26.2	29.0	31.9	24.4	22.6	29.2	28.4	28.3	26.0	26.7	26.0	26.0	22.6	29.5	26.4	22.0	24.0	27.7	29.1	28.1	15.5	28.7	26.6	28.5	25.9	30.3	29.7	26.6	28.1
HR	25.9	27.8	27.4	27.5	25.3	25.5	26.5	26.3	29.1	25.2	29.5	22.6	15.8	24.4	25.1	28.6	26.2	25.6	27.1	26.2	21.3	26.7	24.8	25.8	28.5	26.0	26.1	26.6	27.7
HU	39.4	31.0	32.7	34.1	26.4	45.5	33.1	30.0	31.2	26.9	32.5	29.5	24.4	54.2	25.9	33.4	33.2	31.2	34.4	28.4	24.0	30.3	26.7	33.3	30.1	37.5	56.7	29.1	29.4
IE	25.9	23.5	26.5	26.8	25.3	25.6	25.1	25.5	24.6	25.0	24.5	26.4	25.1	25.9	60.9	27.9	27.4	25.4	23.5	25.9	24.5	23.3	23.1	25.8	23.8	26.7	26.8	26.6	23.0
IT	38.0	36.3	27.9	43.4	25.4	33.3	34.9	29.7	33.8	27.8	37.7	22.0	28.6	33.4	28.0	48.7	43.9	29.6	36.8	29.3	22.3	35.0	28.6	31.0	31.8	29.6	33.3	26.8	32.3
LI	41.7	38.2	31.3	62.6	27.3	36.6	39.7	27.3	32.9	26.6	39.2	24.0	26.5	33.2	27.4	44.2		29.2	59.0	30.6	23.4	31.6	28.5	31.1	31.4	30.6	32.6	28.4	32.6
LT	29.5	29.4	30.0	29.6	26.0	31.3	28.9	50.8	29.2	27.8	29.5	27.7	25.6	31.2	25.4	29.6	29.2	57.4	29.4	55.1	24.6	28.3	23.6	33.9	28.3	28.9	31.8	27.2	27.8
LU	32.7	61.3	30.3	57.5	28.4	33.5	44.7	27.9	33.0	26.8	41.2	29.1	27.1	34.4	23.5	36.8	59.0	29.4		29.4	27.9	55.4	27.9	31.5	31.3	31.8	35.9	28.9	29.8
LV	28.8	29.9	29.3	28.4	26.8	30.2	28.8	60.5	29.0	27.6	29.1	28.1	26.2	28.4	26.0	29.3	30.5	55.1	29.4	61.6	25.4	29.4	20.9	31.5	28.2	29.1	32.3	27.4	28.0
MT	23.6	25.4	17.3	23.7	20.6	23.9	25.1	24.4	26.3	24.5	25.9	15.5	21.3	24.0	24.5	22.3	23.4	24.6	27.9	25.4		26.0	25.4	24.2	25.7	20.2	24.0	20.1	26.2
NL	33.0	57.0	29.3	33.1	26.8	31.7	40.8	29.9	32.3	27.1	37.4	28.6	26.7	30.3	23.3	34.9	31.6	28.2	55.5	29.4	26.0	60.4	28.0	32.3	31.2	30.2	33.8	28.3	30.0
NO	27.2	27.7	27.0	28.6	25.8	26.8	27.8	21.3	28.5	25.2	28.3	26.6	24.8	26.7	23.1	28.5	28.5	23.6	27.8	20.8	25.4	27.9	35.5	26.4	28.1	26.7	27.0	26.3	25.9
PL	32.5	31.8	30.4	30.4	26.5	37.2	32.4	31.7	30.2	26.8	30.9	28.5	25.8	33.3	25.8	31.0	31.1	33.9	31.5	31.5	24.2	32.3	26.4	47.2	29.1	31.0	37.7	27.7	29.0
PT	30.3	31.2	29.2	31.1	27.9	30.2	30.1	28.8	31.4	27.4	30.8	25.9	28.6	30.2	23.9	31.9	31.4	28.3	31.3	28.2	25.7	31.3	28.1	29.1	24.6	29.8	30.1	28.7	28.1
RO	32.1	30.8	47.5	31.2	26.4	34.0	31.0	29.8	30.5	26.9	31.2	30.3	26.0	37.4	26.7	29.6	30.6	28.9	31.8	29.1	20.2	30.2	26.8	31.0	29.7	58.7	35.7	29.4	29.3
SK	40.4	33.9	34.1	33.9	26.6	53.9	34.2	28.7	31.1	27.0	32.7	29.7	26.1	56.7	26.8	33.3	32.6	31.8	35.9	32.3	24.0	33.8	27.1	37.7	29.9	35.7	66.9	28.9	30.3
TR	28.6	28.7	30.2	28.7	21.7	28.9	28.5	27.4	29.0	26.3	29.0	26.6	26.6	29.1	26.6	26.8	28.4	27.2	28.9	27.4	20.1	28.3	26.3	27.7	28.7	29.4	28.9	27.9	28.1
UK	29.6	32.1	28.9	32.0	27.1	29.5	30.1	27.9	29.3	26.6	30.4	28.1	27.7	29.4	23.0	32.2	32.6	27.7	29.8	28.0	26.1	30.0	26.0	29.0	28.0	29.3	30.3	28.1	51.0

The most important conclusion to be drawn from this table is that average speed drops as the distance between countries increases, which also means that speeds within a country are the highest on average. This is of course due to driving and resting times: a single day journey (e.g. within one of the smaller countries or between neighbouring small countries, such as the Netherlands and Belgium) does not require long resting periods to complete.

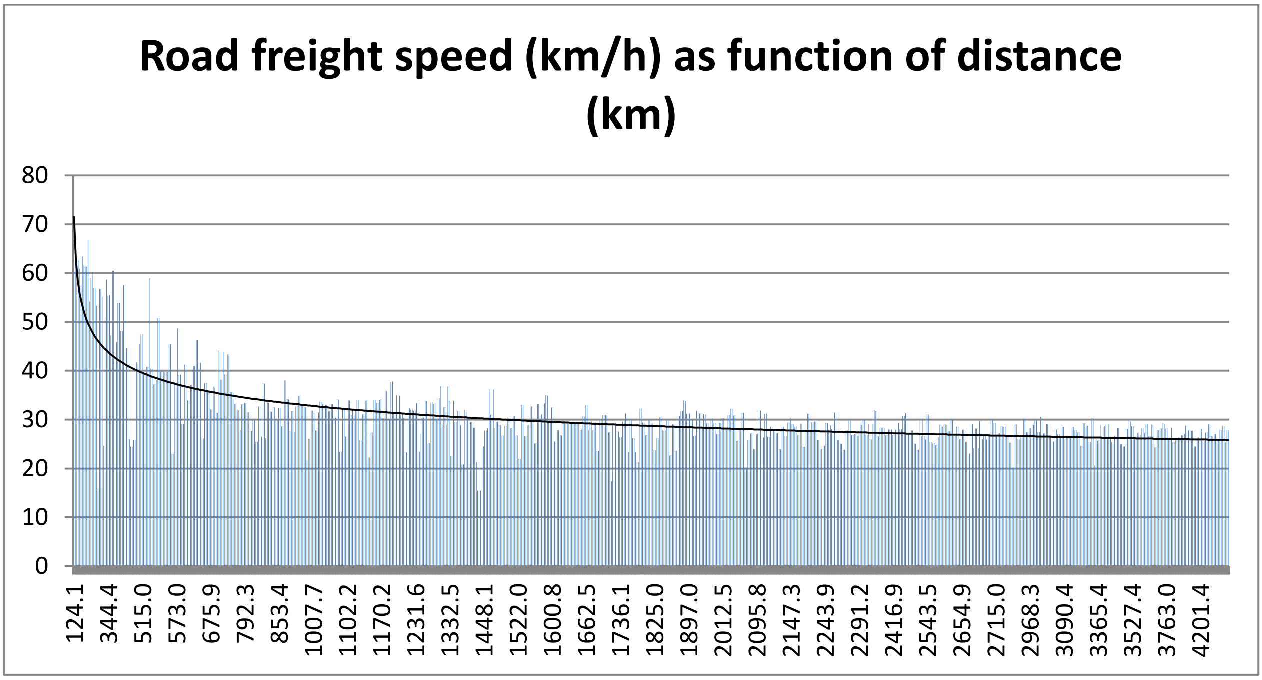


Figure 4-12: Road freight speed as a function of distance (source: ETISplus + own calculations)

Directly linking average speed to distances shows that road freight moves at around 60 km/h for short trips (up to 400 km, which can be covered in one day). Once trips exceed the 800 km threshold, average speed drops to around 30 km/h, and remains at that level for longer trips as well. However, the volume of these very long trips is low.

4.1.3 Market projections

The purpose of this section is to give an overview of available projections of the road freight transport market.

The 2016 EU reference scenario (European Commission, 2016) contains transport projections for all EU28 countries up to 2050, within a multi-model framework covering all aspects of energy, transport and emissions. However, the output of the PRIMES model included in the Annexes of the report is too aggregated to provide much added value. The only direct useful indicator is the growth in total EU28 road freight tkm: from 1915 billion tkm in 2015 to 2446 billion tkm in 2030 (+28%) and 2564 billion tkm in 2035 (+34%).

The OECD-ITF Transport Outlook 2017 (OECD/ITF, 2017) makes projections of the global transport market. Although an important part of the work is the development of quantitative projections, the level of aggregation is too high to be useful for our work, due to modelling limitations. More disaggregated data may become available by early 2019.

The report identifies a number of interesting underlying trends. Specifically for road freight transport, these are:

- Load factor optimisation and reduction of empty running (optimised routing, asset sharing, relaxed delivery windows,…)
- High capacity vehicles
- Autonomous vehicles & the Physical Internet

This matches the findings of D1.1.

These general reports, while references in their field, teach us very little about the domain we are interested in: the evolution of freight transport markets as defined for this project, i.e. per distance class and per commodity type. They are more oriented towards the effects of policy with regard to fuel consumption and fleet evolution, while for AEROFLEX, insight is needed in the demand processes.

A common approach is to derive transport demand from projections of economic activity and trade between countries and regions – as was done using the PRIMES modelling suite for the EU 2016 reference scenario, and also in models such as ASTRA (TRT, MFive, & Fraunhofer ISI, 2018), TRANSTOOLS (DTU et al., 2018), High-Tool (KIT et al., 2016) (all EU), SMILE+ (Bovenkerk, 2005) (NL) and SAMGODS (VTI, 2015) (SE). An investigation of these conversion model methods was performed by Müller, Klauenberg and Wolferman (2014) who also built a proper conversion tool and tested it for Germany. The mentioned models could possibly provide insight in the matter at hand; however, their outputs were not available to the consortium for review.

National sources were then checked for relevant information. Several European national planning agencies make detailed projections approaching the level of detail needed.

For the Netherlands, the Central Planning Bureau (CPB) published projections for freight transport (Romijn et al., 2016), with a time horizon of 2030 and 2050. Using the aforementioned SMILE+ model, freight transport growth rates were projected at the commodity level. It should be noted that these cover all modes, not just road freight.

Table 4-12 Freight transport growth Netherlands per NSTR class (source: CPB)

NSTR	Description	Share of freight transport (2011)	Annual growth 2011-2050 HIGH	Annual growth 2011-2050 LOW
0	Agricultural products and live animals	7%	0.9%	0.2%
1	Foodstuffs and animal fodder	13%	1.0%	0.2%
2	Solid mineral fuels	4%	2.0%	1.3%
3	Petroleum products	7%	0.9%	-0.2%
4	Ores and metal waste	4%	0.6%	0.4%
5	Metal products	3%	2.0%	1.4%
6	Crude and manufactured minerals, building materials	23%	0.4%	-0.3%
7	Fertilizers	3%	0.9%	-0.1%
8	Chemicals	11%	1.3%	0.3%
9	Machinery, transport equipment, manufactured articles and miscellaneous articles	26%	1.4%	0.8%

The strongest growth is projected for NSTR classes 2 (solid mineral fuels) and 5 (metal products), whereas NSTR 6 shows the lowest growth.

The report also mentions that the value/growth ratio is an important reason for the relatively limited increase in transport weight compared to the value of the traded commodities. This fits well within the “decoupling” trend between GDP and transport volume, as was described by (McKinnon, 2007) Furthermore, the CPB also projects the evolution of freight transport (tonnes) in different geographic markets: growth of domestic transport is only 0.5%/year (2011-2030, high scenario), while international transport grows by 1.6%. Per modality, road transport grows the most in absolute terms but only second (to rail) in relative terms, at 1.1%/year (23% over the whole period). The number of trips for road freight grows at a slower pace than the transported tonnes, at 0.6%/year (12% total). This is due to improvements in logistics organisation.

A traffic prognosis for Germany (BVU et al., 2014) up to 2030 was commissioned by the ministry of transport. German road freight transport is expected to grow by 17% between 2010 and 2030 in terms of tonnes, while tkm growth is projected to be 39%. This implies that average trip distance would increase by 19%, from 140km to 167 km.
As for the evolution per good type, the report provides indications based on NST 2007 classification.

Table 4-13: Projected road freight transport growth per commodity type: Germany (Source: BVU)

NST2007	Description	Million tonnes			Billion tkm		
		2010	2030	growth/year	2010	2030	growth/year
1	Products of agriculture, hunting, and forestry; fish and other fishing products	184.6	232.2	1.2%	33.8	51.3	2.1%
2.1.1	Coal	3.8	0.2	-14.3%	0.3	0.1	-4.9%
2.1.2	Lignite	3.6	2.9	-1.1%	0.8	0.9	0.4%
2.2/2.3	Crude petroleum & natural gas	1.2	0.9	-1.7%	0.2	0.2	-0.5%
3.1/3.2	Ores	0.8	1.1	1.8%	0.2	0.4	3.6%
3.3	Fertilizers	4.1	4.4	0.3%	0.4	0.4	0.9%
3.5	Stone, sand, gravel, clay, peat and other mining and quarrying products n.e.c.	862.3	893.5	0.2%	28	34.1	1.0%
4	Food products, beverages and tobacco	341.7	442.1	1.3%	66.8	96.4	1.8%
5	Textiles and textile products; leather and leather products	21.1	27.9	1.4%	6.8	9.3	1.6%
6	Wood and products of wood	166.4	207.2	1.1%	42.2	57.1	1.5%
7.1	Coke oven products	7.1	0.5	-12.5%	1	0.3	-5.7%
7.2	Liquid refined petroleum products	90.6	71.6	-1.2%	9.4	8.3	-0.6%
8	Chemicals, chemical products, and man-made fibers; rubber and plastic products; nuclear fuel	167.5	206.2	1.0%	34.1	45.8	1.5%
9	Other non-metallic mineral products	322.1	375.6	0.8%	36	50.1	1.7%
10	Basic metals; fabricated metal products, except machinery and equipment	174	223.8	1.3%	38.4	55.3	1.8%
11	Machinery and equipment	76	97.3	1.2%	19.5	26.6	1.6%
12	Transport equipment	91.4	116.9	1.2%	21.2	29.4	1.7%
13	Furniture; other manufactured goods n.e.c.	20.9	28	1.5%	6.4	9.4	1.9%
14	Secondary raw materials; municipal wastes and other wastes	254	267.8	0.3%	21.6	27.8	1.3%
15	Mail, parcels	35.2	44	1.1%	8.1	11.2	1.6%
16	Equipment and material utilized in the transport of goods	87.1	115.6	1.4%	14.7	22.1	2.0%
17	Goods moved in the course of household and office removals; baggage and articles accompanying travellers; motor vehicles being moved for repair; other non-market goods n.e.c.	39.1	49.7	1.2%	5.9	8.7	1.9%
18	Grouped goods	114.8	154.5	1.5%	29	41.7	1.8%
19	Unidentifiable goods	46.8	75.2	2.4%	12.4	20.4	2.5%
	Sum	**3116.2**	**3639.1**	**0.8%**	**437.2**	**607.3**	**1.7%**

The largest growth is projected for class 19 “unidentifiable goods” (+2.4%/year tonnes, +2.5% tkm), as this includes combined transport goods, which involve a lot of intermediate goods, moved between specialised production facilities. Very notable is the decrease of fossil energy products like coal, lignite and refined oil products. The overall transport volumes of these goods go down, the decrease is strongest on road. On rail and inland ship, transport volumes remain near their 2010 level.

The projection based on geographic market is similar to that for the Netherlands: slow growth in domestic transport (+0.5%/year), much faster growth in international transport (+2.1%/year) for transport volumes in tonnes. Expressed in tkm, the difference is smaller due to the higher domestic increase (+1.3%/year), with international performance more or less equal to the volume increase. We can conclude that international travel distances remain the same, but trips within Germany will be longer.

For France, the ministry of sustainable development (Pochez et al., 2016) published long term projections for transport demand in 2016. Freight transport as a whole is expected to grow by 2.1%/year between 2012 and 2030. Geographically, the French projection is in line with those of Germany and the Netherlands, expecting stronger growth in tonnes transported as transport distance increases (2.2% annual growth in international transport, 1.7% in interregional transport, 1.4% in intraregional transport – all modes).

Evolution per commodity type is classified per NSTR class.

Table 4-14: Freight transport growth France per NSTR class (source: French ministry of sustainable development)

NSTR	Description	Growth tonnage	Growth tkm
0	Agricultural products and live animals	2.0%	2.1%
1	Foodstuffs and animal fodder	1.5%	1.8%
2	Solid mineral fuels	-2.4%	-1.9%
3	Petroleum products	-1.8%	-1.5%
4	Ores and metal waste	0.7%	1.1%
5	Metal products	2.1%	2.2%
6	Crude and manufactured minerals, building materials	1.3%	1.3%
7	Fertilizers	0.8%	0.8%
8	Chemicals	2.1%	2.5%
9	Machinery, transport equipment, manufactured articles and miscellaneous articles	2.7%	2.9%
Total		**1.6%**	**2.1%**

NSTR class 9 is projected to grow the most, which is in line with the German projection, as is the decrease in transport of solid mineral fuels (NSTR 2) and petroleum products (NSTR 3). Growth in tkm is stronger than in tonnage, again confirming the trend that transport distances will increase. Still, vkm are only expected to increase by 1.4%, which supports the assumption of logistics optimisation to increase load factors.

The last country level projection that was found covers Belgium (Federaal Planbureau, 2015). This publication projects that total tonnage (all modes) will increase by 1.9% annually (2012-2030), with tkm increasing by 2.1%. Domestic tkm would grow by 1.9%, while international transport grows by 2.3% - again in line with the trend of the other national projections of longer transport distances. Most of the tkm growth is expected in non-road modes however, with road freight only expected to increase by 1.8% annually. Road congestion is seen as the main reason for this. Road freight vkm increase by 1.5%/year.

As for the split per commodity type, the report applies a different grouping of categories. While based in NST2007 (like the German projections), the classes 5, 6, 11 and 13-20 are grouped as a single “other” category”.

Table 4-15: Projected total freight transport growth per commodity type: Belgium (Source: Federal Planning Bureau)

NST2007	Description	Million tonnes			Billion tkm		
		2012	2030	growth/year	2012	2030	growth/year
1	Agricultural products	45.3	47.4	0.24%	4.07	4.25	0.22%
2	Coal & Lignite	15.8	14.2	-0.58%	0.83	0.72	-0.73%
3	Ores	135.0	168.6	1.17%	9.77	12.64	1.37%
4	Foodstuff	82.8	134.0	2.57%	8.46	13.55	2.51%
7	Cokes & petroleum products	58.5	58.2	-0.03%	3.28	3.34	0.10%
8	Chemicals	69.8	112.1	2.52%	6.73	10.97	2.61%
9	Minerals	57.0	81.4	1.90%	5.56	8.16	2.05%
10	Metal	58.0	102.7	3.06%	5.95	10.74	3.16%
12	Transport means	15.1	30.5	3.77%	1.33	2.67	3.73%
Other	Other goods	300.1	425.8	1.86%	19.44	27.45	1.83%
	Sum	**837.4**	**1174.9**	**1.80%**	**65.40**	**94.50**	**1.96%**

The decrease for coal, lignite (NST2) and petroleum products (NST7) again appears. For Belgium, it is the strongest for the export volume. The strongest increases are for metal products (NST10) and transport means (NST12), again driven by strong growth in international volumes. Noteworthy but not necessarily important is the relatively small difference in tonnage and tkm evolution: as only km driven within the country are counted, distances are unlikely to increase much in a small country.

The conclusion from these market projections is that solid fuels and petroleum products are expected to grow the least, or even see a decrease in transport volumes, due to the fact that these fossil energy sources are slowly being phased out. The only country projection which estimates growth for these categories is the Dutch projection. However, this is likely due to the fact that the Dutch projection covers all modes and the country has a very high market share in inland waterway transport, which is well suitable to transport these commodities with low value density; it should also be mentioned that the market share of these goods is already relatively small (11% total).

The strongest growth is expected in the grouped and miscellaneous goods, which represent e.g. containers and groupage activities. All identified national projections agree that tkm growth will be higher than tonnage growth, and that the international transport market will grow more than the domestic market. This implies that average transport distances will keep increasing. While modal shift for journeys of at least 300 km may remain an important strategy in the European policy, longer distances by road (as unimodal trip or as part of a multimodal chain) are still projected by the German model.

There is however also an agreement on the lower growth projection for trips and vkm, suggesting that logistics optimisation will improve load factors. The involvement of 3PL and 4PL in synchromodal operations, trends identified in AEROFLEX D1.1, allow for more groupage activities and better coordination of supply chains, which may lead to more cargo per vehicle.

As a final remark, it needs to be mentioned that the conclusions of these quantitative projections at the country level do not necessarily match with those made by forward looking projects that introduce trend breaks in the logistic sector, such as ALICE with the concept of the Physical Internet. The new trends underlying these (non-quantitative) projections are nonetheless interesting to consider, and they were covered in AEROFLEX D1.1. Generally speaking, there would be a return to more local activity, in sourcing (original or recycling), production and thus also in transport, which would then lead to lower growth (or even a decrease) in distance travelled by road freight vehicles (lower trip distances – not necessarily lower total mileage). The ALICE objective is to achieve a transport reduction of 30% by 2030, while also improving vehicle utilisation, reducing empty running, optimising transport routes and promoting synchromodality. Further research into the impact of the Physical Internet on logistics processes will be conducted for D1.3.

Whereas these trends could certainly interfere to some extent with the national projections presented above, the main lesson with regard to market developments is still valid: the strong growth in grouped and miscellaneous goods fits well within the consolidation idea that underlies the concept of the Physical Internet. The use (and therefore the transport) of some primary materials (like petroleum products and ores and metal waste) is likely to decrease as more local (re)use of materials takes place, as part of a cradle-to-cradle product design concept. The difficulty to quantify logistics trends at the level of aggregation provided by the national projections is likely the main reason for the different conclusions with regard to distances, but in general, the conclusions can be aligned with each other.

4.2 Logistics operations

This section describes the results of the assessment of the nominal potential of EMS vehicles concepts (Prime Candidates) in every day transportation operations as substitute for current vehicles according to directive EC96/53 (European Union, 1996) and the amendment EC2015/719 (European Union, 2015). Two different approaches were used to evaluate a) the technical applicability of prime candidates in common logistics applications, i.e. the question if those vehicle concepts fulfil features needed and comply with existing prerequisites and constraints, and b) possible benefits of the use of prime candidates in terms of transport costs, fuel consumption and CO_2 emissions in comparison to current vehicle concepts.

4.2.1 Stakeholder Survey

172 stakeholders of logistics service providers, fleet managers and shippers contributed to the online survey. However, 82 stakeholders completed the survey. Some data are not realistic and overall 74

data sets could be evaluated. Therefore, we have to consider that these data sets are suitable to gain insight into the road freight market based on a number of stakeholders related to their demand. Otherwise, the comparatively limited data sets do not allow us to derive conclusions for the whole European road freight market. Nevertheless, the data are the basis for understanding road freight operations and comparing the input with other results coming from the literature and EUROSTAT data analyses and the workshop with stakeholders.

Twelve stakeholders conduct freight transport for their business and 62 stakeholders are offering road freight transport services. We received 50 data sets from stakeholders coming from Germany, 15 stakeholders from Turkey, four data sets from the Netherlands and five from other stakeholders in EU member countries. All stakeholders operate in road freight transport, 15 stakeholders also have rail freight transport in their market portfolio, ten stakeholders inland navigation transport, twelve stakeholders maritime transport and nine stakeholders air transport.

The majority (38) of the stakeholders operate full load shipping (FTL), 23 stakeholders indicate part load shipping (LTL) and eleven stakeholders are active in bulk transport (Figure 4-13). 18 stakeholders are active in the other three logistics segments: (i) special haulage, (ii) heavy haulage, and (iii) courier, express and parcel segment (Figure 4-13).

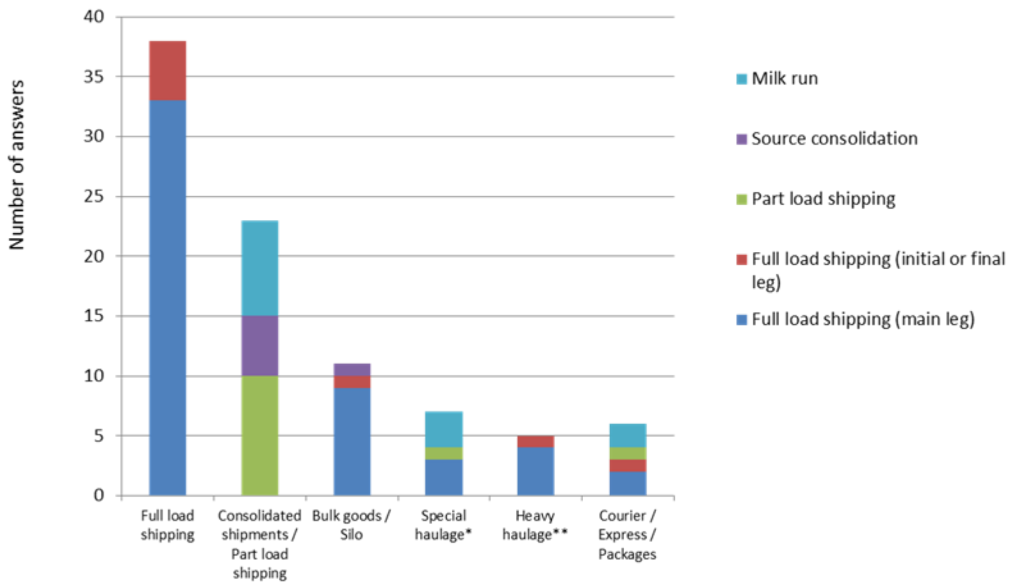


Figure 4-13: Number of logistics segments in the survey data set

The following Table 4-16 indicates several combinations of different route types (e.g. full load shipping, milk run) and different vehicle sizes. The stakeholders were asked to choose one or more vehicle sizes, which they use at their route types (multiple answers were possible).

Table 4-16: Route types in relation with the vehicle permissible laden weight

	7.49 - 11.99 tonnes permissible laden weight	12 - 17.99 tonnes permissible laden weight	≥18 - 42 tonnes permissible laden weight	>42 tonnes permissible laden weight
Full load shipping (main leg)(n= 50)	5	5	38	16
Full load shipping (initial or final leg) (n=7)	3	2	4	5
Part load shipping (n=12)	4	3	9	0
Source consolidation (n=6)	3	2	6	1
Milk run (n=13)	7	8	11	2

n – number of stakeholders that indicated this route type (multiple answers were possible)

The majority of stakeholders consider full load shipping (57 stakeholders) and a lot of those use vehicles with a permissible laden weight more than 18 tons. Milk run tours are conducted by 13 stakeholders. Therefore, the following data evaluation is focused on both logistics segments. Conclusions for the other logistics segments are not reliable due to the low number of nominations. The tour length of full load shipping tours has a high standard variation. The mean value is 815.75 km and the median only 454 km. The trip length of 75% of the trips has a maximum of 545 km. The mean trip length of milk runs is substantially shorter with 212.11 km and a median of 200 km.

Table 4-17: Tour length full load shipping and milk run

		Full load shipping (main leg)	Milk run
n		40	9
Mean		815.75	212.11
Median		454	200
Standard deviation		1232.24	112.35
Minimum		**34**	**54**
Maximum		**5000**	**400**
Percentile	25	170.00	109.5
	50	454.00	200.00
	75	545.00	303.00

n – number of stakeholders that indicated this route type (multiple answers were possible)

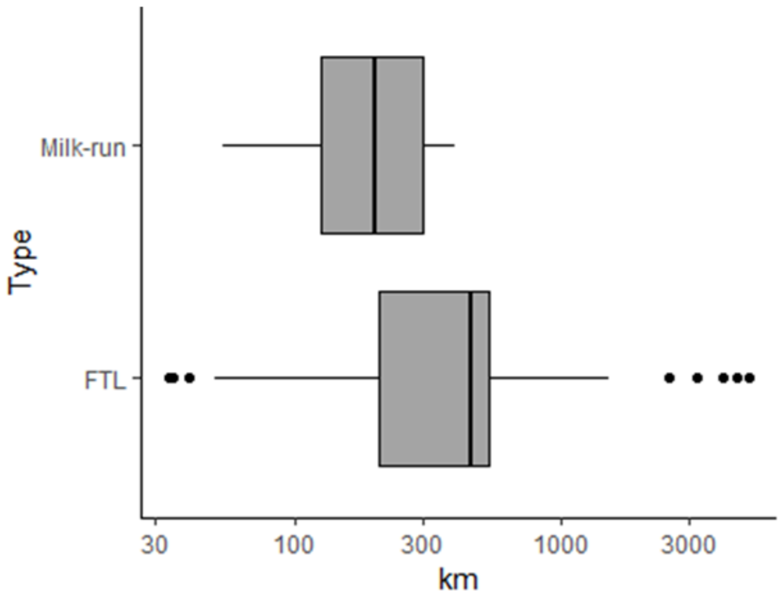


Figure 4-14: Boxplot of the average trip distance

It is conspicuous that the standard deviation is very high in the data for FTL. This could be explained by splitting of the data set by regions.

Table 4-18: Tour length full load shipping by regions of participants

	Germany n=50	other countries n=24	all countries n=74
Mean	356.31	2.653.5	815.75
Standard deviation	284.26	1.810.29	1232.24

The table shows that the data of the other countries indicates a quiet higher mileage than the data coming from German participants. Due to this specific characteristic, the evaluation of all data indicates that the standard deviation is higher than the mean.

The amount of the total vehicle mileage of all cases is about 8.8 billion kilometres, at which FTL represents 6.7 billion kilometres – 77%. This means that the vehicle concepts should be mostly allocated to the logistics segment FTL for a high potential impact on CO_2 emission reduction. The relation between median and standard deviation is caused by the different regions the participants came from. The annual mileage of vehicles indicated by participants coming from Germany or from other EU countries and Turkey is different. Due to the limited number of data sets, we have to consider this particular result.

Table 4-19: Amount of annual vehicle-kilometres (in million vkm) of all cases in the data set

		Full load shipping (main leg)	Milk run	total
n		47	10	68
Mean		143.94	25.34	129.38
Median		6.48	5.50	5.98
Standard deviation		672.29	45.08	571.99
Minimum		0.03	0.22	0.0003
Maximum		4600	132.15	4600
Sum		6765.09	253.41	8797.95
Percentile	25	0.88	1.25	0.92
	50	6.48	5.50	5.98
	75	37.00	32.10	20.90

n – Number of stakeholders that indicated this route type

Within the online survey, input was requested related to load factors, weight, volume and loading metres. For FTL the mean value is 80% related to the weight, about 78.5% related to the volume and 77.7% related to the loading metres. However, not all respondents gave input about all three parameters. It could be concluded that the load factor is quiet high for the FTL data due to the high mean value and the small value of the standard deviation.

For the milk runs the mean of loading metres was the highest with 84%. The mean of the parameter volume is 80% and the mean of weight is 77%. We could consider that the load factor in our sample is high for both logistics segments full load shipping and milk run. The most relevant parameter for full load shipping is the weight and for milk run the load metres. It should be noticed that for the milk runs nine data sets were evaluated. This number of nominations is quiet low to make valuable conclusions.

Table 4-20: Load factors of the tours

	Full load shipping (main leg)		
	tonnes	m³	loading metres
n	47	42	45
Mean	79.43	77.70	78.47
Standard deviation	21.40	22.07	23.23
Minimum	20.00	20.00	10.00
Maximum	100.00	100.00	100.00

	Milk run		
	tonnes	m³	loading metres
n	9	9	8
Mean	76.67	80.00	84.38
Standard deviation	11.46	10.30	5.63
Minimum	60.00	60.00	75.00
Maximum	90.00	90.00	90.00

x

n – number of stakeholders that indicated this route type (multiple answers were possible)

The majority of participants indicated that they carry out their freight transport by using tractor semitrailer combinations. Rigid or rigid trailer combinations are used for some milk runs.

The data evaluation shows a mixed picture concerning the transported types of goods (Table 4-21).

Table 4-21: Cargo groups transported by stakeholders of the survey (n=74)

Goods category	Number of yes responses	Goods category	Number of yes responses
Agricultural and forestry products	11	Other mineral products (glass, cement, gypsum, etc.)	14
Hard coal	2	Metals and metal products	18
Brown coal	1	Machinery and equipment, household appliances, etc.	21
Crude oil and natural gas	1	Vehicles	7
Ores	2	Furniture, jewellery, musical instruments, sports equipment, etc.	5
Fertilisers	7	Secondary materials, waste	8
Stones and earths, other mining products	10	Post, parcels	2
Foodstuffs, drinks and tobacco	22	Goods forwarding equipment and materials	6
Textiles, clothing, leather and leather goods	13	Removal items and other goods not intended for the market	0
Wooden goods, paper, cardboard, printed matter	21	Consolidated cargo	12
Coke	0	Unknown goods category	0
Petroleum products	4	Other goods	14
Chemical products	15		

n – number of stakeholders that indicated this route type (multiple answers were possible)

The types of goods ‚Foodstuffs, drinks and tobacco‘ (22 nominations), ‚Wooden goods, paper, cardboard, printed matter‘ and ‚Machinery and equipment, households, appliances, etc.’ (both 21 nominations) as well as ‚Metals and metal products‘ (18 nominations) are most frequently mentioned . 40% of all cargo transported by the respondents of the online survey is assigned to these four types of goods. If we add the next four types of goods in our table list, then 76% of all transported cargo is allocated to these eight types of goods. Based on the online survey, it could be concluded that these types of goods show a high potential for vehicles with an improved efficiency in road transport by new vehicle concepts. There is a similarity with data from EUROSTAT that were evaluated in WP1.

The last questions of the survey asked,

- if the stakeholders already considered longer/heavier (>44 tonnes / >18.75 m) vehicles: 37.9 % indicate no and 62.1 % yes (n=58);
- how high would they rate for being able to make economic use of vehicles with more loading metres than are currently possible (e.g. more shipping units per vehicle / >18.75 m),): 17.5% low; 17.5 % rather low; 19.3 % neutral; 24.6% rather high; 21.1 % high (n=57);
- how high would be the stakeholders rate being able to make economic use – of vehicles with a higher tonnage (>44 tonnes) than is currently permitted by law: 21.1% low; 21.1% rather low; 19.3% neutral; 21.1% rather high; 17.5 % high (n=57).

To finalise the survey, the stakeholders were asked to rank twelve requirements regarding EMS vehicles in order of relevance, with number 1 being the most important requirement. Table 4-22 summarises the overall ranking from the most important to the lowest.

Table 4-22 Ranking of criteria to use EMS and estimated likelihood to meet criteria

impor-tance	criteria, that have to be met before you would consider using EMS vehicles	Rank (weighted average)	likelihood to meet the criteria by EMS[1)]
1	Vehicles are compatible with transportation infrastructure	4.4	57.6%
2	Lower transport costs	4.8	51.7%
3	Increasing transport volumes	5.24	63.3%
4	Increase in turnover	5.29	49.5%
5	Vehicles offer appropriate carrying capacity	5.31	58.2%
6	Vehicles allow the desired service level to be achieved	5.6	62.5%
7	No increased investment costs	6.4	30.0%
8	No negative impact on the traffic situation	6.9	61.2%
9	Adherence to specified delivery dates	7.4	56.5%

10	Willingness to cooperate (among consignors and among logistics companies)	7.6	43.5%
11	Public acceptance of new vehicles	8.48	42.6%
12	Ability to integrate them into IT systems (supply chain integration)	8.54	66.0%

1) answers were given in percent and averaged (number of responds between n=44 - 53)

The likelihood that the criteria could be met by EMS is considered as lowest regarding that investment costs will not increase and regarding the public acceptance. There is a high expectation, that EMS can be integrated in IT systems (supply chain integration) and that the transport volume is increasing.

4.2.2 Expert Interviews

4.2.2.1 Achieved Coverage of Market Sectors

Chapter 2.2.2 showed an overview of the targeted market sectors that should have been covered with one of the collected use cases (see Table 4-23). As mentioned earlier only convenience sampling was possible, which lead to the situation that not all selected market segments could be covered until September 2018. On the other hand several use cases could be collected for which participants considered EMS as a feasible and advantageous technology. These sectors added up to an overall market coverage of about 35% to 42% that could be achieved for the single KPIs to this state (see Table 4-23). For each of the stated sector at least one use case could be collected. The partners of WP1 agreed to continue conducting expert interviews to further improve market coverage and thus improve data quality for later tasks in the project until mid of 2019. The according results will be incorporated in the coming deliverable of WP1.

Table 4-23 Achieved coverage of market sectors

No.	NST Category	Distance [km]	VKM [%]	Ton [%]	TKM [%]	BTO [%]
Target sectors covered						
1	Products of agriculture, hunting, and forestry; fish and other fishing products	500 - 999	1.78	0.42	1.98	0.31
3	Metal ores and other mining and quarrying products; peat; uranium and thorium	< 50	1.56	18.5	2.37	1412
		50 - 149	1.27	4.22	2.46	2.11
4	Food products, beverages and tobacco	< 50	0.74	3.32	0.57	3.78
		50 - 149	3.27	3.87	2.51	4.16
		150 - 299	4.43	2.78	4.00	2.54
		300 - 499	3.30	1.46	3.69	1.07

		500 - 999	3.04	0.83	3.84	0.56
18	Grouped goods: a mixture of types of goods which are transported together	150 - 299	2.51	1.43	2.01	1.39
		300 - 499	2.27	0.87	2.13	0.74
		500 - 999	2.53	0.58	2.56	0.46
Targeted coverage per KPI			**38.99**	**63.97**	**41.36**	**59.87**
Achieved coverage per KPI			**26.70**	**38.33**	**28.12**	**31.23**
Additional covered sectors						
4	Food products, beverages and tobacco	2.000 - 5.999	0.59	0.04	0.77	0.03
10	Basic metals; fabricated metal products, except machinery and equipment	150 - 299	1.2	0.74	1.19	0.67
10	Basic metals; fabricated metal products, except machinery and equipment	300 - 499	1.12	0.45	1.30	0.36
10	Basic metals; fabricated metal products, except machinery and equipment	500 - 999	1.46	0.35	1.81	0.26
11	Machinery and equipment n.e.c	300 - 499	0.59	0.16	0.44	0.19
12	Transport equipment	50 - 149	0.41	0.39	0.26	0.55
12	Transport equipment	150 - 299	0.71	0.34	0.53	0.40
12	Transport equipment	500 - 999	1.32	0.22	1.10	0.22
12	Transport equipment	1.000 – 1.999	1.18	0.10	1.07	0.10
18	Grouped goods: a mixture of types of goods which are transported together	<50	0.33	1.19	0.19	1.74
20	Other goods n.e.c.	300 – 499	0.68	0.14	0.74	0.12
20	Other goods n.e.c.	500 – 999	0.68	0.14	0.74	0.12
Achieved additional coverage			**10.27**	**4.26**	**10.15**	**4.77**
Total coverage			**36,97**	**42,59**	**38,27**	**35,99**

The further effort to collect use cases will therefore be focused on the following missing market sectors (Table 4-24).

Table 4-24 Additional market sectors to be covered

No.	NST Category	Distance [km]	VKM [%]	Ton [%]	TKM [%]	BTO [%]
1	Products of agriculture, hunting, and forestry; fish and other fishing products	< 50	0.47	2.89	0.50	2.77
		50 - 149	1.69	3.08	1.99	2.32
		150 - 299	2.00	1.61	2.30	1.18

4	Food products, beverages and tobacco	1.000 – 1.999	1.55	0.20	2.07	0.14
8	Chemicals, chemical products, and man-made fibers; rubber and plastic products ; nuclear fuel	500 - 999	1.51	0.36	1.84	0.27
9	Other non-metallic mineral products	< 50	0.97	7.38	1.02	7.56
		50 - 149	1.31	2.53	1.62	1.88
14	Secondary raw materials; municipal wastes and other wastes	< 50	0.85	4.50	0.57	6.17
		50 - 149	1.32	2.16	1.19	1.88
16	Equipment and material utilized in the transport of goods	< 50	0.63	0.93	0.14	4.47
	Targeted additional coverage by KPI		**12.30**	**25.64**	**13.24**	**28.64**

4.2.2.2 Description of the Collected Use Cases

Overall we were able to gather 25 different use cases, i.e. individual transports defined by a route, sources and sinks and its load. Some of the use cases consisted of several different legs, i.e. the type of route, the vehicle or transport mode changed in the course of the transport. These legs are treated and analysed as separate transports with an overall number of 34 legs. The use cases involved 17 countries either as origin, destination or as transit country (D, NL, SU, AT, LU, F, ES, TR, BG, SRB, HU, SK, CZ, SW, DK, B, IT). 21 of the available 27 Prime Candidates (see appendix D) have been chosen as possible vehicle concepts to be used in these transports.

As in particular the fuel consumption simulations required extensive effort to deliver high quality data, we were not able to analyse all gathered use cases in time for this report. In order to further improve quality of data, cover the remaining market sectors and broaden the information basis for recommendations, it was decided to not only deliver the rest of the already available use cases in a later deliverable, but also to continue conducting expert interviews and gathering use cases until approximately mid of 2019.

Based on the above described situation a total of 15 use cases with 18 different legs and 15 chosen Prime Candidates could be analysed so far. This resulted in 51 analysed combinations of tour, vehicle and load variants. Table 4-25 and Table 4-26 displays an overview of the stated combinations of Prime Candidates with goods category according to NST2007 (European Union, 2007) and distance category and with logistics sector and type of route. For an overview of the Prime Candidates please see appendix D.

Table 4-25 Overview of Prime Candidates per goods category and distance

No.	Category	Distance	Prime Candidates
1	Products of agriculture, hunting, and forestry; fish and other fishing products	500 - 999 km	6.1
3	Metal ores and other mining and quarrying products; peat; uranium and thorium	< 50 km	1.1, 1.3
		50 - 149 km	1.1, 1.3

4	Food products, beverages and tobacco	< 50 km	3.2, 3.3, 6.3
		50 - 149 km	1.4, 3.4, 4.3
		150 - 299 km	1.4, 3.4, 4.1, 4.3, 5.1, 5.3
		300 - 499 km	3.2, 3.3, 6.3
		500 - 999 km	6.1, 6.2
		2 000 - 5 999 km	1.4, 3.4, 4.3
10	Basic metals; fabricated metal products, except machinery and equipment	150 - 299 km	6.1
		300 - 499 km	1.4, 4.4, 4.7
		500 - 999 km	6.1
11	Machinery and equipment n.e.c.	300 - 499 km	3.2, 4.5, 6.1
1	Transport equipment	50 - 149 km	6.1, 6.2
		150 - 299 km	1.2
		500 - 999 km	6.1, 6.2
		1 000 - 1 999 km	4.3
18	Grouped goods: a mixture of types of goods which are transported together	< 50 km	2.2
		150 - 299 km	1.2, 4.1, 6.1
		300 - 499 km	3.1, 4.3, 6.1
		500 - 999 km	1.4, 3.2, 4.2, 4.5, 5.3, 6.1
20	Other goods n.e.c.	300 - 499 km	2.1, 2.2, 4.5
		500 - 999 km	2.1, 2.2, 4.5

Table 4-26 Overview of prime Candidates per market sector, route type

Market Sector	Route Type	Prime Candidates
Bulk	FTL - Main run	1.1, 1.3
CEP	FTL - Main run	3.2, 4.5, 6.1
Consolidated Cargo / LTL	FTL - Main run	3.1, 4.1, 4.3, 6.1
Consolidated Cargo / LTL	FTL - Pre/Onward	1.2
Consolidated Cargo / LTL	Milk Run	2.1, 2.2, 4.5, 6.1
Consolidated Cargo / LTL	Source Consolidation	6.1
FTL	FTL	6.1, 6.2
FTL	FTL - Main run	1.2, 1.4, 3.2, 3.3, 4.2, 4.4, 4.5, 4.7, 5.3, 6.1, 6.2, 6.3
FTL	FTL - Pre/Onward	4.1, 5.1,.5.3
Special transport	FTL - Main run	1.4, 3.4, 4.3
Special transport	LTL	1.4, 3.4,.4.3
Special transport	Milk Run	2.2

For each use case the vehicle that currently serves the tour has to be stated. Thus it is possible to link a current vehicle or combination to one or several Prime Candidate(s) that are supposed to be used in the according use case. This can be seen in Table 4-27 below. For an overview of the prime candidates see appendix D.

Table 4-27 Link between Prime Candidates and current vehicle concepts per logistics sector and route type

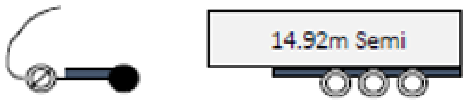
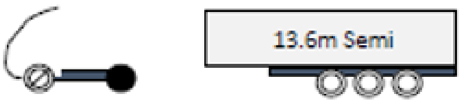
Logistics Sector	Route Type	Reference	Prime Candidates
Bulk	FTL - Main run	2-axle tractor with 3-axle semi-trailer	1.1, 1.3
		3-axle rigid with 2-axle trailer	1.1, 1.3
CEP	FTL - Main run	3-axle rigid with 2-axle trailer	3.2, 4.5, 6.1
Consolidated Cargo / LTL	FTL - Main run	2-axle tractor with 3-axle semi-trailer	4.3, 6.1
Consolidated Cargo / LTL	FTL - Main run	2-axle rigid with 2-axle trailer	3.1, 4.1, 4.3, 6.1
Consolidated Cargo / LTL	FTL - Pre/Onward	2-axle tractor with 3-axle semi-trailer	1.2
Consolidated Cargo / LTL	Milk Run	2-axle tractor with 3-axle semi-trailer	6.1
		2-axle rigid	2.1, 2.2, 4.5
Consolidated Cargo / LTL	Source Consolidation	2-axle tractor with 3-axle semi-trailer	6.1
FTL	FTL	2-axle tractor with 3-axle semi-trailer	6.1, 6.2
FTL	FTL - Main run	2-axle tractor with 3-axle semi-trailer	1.2, 1.4, 3.2, 3.3, 4.2, 4.4, 4.7, 6.1, 6.2, 6.3
FTL	FTL - Main run	3-axle rigid with 2-axle trailer	3.2, 4.5, 5.3, 6.1
FTL	FTL - Pre/Onward	2-axle rigid with 2-axle trailer	4.1, 5.1, 5.3
Special transport	FTL - Main run	2-axle tractor with 3-axle semi-trailer	1.4, 3.4, 4.3
Special transport	LTL	2-axle tractor with 3-axle semi-trailer	1.4, 3.4, 4.3
Special transport	Milk Run	3-axle rigid with 2-axle trailer	2.2

As load consolidation supposedly is a key factor to the use of EMS vehicles an index figure was calculated, that serves as indicator whether a use case represents rather a tonnage transport or a volume / loading meter transport.

4.2.2.3 Preferred Prime Candidates

Interviewees were also asked to select Prime Candidates per logistics segment and route type combination which, in their opinion, could be used in their daily business providing biggest potential for economical and logistical benefits. The 229 votes cast were spread over 24 of the available 27 Prime Candidates. 55% of the votes were given to the following 6 Prime Candidates in descending order of vote share: 2.1,.3.1,.6.1,.1.4,.4.7 and 2.2 (see also Table 4-28). The shares ranged from 10,9% to 6,6%. An additional 10,9% was achieved by Prime Candidate 1.3, which is a standard 4x2 tractor unit with a 13,62m semi-trailer. Three candidates didn't get any vote (4.6, 5.4, 5.5). The remaining candidates achieved shares between 0,4% and 5,2% (for reference of the Prime Candidates see Appendix D).

Table 4-28 Share of votes of preferred Prime Candidates

No.	Prime Candidate	Share of votes
2.1		10,9 %
3.1		10,9 %
6.1		10,5 %
1.4		9,2 %
4.7		7,0 %
2.2		6,6 %
1.3		10,9 %

As described above the interviews were conducted under the premise that no regulatory limits shall be regarded. One exception was made in this respect for the axle loads, as they have to be fixed to comply with current legislation to avoid any increase in road wear and tear or bridge stain. This also included the allocation of GCW to driven axels as explained in chapter 3.2.2.4. Therefore no primary data were collected regarding axle formula, especially on the differentiation between 6x2 and 6x4 rigid trucks and truck tractors. The recommendation of this deliverable will be to examine the revocation of the 25% limit and to further address this subject in later stages of the project.

Most votes were allocated to the logistics sectors FTL (41%) and LTL (24,9%) as can be seen in Figure 4-15. Within these two sectors the votes were distributed over the route types FTL main run and pre- and onward carriage (30,1%), distribution runs (source consolidation and milk run) 21,8% and LTL (14%). The remaining logistics sectors (special haulage, bulk goods, CEP, heavy haulage) reached shares of 2,2% up to 9,6% with minor shares for the specific route types (see Figure 4-16). The strong focus isn't necessarily representative for the market. This may well be an effect of the sample composition and should come under scrutiny in later steps of the AEROFLEX project or even in future projects.

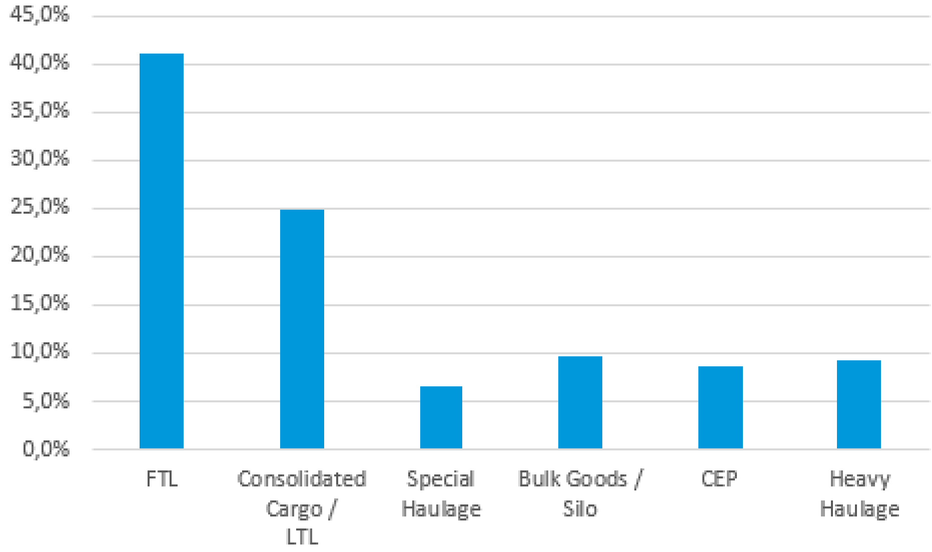


Figure 4-15 Distribution of votes for preferred Prime Candidates per logistics sector

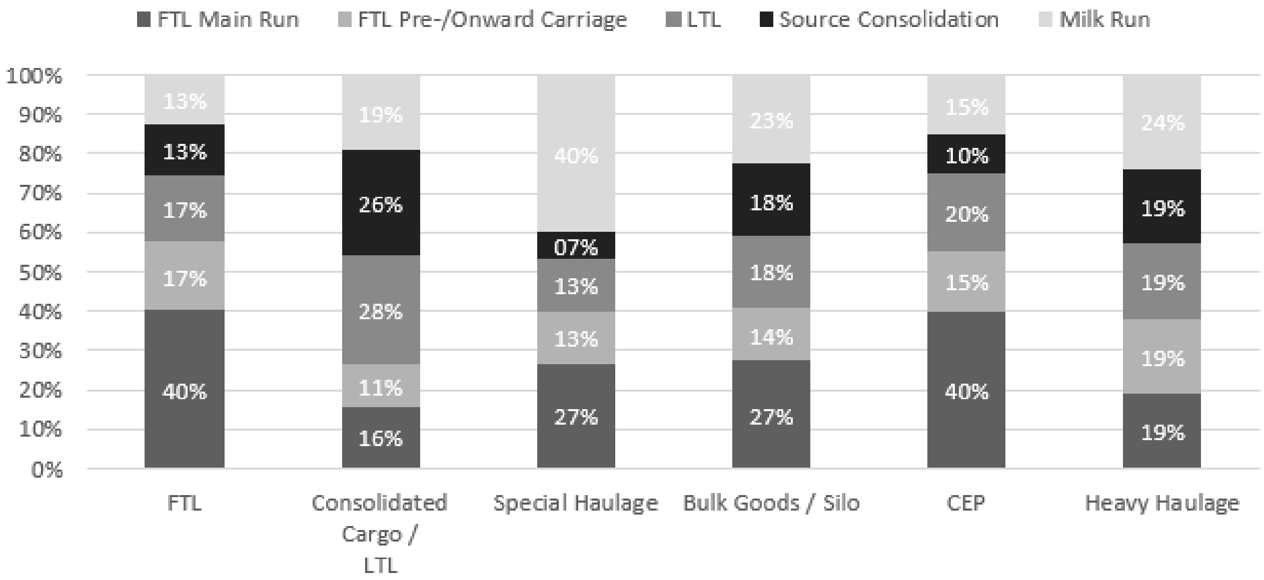


Figure 4-16 Shares of votes per route type within the logistics sectors

Though the sample size of this study is not sufficient to deliver statistically valid figures, the results show and confirm the fact, that logistic operations are extremely variable. Due to widely individual and volatile demands and constraints, a wide variety of vehicle concepts is expected to be necessary to meet market requests and harvest efficiency increase potential.

4.2.2.4 Tonnage vs volume Usage

In order to simulate a potential for fuel and CO_2 emissions savings a standard load for the current vehicle concepts was calculated for each use case. Therefore, the given load per source and sink was weighted with the according driven distance, such that an average load for the complete tour distance resulted. Following, the chosen Prime Candidates were analysed once with this standard load to get a direct comparison of the two combinations and once with a usage of 100% either in terms of tonnage, volume or loading meters, depending on which capacity reached 100% first, whereby opportunity to consolidate was assumed to overcome any constraints and get a best case scenario. Obviously this depended on whether the use case described was a tonnage or a volume transport.

For the quotient of the maximum utilization of the reference vehicle and the optimized utilization at full capacity of the Prime Candidates the expression “utilization factor” is introduced in this report. To allocated a given use case to tonnage respectively volume / loading meter transport we calculated an index figure that serves as indicator for the kind of transport. This was done by dividing the maximum utilization in terms of loading meter (in %; if not available than in terms of volume) by the usage in terms of tonnage (in %) for reference vehicles of the use cases. This lead to values between 0.95 and 1.05 if volume and tonnage utilization were about the same. Index values below 0.95 represent tonnage transports and values above 1.05 for volume or loading meter related transports. This analysis showed a range of values between 0.43 and 2.75, whereas volume transport had a share of 69.4%, tonnage transports 10.2% and 20.4% of the Use cases were tonnage-volume balanced transports.

Tonnage, volume and loading meter usage was calculated each for the reference vehicles currently in use and for the chosen Prime Candidates once with standard and maximum loads as stated in the use case and once with optimised load (best case scenario) as explained above. As can be seen in Table 4-29 below, in all three dimensions usage for the Prime Candidates for the standard and maximum loads is significantly lower than for the reference vehicles, which is logic due to the fact that Prime Candidates provide generally more capacity in all three dimensions. With optimized loads the usage improves remarkably in all dimensions with special emphasis on volume and loading meters, whereby loading meters actually reached full capacity use. This fits the fact that the majority of the use cases represent volume driven transports.

Table 4-29 Usage in % for weight, volume and loading meters for reference and capacity optimized loads

		Reference vehicle	Prime Candidate
Tonnage			
Use case	Average standard load	65.6%	37.8%
	Maximum Load	78.5%	41.7%
Optimized	Average standard load		49.3%
	Maximum Load		60.9%
Volume			
Use case	Maximum volume	79,.7%	57.5%
Optimized	Maximum volume		81.5%
Loading meter			
Use case	Maximum loading meters	99.0%	67.4%
Optimized	Maximum loading meters		99.5%

4.2.2.5 Cost and CO_2 efficiency improvement potential

As described in chapter 3.2.2.4 several KPIs were calculated and compared. These comparisons were realised on use case and single vehicle level, i.e. the results of the reference vehicles stated in the use case as currently used concept were compared to simulated results for the chosen Prime Candidates using the procedure as explained in 3.2.2.4.

4.2.2.5.1 General savings potential

An overview of the resulting differences between reference vehicles and Prime Candidates for the different KPIs can be seen in Table 4-30. Displayed are overall means (all use cases included) and standard deviations. As sample size was too small to further differentiate into logistics sectors, route types, commodity types or distance categories. This will be implemented in a later report, when the expert interviews are concluded and the results of all collected use cases are reported.

Table 4-30 Mean savings potential in % for different KPI. Standard deviation in parenthesis. Negative values indicate advantages for the Prime Candidates.

	€/tkm	€/km	Cost/tour	CO2e TTW	Co2e WTW
Standard average load	17.2 (10.2)	17.8 (10.6)	17.8 (10.6)	29.2 (16.8)	21.1 (11.8)
Maximum load for Prime Candidate	-23.3 (12.4)	25.8 (14.6)	-23.2 (12.2)	-12.7 (10.2)	-16.3 (15.3)

The transport cost per tonne-kilometre and the two CO2 emissions KPIs suggest a significant savings potential of about 12%-23% for the Prime Candidate compared to the reference vehicles, given a 100% utilization can be realized. Noticeable are the high values for standard deviation, i.e. the actual savings potential is highly individual to the use cases and their according parameters.

One use case showed advantages for the use of EMS vehicles already with a standard load with all KPIs, i.e. without load consolidation but with an actual decreased utilization compared to the reference vehicle. The according use case was a high density goods transport in the bulk sector and the positive outcome was caused by lower fuel consumption due to a different vehicle layout. The reference vehicle was as 4-axle drawbar combination and the compared Prime Candidate a 5-axle tractor-semi-trailer combination which provided a lower tare weight and with this a lower GCW. Two other use cases delivered no significant differences with standard load. Both low to very low density goods transports that benefited from the additional volume capacity of the chosen 14.92 m semi-trailer compared to a standard 13.62 m Megatrailer. All other use cases showed significantly negative results on standard load level, which is probably mostly due to the higher tare weights of the Prime Candidates.

With the maximum load scenario three use cases showed no significant difference for the €/tkm and cost per tour KPI and small to rather small differences for the emissions KPIs. All three were characterized by no or only a small increase in capacity in all dimensions between reference vehicle and chosen Prime Candidate (between 0% and 9,5%). Interestingly there were both, volume and tonnage transports among the concerning use cases.

Figure 4-17 shows the savings potential in terms of transport cost per tkm and per tour as well as in terms of CO_2 emissions (TTW and WTW) for all reference vehicles compared to the chosen Prime Candidates over all use cases. If reference vehicles are similar to a Prime Candidate, e.g. 1.3 (standard 4x2 semi-trailer) or 2.2 (3-axle towing rigid with 2-axle trailer) these numbers are stated. For all other reference vehicles a short description is stated, e.g. 4x2 drawbar (2-axle towing rigid with a 2-axle trailer). The addition “Mega” refers to a Megatrailer semi-trailer of 13.62m length. Additionally the line on the secondary axis displays the consolidation factor. Thus the correlation between savings potential an consolidation factor as described in the following chapter gets visible.

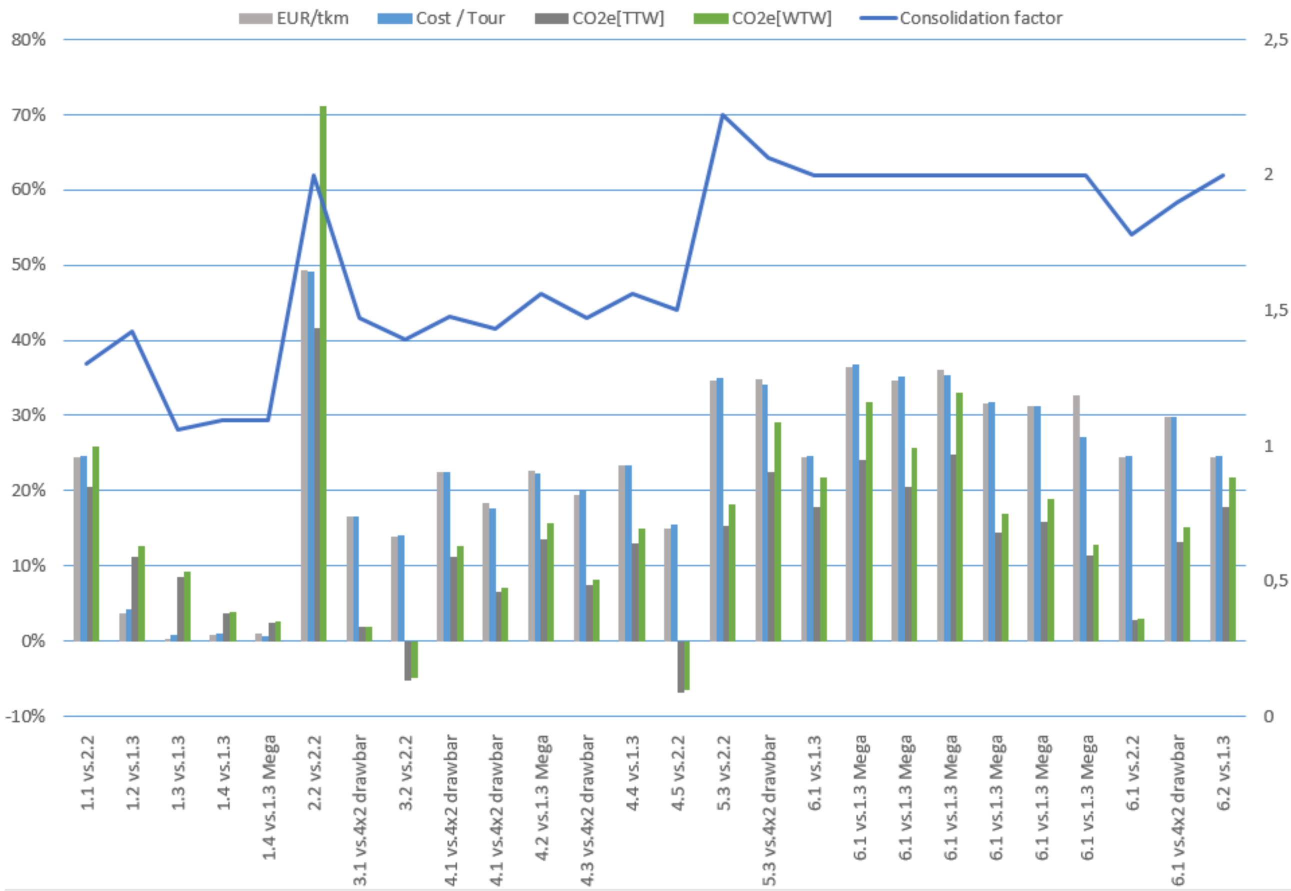


Figure 4-17 Savings potentials (%) for different KPIs per chosen Prime Candidate and its according reference vehicle

4.2.2.5.2 Influencing factors

To identify the variables that influence cost and energy efficiency most, the values for transport cost savings potentials (€/tkm, cost per tour) and for CO_2 emissions savings potential (kg CO_2 equivalent for TTW and WTW) were set as dependent variables. Subsequently the Pearson product-moment-correlation was calculated with the independent variables consolidation factor (see chapter 3.2.2.4), differences in permissible GCW, available volume and loading meter as well as the driven km per tour and the weight/volume index.

The savings potentials for the transport cost in €/tkm were highly correlated to the consolidation factor (r= 0.87) which is defined as the ration between current maximum utilization and optimized utilization for the LHCV, i.e. the more load can be consolidated in a Prime Candidate, the bigger the savings potential for transport costs. Consequently the difference with permissible GCW (r=-0.61), available volume (r=0.56) and loading meter (r=0.61) showed medium to strong correlations to transport cost savings. The driven vehicle distance as well as the weight/volume index showed no significant correlation (r=0.04 and r=-0.09).

For the transport cost in €/km results showed logic dependencies. Consolidation factors correlated highly with transport costs (r=0.71), as the resulting higher tonnage is the main influencing factor for the fuel consumption. Accordingly driven distance gained some impact on transport cost, but only on a small to medium basis with r=0.29. This is also supported by the medium to strong correlation between transport cost in €/km and difference in GCW, volume and loading meter (r=0.77, r=0.77, r=0.82). The weight/volume index remained insignificant with r=-0.04.

For the cost per tour the influence of the driven distance interestingly showed no significant impact on savings potential with r=0.03). In turn the consolidation factor increased to a high correlation of r=0.87. The correlation with differences in GCW (r=0.60), volume (r=0.54) and loading meter (r=0.60) remained on a medium level. Again weight/volume index remained on a low level with r=-0.07.

For the savings potential in terms of emission – TTW and WTW – one variable showed most importance. The consolidation factor correlated on a medium level with TTW (r=0.60) and WTW (r=0.55), i.e. the more load can be consolidated the higher the savings potential. Additionally the driven distance of the tour correlated on a medium level with TTW (r=0.46) and WTW (r=0.42) but without 3 extreme values the correlation decreased to a small r=0.10 and 0.09. One of these extreme values was caused by a the fact, that the same the chosen Prime Candidate was identical to the reference vehicle (4-axle drawbar combination) but with a higher permissible GCW, i.e. more load with same tare weight. The other two extreme values were caused by a very large difference in fuel consumption between reference vehicle and chosen Prime Candidate. The variables difference in GCW, volume and loading meters as well as weight/volume index showed none to small correlations with r between -0.04 and 0.22. Figure 4-18 shows the correlation between the savings potentials of the different KPIs and the consolidation factors per use case.

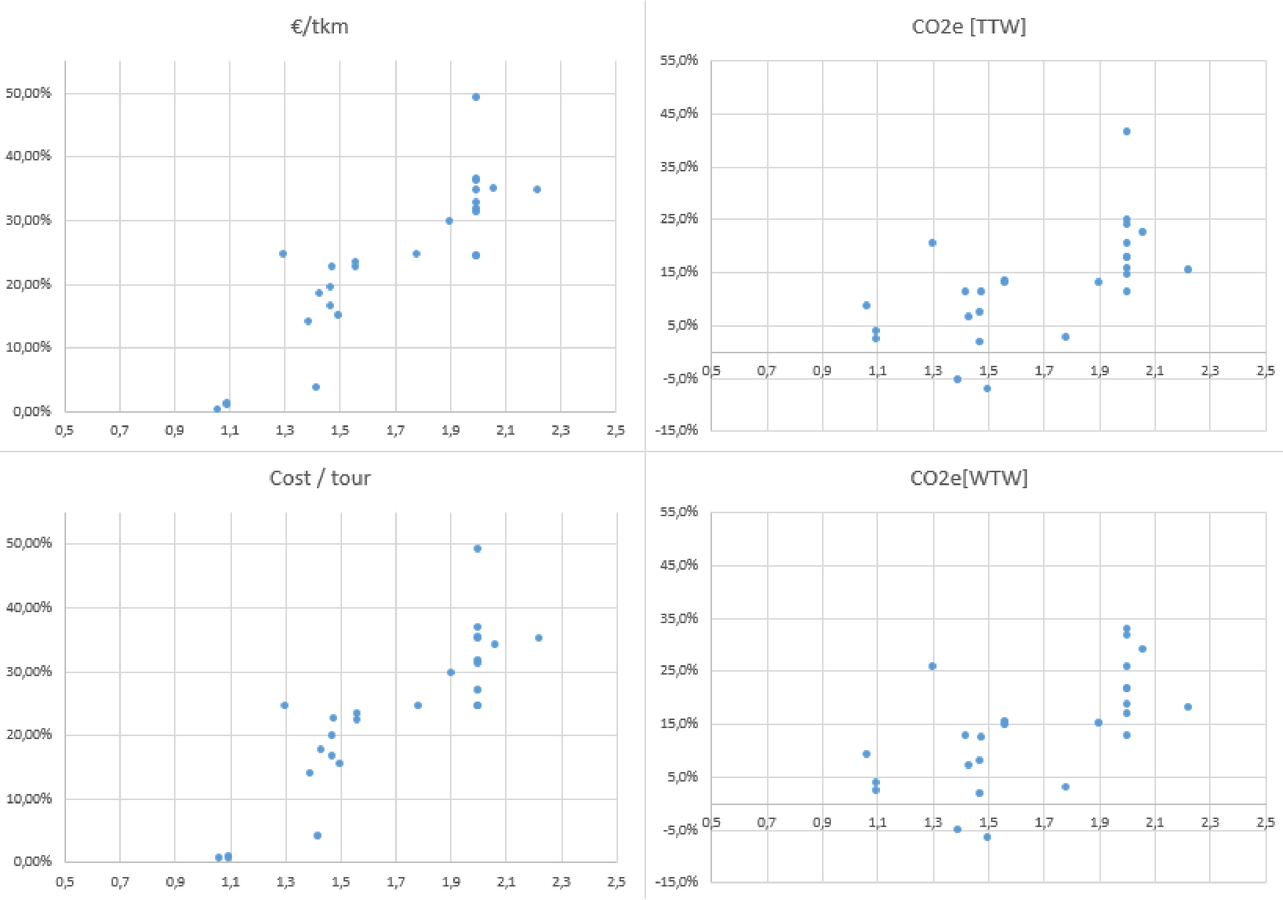


Figure 4-18 Scatterplots of savings potential per KPI (%) and consolidation factors

Another variable with high influence on savings potential on all KPIs of course is the fuel consumption. As explained before, further details about the fuel consumption simulation and its results cannot be undisclosed due to legal reasons. Nevertheless, it can be stated that the fuel consumption depends mainly on the factors GCW respectively load, vehicle layout (aerodynamic, number of axles and loading units etc.) and route profile. Particularly the topography of the tour and the number of stops have strong effects. Thus, expectable savings potentials are highly variable, which, at this stage of the project, makes case by case analyses necessary to get valid conclusions.

4.2.2.5.3 Fleet level

Having a look at the load factors ranging from 1.06 to 2.22 and the impact they have on savings potential for all of the reported KPIs, it is obvious that the savings potential even increases more the more load can be consolidated and the current vehicles can be replaced by fewer EMS vehicles. Even more so, as the three main cost categories will benefit from load consolidation and fleet reduction. Fuel consumption is the leading cost factor, with an average share of ca. 25% of the TCO (all percentages in this paragraph based on the calculations of this study). Though consumption will increase on single vehicle basis, due to the fact that EMS vehicles carry more load and have therefore a higher GCW, on fleet level the consumption will decrease in dependence on the load consolidation factor and the number of vehicles that can be replaced. Labour cost with a TCO share of ca. 26% will benefit from the same mechanism. Invest respectively depreciation cost with a TCO share of ca. 15% will also take advantage from a fleet reduction as fewer towing will be needed. The possibility to use already available standard loading units, thus no invest in new equipment is needed supports the positive development. Only the future towing vehicles will probably cause higher invest to some extend as they are expected to have three instead of mostly 2 axles and more engine power. According to these information it is necessary to analyse the effects of EMS not only on vehicle basis but also on fleet basis.

4.2.2.6 Requirements and constraints for EMS vehicles

Estimations and qualitative statements about requirements and constraints for the future use of EMS vehicles have been collected on two different occasions. Once during the above mentioned workshop in Dortmund at an early stage of the work for deliverable D1.2.These statements resulted from group discussions during a one day event and were related to first exemplary and roughly defined use cases. This subject has also been addressed during the expert interviews. In this case the questions were structured and linked to specifically detailed use cases, reference vehicles and Prime Candidates. Therefore the outputs of these two occasions are reported separately, to show the qualitative difference that resulted from the different research approaches and points of time.

4.2.2.6.1 Results of the Dortmund Workshop

1. Loading units
    a. Loading units should be suitable for multimodal transports
    b. Loading units should be flexibly adaptable to the application, e.g. long haulage or urban distribution, and compatibility with future towing vehicles has to be ensured.
    c. It is not expected that one type of loading unit can be used for complete transport chains. Rather the transhipment within a hub-and-spoke-system is seen as probable.
    d. For LTL and urban delivery smaller loading units are seen as more practical, as a quick exchange is possible.
    e. Different (smaller) loading units will still be used in future. EMS vehicles have to be flexible enough to use those and to optimize use of floor space.
    f. Loading units have to be compatible to take up many different secondary loading units, which leads to unused floor space. Special equipment could increase efficiency but at the costs of flexibility. Thus flexible loading units in a vehicle concept would allow specialized transports.
2. Infrastructure
    a. Constraints and limitations of infrastructure have to be met, to avoid an increased wear and tear of infrastructure.

   b. EMS should be compatible with today's (manual) loading infrastructure as well as it should be ready for automation.
   c. Easy shift of transport mode for the loading units is needed
3. Operations
   a. Ideally specific EMS concepts can also be used in urban delivery from a DC or hub.
   b. When thinking about EMS, trucks for urban delivery and the compatibility to those have to be considered as well.
   c. Safety while loading and during the transport has to be ensured.
   d. Loading factor is a key factor for the use of EMS. This premise also includes the increased use of sharing economy approaches like freight brokers and other digital platforms.
   e. First and last mile transports have more requirements and requests towards the vehicle concepts than main run transports. These have not been specified any further.
   f. Collaboration between operators is seen as the most import factor for efficiency increases, not only in main run but also in first and last mile transports.
   g. Driver shortage remains one of the main risk factors in transportation. Focus should be on driving, not on freight handling etc.
   h. ROI should be around 3-4 years, while average period of use is around 6-8 years.
4. Time
   a. Coupling and decoupling of loading units possible takes more time than today. Automated systems, like a smart dolly can solve this issue.
   b. Digitalisation is a subject that should be involved in EMS considerations. As load consolidation is one of the key factors for a successful use of EMS data of all involved components of a transport should be made available digitally, e.g. loading units, secondary loading units, freight and state of the freight. The Physical Internet approach is an opportunity to realise this.

4.2.2.6.2 Results of the expert interviews

One part of the questionnaire that was used for the **expert interviews** asked for the opinions and judgments of the participants about prerequisites for the use of EMS and requirements those vehicle concepts have to meet in the future. The answers were structured by topics in different categories to ease the estimation process for the participants. The key findings are listed below.

1. Cost
   a. Investment cost

      The initial cost for future vehicle concepts may rise moderately. This is mainly accepted due to the fact that the according towing vehicles will have more engine power, in many cases one more axle than currently used vehicles and probably will be equipped with additional safety and security systems. Though higher investment is accepted to a certain degree, stable TCO and transport cost have to be maintained. A range for an acceptable cost increase is stated sporadically with 10-20%. ROI specific targets have not been mentioned.

b. Insurance / tax

Insurance contributions as well as taxes should remain stable in relation to the increasing transport volume, so that again TCO and transport cost would remain stable. It was also stated that CO_2 tax reduction for EMS are favourable.

c. Transport cost

Transport cost should also remain stable or even decrease, which is mostly expected. Main reasons mentioned for this are the reduced number of towing vehicles, fewer drivers needed and fuel consumption savings. Expectations ranged from 20-30% reduction. Emphasis was also put on the wish that toll fees should not be influenced by choosing for an EMS vehicle.

2. Operations

a. Transport time

Transport time turned out to be one of the most crucial factors EMS vehicles have to deliver a solution for. The participants almost unanimously stated that transport time is a risk factor in many applications and has to remain on the same level as today. Transport time and delivery time windows are heavily influenced or even obligatory set by customers, which often leads to non-optimized tour planning and inefficient transports. On the upside it was stated that the risk for delays is reduced due to the use of less vehicles that can be late.

b. Intermodality

Though intermodality is one of the major aspects of the AEROFLEX project, the participants' answers revealed a common sense that it is generally desirable but not necessarily required for all transports. Nevertheless, for according assignments it is mandatory. A threshold of 250km transport distance is stated for intermodal transport to be reasonably used. It is important that the EMS is compatible with other transport modes and that acceptance is ensured.

c. Road accessibility

Road accessibility is seen as a risk factor to the measures of EMS. In general, EMS vehicles should be compatible with all kinds of roads, though it is not crucial for some possible major applications they can be used for, e.g. transports between hubs and terminals which are located near highways and have low share of other kinds of roads. It was emphasised that a consistent European solution is preferred that allows cross border transports.

d. Driver qualification

Additional driver trainings will probably be necessary, focussing on different driving dynamics, manoeuvring etc. This is expected to be easily implemented in current training procedures and it is required that no further licenses should be necessary. The demand for higher qualification and possible higher responsibility are judged heterogeneously. Some participants see it as an opportunity to ease driver scarcity as the job description for truck drivers gets more attractive. Others see the same reasons as threshold to choose this profession.

e. Supply Chain integration (IT)

Supply chain integration is generally seen as a necessary prerequisite for EMS but it is expected that this can be implemented with little effort and cost. Thus EMS needs to be compatible with TM-Systems, fleet- and yard-management-systems, telematics and freight broker platforms.

f. Willingness to cooperate horizontally and vertically

Cooperation is generally seen as key factor for optimized transport efficiency but it is not applicable for all types of transports and businesses. Thus SME should benefit more from cooperation than larger groups which have enough transport volume to consolidate within their organization. There is generally rather a willingness to cooperate vertically than horizontally due to strong concerns regarding competitive disadvantages resulting from possible information disclosure and lack of experience with this business model. An estimated 10% cost reduction potential was stated sporadically.

g. CO_2 emissions / Sustainability

The majority of the participants stated that EMS should target on reducing CO_2 emissions and supporting sustainability through innovative technology (including alternative drivetrains), optimization of logistics processes and improved capacity usage. This is also partly expected to be feasible (estimation ~ 20% improvement). For those companies environmentally friendly operations are an important part of their corporate philosophy. Others stated that CO_2 emissions and sustainability are not a prioritized matter in their organization and some expect no positive or even negative effects of EMS in this respect. Environmental objectives are expected to shift into companies’ focus if they can benefit from it.

h. Public acceptance of EMS vehicles

Opinions on public acceptance are quite heterogeneous. Some participants expect little public acceptance – either in general or particularly in urban transport, some regard it as already present, mainly because of the positive results of the diverse pilot projects in different European countries. Slightly more participants see it rather as an import than unimportant factor for the use of EMS vehicles. Those who rate it as important recommend that the proven positive effects of EMS and possible advantages, especially for cities, traffic and general public, should be communicated actively. Ideally in combination with autonomous driving and enhanced safety features. In general, the image of transport business should be improved.

3. Infrastructure
   a. Loading dock

      Respondents stated unanimously that compatibility with loading docks are a key factor for the successful use of EMS vehicles as they are standard in transportation operations. It was also stated that there are a lot of transport that are not laden and unloaded at docks, e.g. on customer premises. Generally, there are no problems expected, as EMS vehicles are composed with standard loading units.
   b. Manoeuvre areas

      Due to the extended combination length (depending on the specific Prime Candidate in use) manoeuvre areas are seen as bottleneck and risk factor. This is particularly relevant for on-site deliveries, e.g. construction sites, industrial facilities, SME clients etc. Nevertheless, some participants stated to have enough space available at their premises. There is also a negative impact on transport time assumed as additional manoeuvring takes more time.
   c. Parking areas (also for loading units)

      Parking areas for combinations as well as for currently unserved or unused loading units are stated to be available at larger LSPs premises and shippers. On the other hand there will be a demand for additional space at many other locations in the transport chain. Not only space for loading and unloading but also and especially alongside highways parking facilities will probably have to be adjusted to fit EMS combinations and their capacity has to be expended.
4. Load / Loading / Unloading
   a. Accessibility (side/rear/front/load through)

      Lateral (both sides) and backside accessibility is needed most. The need for load through accessibility depends on the specific vehicle concept and transport application, i.e. characteristics of the location and freight. Though, support of loading from all sides improves flexibility of a vehicle concept.

b. Payload / GCW

A topic that showed the diversity of transportation and its specific needs. Most participants agree that payload difference between current vehicle combinations and EMS need to reach a certain extent in order to be able to yield positive effects in terms of efficiency. Estimations ranged from

- minimum 75% more payload, to preferred 100% (related to Prime Candidates 1.4, 4.2, 5.3)
- 25 t and 34 t as favourable
- at least 60 tonnes were mentioned as target value (related to Prime Candidates 3.1, 4.3, 6.1)
- payload and GCW should be as high as possible (related to Prime Candidates 3.2, 4.5 and 6.1)
- no further payload increase is necessary, 18 t is enough (related to Prime Candidate 4.1)

Important seems that the available volume fits to the requested volume and that volume usage should remain at least on same level as with current vehicles, which matches one of the propositions within the AEROFLEX project. Another central request was to revoke the GCW limitation of 40 t for non-intermodal transports. GCW for four and five axle combinations between 50-55 t and for six axle combinations of up to 60-65 t have been stated as favourable. These proposals are also reflected in the use cases.

c. Loading time

Loading times are often set or influenced by the customer or by the loading facilities' operations and should therefore be reduced or at least kept on the same level as today. Times of maximum 1.5 hours in total (related to Prime Candidates 1.4,.4.2 and 6.1) or 10-30 minutes more than today's standard combinations (related to Prime Candidates 1.4, 4.4 and 4.7) are stated. Most of the participants expected no significant increase of loading times or even a reduction, e.g. bulk and silo transports. Others estimated an increase of 30-60 minutes (related to Prime Candidate 4.3).

5. Other subjects

A couple of diverse subjects have been stated which will be listed here to provide completeness of the responses

- The limitation of combination length has negative effects on available transport volume if additional superstructure is used, e.g. cranes.
- Optimization or restructuring of logistics processes can yield significant efficiency increases, even on company internal level. 25% have been reported.

- Freight theft generally is an issue that should be tackled in context of EMS. GPS tracking is not sufficient, as GPS devices are removable.
- Safety and security of EMS vehicles have to be maintained by use of according technology.
- Dangerous goods transport has to be regarded in this discussion.

5 Recommendations

5.1 Transport market

In general the objective is the use of loading units optimizing road transport by increase efficiency, reducing emissions, contributing to reduce driver scarcity, and last but not least to fit for existing infrastructure. The analysis of the EUROSTAT micro data showed, that FTL transports are of high importance for the European freight transport. The selected commodities – which are most interesting for the EMS vehicles – are primarily transported on pallets within semitrailers. EMS vehicles should consider transports by a semitrailer due to this are the most common equipment and users are familiar. Nevertheless, other loading units like containers have a high relevance for intermodal freight transport chains or hinterland transports. The selected prime candidates should therefore consider an EMS vehicle concept with sea container and for multimodal transport, optimizing rail/road in the context of corridors and regional areas.

Eastern Europe and Italy have some of the largest and oldest vehicle fleets, most in need of replacement. While these vehicles spend a significant part of their long distance drives on dense Western European road networks, the driving conditions in the home countries are important as well. Large articulated vehicles have the highest annual mileages and therefore the likeliest to operate in the long haul cycle.

Grouped and miscellaneous goods are expected to grow the most in the limited projections available. Specifically for these goods, the opportunity for Smart Loading Unit applications is great.

Based on the presentations and discussions on the HVTT15 conference (Rotterdam 2-4 October 2018), it could be considered that there exist valuable experiences in use of Performance-Based Standards (PBS) vehicles in some parts of the world e.g. in Australia and South Africa. Based on the current status of readiness to market of alternative drive trains for heavy vehicles, EMS would highly contribute behind expected progress in fuel efficiency to make road freight transport more environmentally friendly in the next decade. As one of the results of the side event of project AEROFLEX that was organized in this conference, it could be further concluded a high interest to EMS vehicles due to the expectation for a high impact concerning efficiency, reduction of drivers scarcity and less fuel consumption in the future exist on the side of LSP. The opportunity to consolidate shipments and to cooperate in logistics processes will increase in case EMS vehicles are in place. Current trends in the logistics and improved IT solution to organise the transports will support efficient logistics.

5.2 Logistics operations

This paper was aimed on answering the question if EMS vehicles do provide a potential for efficiency increase in terms of transport cost and CO_2 emissions. The conclusion that can be drawn from the results of the use case analysis is, that an efficiency increase on cost side as well as on CO_2 emissions can be expected if EMS would be used in Europe. Though the calculations yielded potentials of up to almost 50% for transport cost (€/tkm) and 40% (TTW) respectively 70% (WTW) for CO_2 emissions, it is important to point out that these are based on a best case scenario approach with several assumptions that had to be made in order to be able to conduct the analysis. Furthermore the results showed a large variance within the potential savings that are depending on many variables which are partly case sensitive. It is therefore recommended to put the findings of this study to further scrutiny in later stages of the AEROFLEX project. It might be even necessary or useful to address specific questions that are beyond the scope of AEROFLEX to separate research projects to be set up in the future. Additionally work package 1 will continue conducting expert interviews to broaden the information base and improve insight in this complex matter. Nevertheless the outcome of this study delivers useful insight in savings potential and conditions that are needed to foster it. Following, these information will be specified in recommendations for further proceedings.

- The use case calculations could confirm the estimations of the interviewees that a certain increase in GCW for the EMS vehicle in comparison to the according currently used vehicles is needed. Though positive effects in cost and emissions could even be detected at a consolidation factor of 1.06, i.e. 6% capacity increase, the height of savings potential is highly depending and correlated on this capacity increase. But also tour specific variables like route profile, level of GCW and utilization, vehicle layout and tour length pose important influence. Thus it is not possible to state a certain breakeven point for the consolidation factor. Much more it needs to be a case by case evaluation.
- The results of the analysis support the request of the interviewees to revoke the 36 t / 40 t / 44 t permissible GCW limitation as defined in (European Union, 1996). As mentioned above, the effects of this measure should be examined in detail, on transport cost and emissions as well as on infrastructure, traffic, road utilization etc. For this analysis the stated list of Prime Candidates as well as the according defined permissible GCWs should be taken into account.
- In connection with the last point the possibilities and effects of revoking the regulation to carry at least 25% of the GCW on driven axles (European Union, 1996) should be further examined as well. Especially under the premise that the introduction of distributed powertrains, as addressed by work package 2 of the AEROFLEX project, could solve this issue by adding additional driven axles.
- As stated in the introduction chapter, the results of the expert interviews and the stakeholder survey suggest, that there is potential for efficiency increase all across the logistics market from distribution to Long Haulage. Specifically use cases regarding bulk transports delivered significant potentials for local transports below 100 km tour distance for all KPIs. As not all collected use cases have been analysed yet and the gathering of use cases is planned to

continue until mid-2019, it is too early to state final conclusions. Nevertheless, the recommendation regarding the scope of the targeted market is, to expand the analysis to the complete transport market without regard to any distance segmentation. As LSP can use their vehicles freely and flexibly for whatever assignment they consider it useful, it is crucial to provide a picture of the impact of LHCV on the entire market to policy makers, in order to facilitate information based decisions.

- As increased permissible GCW plays a major role to generate savings potential, one of key factors for a successful use of EMS is the consolidation of load. Though large LSP probably would have the opportunity to consolidate load within their own organisation, as their transport volume is big enough, the majority of market participant would have to consolidate across their own company's borders. That implicates that the development of horizontal collaboration among LSP will play a major role in establishing the use of EMS. This is supported by the results of the customer survey, were 40% of the participants rated horizontal collaboration as an opportunity.
- The large number of mentioned Prime Candidates to be potentially usable in the defined use cases show, that the transportation business is very complex with high degree of individualization. Therefore, it is assumed that this large number of vehicle concepts is not only needed to meet all relevant customer and operational demands, but the range is likely to even expand. The question about preferred and most flexible axle formula for the towing vehicle, i.e. 4x2, 6x2 or 6x4 has not been addressed during the expert interviews as those were conducted under the scenario that no legislative regulation was in state. This subject will be shifted to a later stage of the project, when interviewees will be contacted again.
- Even though a significant part of the participants of the survey rated collaboration positive and 46% rated longer and 39% heavier vehicles as potentially useful (35% respectively 42% voted for not useful) for their logistics operations, there are still high barriers for LSP to establish horizontal collaboration as common business model (Cruijssen, Cools, & Dullaert, 2007; Gray, 1989; Krajewska, Kopfer, Laporte, Ropke, & Zaccour, 2008). An EC directive (European Union, 2011) that sets a framework for collaboration among competitors in transportation to provide legal security for market participants has already been installed, but the scope of concerns is wide. Therefore it is recommended to support horizontal collaboration by an integrated approach covering political and administrative actions, as well as communication of possible benefits and already successfully realized use cases (European Commission, 2014).
- The calculations are based on data available as today, i.e. the effects of the other AEROFLEX work packages – AEMPT, aerodynamic improvement and smart loading units – as well as future developments of cost components should be included in further analysis as soon as

they are available. Though, as mentioned above, it is expected that all mentioned factors have positive influence on savings potentials.

- For the presented study a number of assumptions had to be made, to be able to conduct the analysis. Among others an opportunity to consolidate was assumed, transport time, loading and unloading time, the fit of the vehicle concepts in logistics operations and manoeuvring areas could not be regarded. These assumptions should be evaluated in field tests so that later calculations can use real world data to deliver more reliable data. Therefore it is recommended to consider the approval of field tests with actual LSP on public roads. Ideally this can be realized even during the AEROFLEX projects but it might be also done in further projects.
- Participants stated that public acceptance for EMS is not a critical factor to consider the use of these kinds of vehicles. It is still recommended to accompany the possible future legalisation by extensive communicative measures to support public acceptance and to overcome false information about negative effects.
- The customer survey as well as the expert interviews revealed that sustainable transport and CO_2 emission reduction still seem to be not prioritized by LSP. This subject should be tackled by political action to create a pull effect for EMS vehicles and strengthened focus on environmentally friendly transportation in general.
- Obviously freight security (theft) plays a role in every day logistics. These concerns would be intensified by the use of EMS as more load would be carried by a single vehicle. The popular concepts of Physical Internet (PI) could be part of a solution for this subject. Additionally increased transparency PI provides would support more efficient transport and Supply Chain operations.

References

ACEA. (2017). Vehicles in use Europe 2017.

Bovenkerk, M. (2005). *SMILE+*. Retrieved from https://trid.trb.org/view.aspx?id=846407

BVU, Intraplan, IVV, & Planco. (2014, June 11). Verkehrsverflechtungsprognose 2030.

CEDR - Conference of European Directors of Road. (2018). *Freight and Logistics in a Multimodal Context*. CEDR - Conference of European Directors of Road. Retrieved from http://www.cedr.eu/download/other_public_files/research_programme/call_2015/freight_and_logistics_in_a_multimodal_context/falcon/CEDR-Call-2015_Summaries-FALCON.pdf

Cruijssen, F., Cools, M., & Dullaert, W. (2007). Horizontal cooperation in logistics: Opportunities and impediments. *Transportation Research Part E: Logistics and Transportation Review*, *43*(2), 129–142. https://doi.org/10.1016/j.tre.2005.09.007

Deutsches Institut für Normung. (2013). DIN EN 16258.

DTU, ITS Leeds, KTH, Rapidis, Tetraplan, univeristy of Oxford, … VTI. (2018). *TRANSTOOLS v3*. Retrieved from http://www.transportmodel.eu

Emisia. (2013). TRACCS. Retrieved from http://traccs.emisia.com

European Commission. (2014). CO3 - Collaboration Concepts for Co-Modality. Retrieved from http://www.co3-project.eu/

European Commission. (2016). EU Reference Scenario 2016 Energy, transport and GHG emissions Trends to 2050. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf

European Commission. (2018). *The European Commission's Oil Bulletin Prices History*. Brussels. Retrieved from ec.europa.eu/energy/observatory/reports/Oil_Bulletin_Prices_History.xlsOil_Bulletin_Prices_History.xls

European Union. (1996). Council Directive 96/53/EC of 25 July 1996 laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic. *Official Journal of the European Union*, *L235*(59), 59–75.

European Union. (2007). Commission regulation (EC) No 1304/2007. *Official Journal of the European Union*, *L290*, 14–16.

European Union. (2011, January 14). Leitlinien zur Anwendbarkeit von Artikel 101 des Vertrags über die Arbeitsweise der Europäischen Union auf Vereinbarungen über horizontale Zusammenarbeit. Retrieved from http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52011XC0114%2804%29

European Union. (2015). Directive (EU) 2015/719 of the European Parliament and of the Council of 29 April 2015 amending Council Directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic. *Official Journal of the European Union*, *L115*(58), 1–10.

EUROSTAT. (2002). Mean monthly earnings by sex, age, occupation. Retrieved from http://ec.europa.eu/eurostat/en/web/products-datasets/-/EARN_SES_AGT21

EUROSTAT. (2011). Anonymised Road Carriage micro-data. User Manual.

EUROSTAT. (2014). Methodologies used in surveys of road freight transport in Member States, EFTA and Candidate Countries. European Union.

EUROSTAT. (2016). Road Freight Transport Methodology. European Union.

EUROSTAT. (2017a). Annual road freight transport by distance class with breakdown by type of goods (1 000 t, Mio Tkm, Mio Veh-km, 1 000 BTO), from 2008 onwards. Retrieved from http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_go_ta_dctg&lang=en

EUROSTAT. (2017b). Annual road freight transport, by load capacity of vehicle (Mio Tkm, Mio Veh-km, 1 000 Jrnys). Retrieved from http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

EUROSTAT. (2017c). Labour cost levels by NACE Rev. 2 activity. Retrieved from http://ec.europa.eu/eurostat/en/web/products-datasets/-/LC_LCI_LEV

Federaal Planbureau. (2015). *Vooruitzichten van de transportvraag in België tegen 2030*.

Gray, B. (1989). *Collaborating: finding common ground for multiparty problems* (1st ed). San Francisco: Jossey-Bass.

KIT, Fomterv, Mcrit, MKmetric, Panteia, Significance, TNO. (2016). *HIGH-TOOL*.

Krajewska, M. A., Kopfer, H., Laporte, G., Ropke, S., & Zaccour, G. (2008). Horizontal cooperation among freight carriers: request allocation and profit sharing. *Journal of the Operational Research Society*, *59*(11), 1483–1491. https://doi.org/10.1057/palgrave.jors.2602489

LimeSurvey GmbH. (2012). *LimeSurvey: An Open Source survey tool*. Hamburg, Germany: LimeSurvey Project. Retrieved from http://www.limesurvey.org

McKinnon, A. (2007). Decoupling of Road Freight Transport and Economic Growth Trends in the UK: An Exploratory Analysis. Retrieved from https://doi.org/10.1080/01441640600825952

Müller, S., Klauenberg, J., & Wolfermann, A. (2014). How to translate economic activity into freight transportation? Presented at the European Transport Conference 2014.

OECD/ITF. (2017). ITF Transport Outlook 2017. OECD Publishing, Paris. Retrieved from http://dx.doi.org/10.1787/9789282108000-en

Panteia. (2016). Kostenbarometer 2015.

Panteia, TRT, MKmetric, NESTEAR, KIT, & TML. (2012). ETISplus.

Pochez, R., Wagner, N., & Cabanne, I. (2016). Projections de la demande de transport sur le long terme. Le Service de l’économie, de l’évaluation et de l’intégration du développement durable.

PTV, Enide Solutions, Mosaic Factor, P&G, Nallian NV, Bluegreen Strategy, & Van Eck. (2018). CLUSTERS 2.0.

Romijn, G., Verstraten, P., Hilbers, H., & Brouwers, A. (2016). GOEDERENVERVOER EN ZEEHAVENS WLO – Welvaart en Leefomgeving Scenariostudie voor 2030 en 2050.

Schroten, A., van Essen, H., Scholten, P., van Wijngaarden, L., ’t Hoen, M., Breemersch, T., … Esztergàr, D. (2017). Case study analysis of the burden of taxation and charges on transport.

TRT, MFive, & Fraunhofer ISI. (2018). *ASTRA Model*. Retrieved from http://www.astra-model.eu/

VTI. (2015). *SAMGODS*.

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Project partners:

#	Partner	Partner Full Name
1	MAN	MAN TRUCK & BUS AG
2	DAF	DAF Trucks NV
3	IVECO	IVECO S.p.A
4	SCANIA	SCANIA CV AB
5	VOLVO	VOLVO TECHNOLOGY AB
6	CRF	CENTRO RICERCHE FIAT SCPA
7	UNR	UNIRESEARCH BV
8	SCB	SCHMITZ CARGOBULL AG
9	VEG	VAN ECK BEESD BV
10	TIRSAN	TIRSAN TREYLER SANAYI VE TICARET A.S.
11	CREO	CREO DYNAMICS AB
12	MICH	MANUFACTURE FRANCAISE DES PNEUMATIQUES MICHELIN
13	WABCO	WABCO Europe BVBA-SPRL
14	CHALM	CHALMERS TEKNISKA HOEGSKOLA AB
15	DLR	DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV
16	FHG	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.
17	HAN	STICHTING HOGESCHOOL VAN ARNHEM ENNIJMEGEN HAN
18	IDIADA	IDIADA AUTOMOTIVE TECHNOLOGY SA
19	NLR	STICHTING NATIONAAL LUCHT- EN RUIMTEVAARTLABORATORIUM
20	TML	TRANSPORT & MOBILITY LEUVEN NV
21	TNO	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO
22	MHH	MEDIZINISCHE HOCHSCHULE HANNOVER
23	UIRR	UNION INTERNATIONALE DES SOCIETES DE TRANSPORT COMBINE RAIL-ROUTE SCRL
24	WABCO-NL	WABCO AUTOMOTIVE BV
25	WABCO-DE	WABCO GMBH

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Disclaimer

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Appendix A – Risk table

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
1	External / Legislation] Major change in legislation regarding vehicle dimensions, emissions and fuel efficiency reducing the impact of AEROFLEX targeted outcomes.	WP1, WP2, WP3, WP4, WP5	Major activities in WP7 on mapping current and future regulations and interaction via Sounding Board
2	Internal / Management] Partner not performing as expected in the technical annex.	WP9	Regular synchronization and appropriate project monitoring and governance structure (See Section 3.2).
3	[Internal / Management] Confidentiality issues between the AEROFLEX partners or towards external partners.	WP1, WP2, WP3, WP4, WP5, WP6	Appropriate data and confidentiality management. Deployment of appropriate framework, e.g. data exchange platform with different access rights. Possibility to escalate at project management level (WP9) in case an issue is detected.
	[Technical] Accident data does not reveal sufficient level of information or access is not possible. Weighting		Check to ensure sufficient data is available and whether alternative datasources are needed.
4	of detailed data databases from national to European level difficult to achieve for benefit analysis.	WP5	Although the databases have been selected carefully, if needed, alternative data sources can be accessed. Data sources may not allow full scaling to European level. Partner experience will be used to create alternative analysis methods
5	[Technical] No authorization received from local authorities to perform tests with demonstrator vehicles on real roads	WP6	IDIADA maintains a strong link with public authorities and has often conduct similar tests with prior authorisation from both regional and national traffic authorities
6	[Technical] Changing environmental conditions during tests of reference and demonstrator vehicles can, which can influence comparability of testing results	WP6	Reference and demo tests are scheduled at the same season of the year. In the case the tests were moved in time, IDIADA has flexibility and experience to move the tests another time (e.g. at night temperatures are lower) in order to

			similar conditions among the different tests. IDIADA is
7	[Management] Lack of contributions and expertise from Sounding Board members and lack of attendants to Sounding Board meetings	WP7	All SB members have signed a Letter of Support and they will receive travel compensation as an incentive to attend the meeting
8	[Management] No coherent Interest of the Sounding Board members in the outcome (results and recommendations) of the AEROFLEX project.	WP7	The governance of the Sounding Board is setup in a way that all results and recommendations will be discussed with the technical members (TAA) and the policy/regulatory members (PRCG) separately. The finalization of all results, reporting and Book of Recommendations will be mutually agreed with the complete Sounding Board (CSG). See Task 7.1
9	[Technical] Simulations are too complex or not consistent with the background crash analysis based on the accidentology data	WP5	Simulations must be done using representative and simplified crash scenarios. They must represent adequately accident events avoiding variables that may increase the complexity of the simulations without additional value.
10	[Technical] Crash simulation state-of-the-art is mature and the main issue is the availability of open-source models.	WP5	The consortium has partners with experience with open-source models from NCAC in the US
11	[Technical] Interface problems when installing the scale model in the wind tunnel (either static connection to the wind tunnel balance or non-optimum dynamic behaviour between the moving belts and the wheels of the model).	WP3	CRF will share to NLR the geometry of wind tunnel ground and support system, to be included into the design of the model from the beginning. Periodic update of the progress to WP lead and partners. If relevant issues will persist that can not be addressed by modification to the design of the scale model , the possibility to perform tests in another wind tunnel will be explored.
12	[Technical] Transient flow phenomena (related to blockage or Reynolds number) in the wind tunnel tests that prevent the identification of the most effective concepts.	WP3	Use CFD to compare drag benefit ofselected concepts model in open-air and wind tunnel conditions (i.e. including wind tunnel geometry as boundaries in CFD simulations for verification)

13	[Technical] Difficult to interpret the results from the concept development due to differences in the methods used by the individual partners.		Agree on a common CFD strategy, including (but not being limited to) requirements on CAD input, boundary conditions and data output before the concept development simulations commences. Generic cases will be perfomed by multiple partners to converge to highest possible similarity in solutions. Limit the number of different CFD tools as much as possible (ideally to one or two CFD tools).
14	Poor convergence of the transient simulations, and as a consequence non-reliable time averaged results and/or too expensive simulations.	WP3	Run longer time-histories for verification (may require a big increase in the amount of computational resources required). Reduce the number of steady CFD simulations to release cpu hours for the transient runs
15	Wrong performance predictions due to over- simplified geometries in the CFD models.	WP3	Do not introduce simplifications of the geometries in the models. Verify that the simplifications do not influence the CdxA values.
16	Interface problems for the demonstrator related to shared responsibilities, potentially giving poor performance and increased risk for not meeting cost and time targets.	WP3	Define clear interfaces for the different parts of the demonstrator. Work with 3D CAD tools and make use of available tools for data exchange. Manufacturing of demonstration vehicles with its aerodynamic features should be based on final drawings (design freeze) to as large extent as possible, in order to avoid large deviations and thus assembling issues.
17	Deviation between results from on-road measurements compared to simulation results & wind tunnel measurements	WP3	Verify the fidelity of CFD models after the first wind tunnel campaign. Use the experience of the partners from on-road measurements, to identify critical components and reduce the risks. Co- operate closely with WP6.

Appendix B – Stakeholder Survey Questions

Details of your company/branch

1. For what purposes do you primarily use your vehicle fleet?
    a. For shipping goods as a haulier/freight forwarder
    b. For shipping your own products/goods. Shipping is not the primary business of the company.

2. Which of the following transport modes did your company/branch use in 2016?
    a. Road transport
    b. Rail transport
    c. Inland waterway transport / Short sea shipping
    d. Ocean shipping
    e. Air transport

3. For the purpose of answering the shipping data questions, please choose one logistics sector from the list below:
    a. Full truck load shipping
    b. Consolidated cargo / Less-than-truck-load
    c. Bulk goods / Silo
    d. Special haulage*
    e. Heavy haulage**
    f. Courier / Express / Parcel

    *Special haulage: All types of shipping that cannot be handled with a standard vehicle or with a standard body, e.g. shipping of refrigerated and frozen goods, livestock transport, textile transport, tipper trucks, cement mixers.

    **Heavy haulage: All types of shipping involving non-standard dimensions and weights.

4. From the list below, please choose the type of transport route that you want to use for the purpose of answering the shipping data questions: (You may select more than one option)
    a. Full-truck-load (main run)
    b. Full-truck-load (pre-carriage or onward-carriage)
    c. Less-than-truck-load
    d. Source consolidation
    e. Milk run

    The type of transport route describes a typical route structure, which is determined by how many sources and how many sinks there are. It is not the entire distance that is taken into account (pre-carriage + main run + onward-carriage) but only one section (pre-carriage, main run or onward-carriage).

5. Who is actively involved in planning the trips for the shipping orders that your company handles in the context of your selected logistics sector and type of transport route?
    a. Your company only
    b. Your client / the consignor only
    c. Both
6. How many vehicles did you use in 2016 in the context of your selected logistics sector and type of transport route?
    a. 7.49 - 11.99 tonnes GVW
    b. 12 - 17.99 tonnes GVW
    c. ≥18 - 42 tonnes GVW
    d. >42 tonnes GVW

Freight and cargo

In this section, we would like you to provide a few details about the goods and cargoes that you transport *within the context of your selected logistics sector and type of transport route*. (Average values for 2016)

1. What was the average shipping volume per transport unit (e.g. box body, ISO container, swap body, semi-trailer)?
    a. m³
    b. tonnes
    c. loading metres

2. What was the average percentage utilisation per transport unit (e.g. box body, ISO container, semi-trailer, swap body)?

3. What was the average number of transport units per vehicle per trip?

4. What was the average shipping volume per shipping order?
    a. m³
    b. tonnes
    c. loading metres

5. Thinking about your selected logistics sector and type of transport route, what percentage of your total annual shipping volume does each of the following transport units account for?
    a. 20 ft ISO containers
    b. 40 ft ISO containers
    c. 45 ft ISO containers
    d. Swap bodies
    e. Semi-trailers
    f. Permanently attached bodies and trailers (e.g. box bodies)
    g. Other

Times

In this section, we would like you to provide a few details about the trips your company completed in the context of *your selected logistics sector* and *type of transport route*. (Average values for 2016)

1. How many trips were completed in 2016 in total?
2. What was the average annual distance travelled by each vehicle in 2016?
3. For how many days was each vehicle used on average in 2016?
4. How many trips per day did each vehicle complete on average in 2016?
5. What was the average loading and unloading time (or make-ready time) per trip in 2016? (Incl. waiting time)
6. What was the average shipping time per consignment from the source to the sink in 2016? (Incl. loading and unloading times and breaks)
7. What was the average journey time per trip in 2016? (Incl. loading and unloading times and breaks)

Trip data

In this section, we would like you to provide a few details about the trips your company completed for your selected logistics sector and type of transport route. (Average values for 2016)

1. What was the average trip distance in 2016?
2. What was the average number of consignors (sources) per trip in 2016?
3. What was the average number of consignees (sinks) per trip in 2016?
4. What was the average number of unloading points per shipping address in 2016?
5. What was the average trip density (number of consignees per km²) in 2016?
6. What percentage of the total distance travelled (km) in 2016 consisted of empty runs?
7. On average, how many vehicles were used in parallel within the same destination region in 2016 (radius <100 km)?

Future prospects

The following questions concern future prospects for new vehicle concepts (>18.75 m / >44 tonnes) and we would like you to rate their importance.
Important: For the purpose of answering the questions, please assume that no legal restrictions apply to the use of new vehicle concepts.

1. Have you already thought about longer/heavier (>44 tonnes / >18.75 m) vehicles?
   Yes
   No
2. How highly would you rate being able to make economic use – at your company – of vehicles with more loading meters than are currently possible? (e.g. more transport units per vehicle)

   Low, Rather low, Neutral, Rather high, High

3. How highly would you rate being able to make economic use – at your company – of vehicles with a higher tonnage (>44 tonnes) than is currently permitted by law?

   Low, Rather low, Neutral, Rather high, High
4. What criteria would have to be met before you would consider using new vehicle concepts (longer/heavier) at your company?

   Please number the criteria from 1 to 12 in order of relevance, with number 1 being the most important criterion.

   Increase in turnover
   Vehicles offer appropriate carrying capacity
   Vehicles allow the desired service level to be achieved
   Lower transport costs

Adherence to specified delivery dates
Ability to integrate them into IT systems (supply chain integration)
No increased investment costs
Willingness to cooperate vertically and horizontally (among consignors and among logistics companies)
Vehicles are compatible with transportation infrastructure
Public acceptance of new vehicles
No negative impact on the traffic situation
Increasing transport volumes

5. How likely do you think it is that new vehicle concepts will be able to meet these criteria? (Please answer in percent)

Lower transport costs
No increased investment costs
Increase in turnover
Vehicles offer appropriate carrying capacity
Vehicles allow the desired service level to be achieved
Adherence to specified delivery dates
Ability to integrate them into IT systems (supply chain integration)
Willingness to cooperate vertically and horizontally (among consignors and among logistics companies)
Vehicles are compatible with transportation infrastructure
Public acceptance of new vehicles
No negative impact on the traffic situation
Increasing transport volumes

5. What factors would negatively affect your willingness to use new vehicle concepts at your company?

6. What is your response to the following statement?

   Storage, handling and transport capacities are shared by several consignors and logistics service providers. For you as a logistics service provider, this represents:

   Risks 1 2 3 4 5 Opportunities

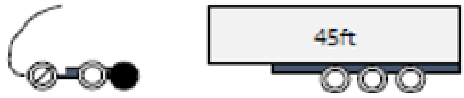
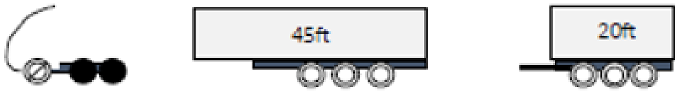
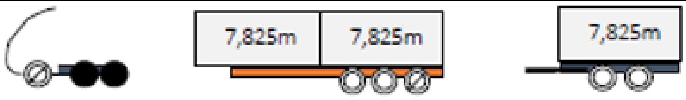
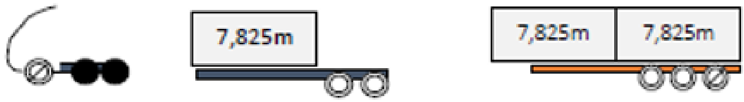
7. Would you be willing to take part in another survey about the new vehicle concepts that are created based on this study?
   Yes / No

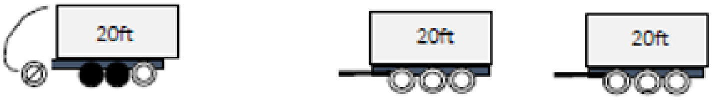
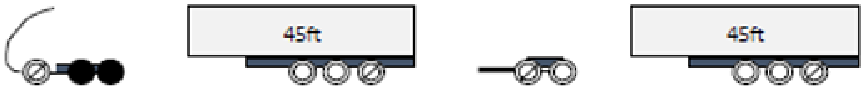
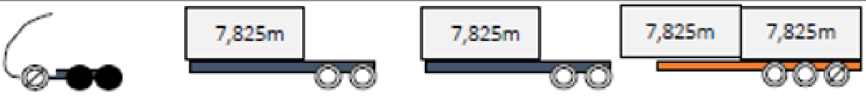
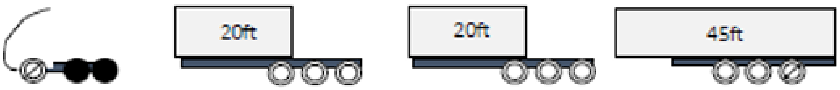
Appendix C – TCO Calculation Variables

Cost category	Remark
Yearly mileage [km]	No. of km per vehicle per year defined for a specific use case
Yearly days of use [d]	No. of days a vehicle is used within the last calendar year for a use case; either stated by participants or standard value 250 days used
Average weight utilization [%]	Average percentage of the used tonnage capacity as specified in the use cases
Initial cost [€]	Sum of the estimated or stated average initial cost (European level) for all hardware components defined for a use case, incl. towing vehicle, (semi-)trailer, loading units etc.
Repair and Maintenance [€]	Estimated monthly costs / rates for repair and maintenance
Value loss rate / month [%]	Estimated monthly loss in value over the usage period
Usage time [y]	Period of time in which the defined vehicle is used in the use case; 4 years used
Capital interest rate [%]	Targeted average annual interest rate (derived from current interest level); 6% value used
Ownership tax [€]	Estimated average ownership tax (European level) incl. CO_2 based excise duties
Insurance [€]	All ownership related insurance incl. liability, physical damage, carrier liability. Estimated average rates (European level)
Telematics Services [€]	Monthly fee for telematics services; estimated values
Allocation of overheads [%]	Standard value of 2% of operations costs (fix costs + variable costs; w/o overhead costs)
Lubricant cost [%]	Standard value as percentage of fuel costs
Driver wage [€]	Monthly salary for drivers. Based on EUROSTAT (2002), NACE Rev 2 Category H, OC8, EU current composition; 2,008 €/month used
Non-wage labour cost [%]	Monthly percentage of driver wage. Based on EUROSTAT (2017c), NACE Rev2 Category H, EU current composition; 26.4% value used
Cost for driver training [€]	Estimated average value
Fuel consumption [l/100km]	Average fuel consumption for the tour specified in the use case
AdBlue consumption [l/100km]	Average fuel consumption for the tour specified in the use case

Tyre mileage [km]	Overall mileage tyres can be used before being refurbished or replaced; estimated values
Number of tyres [pcs.]	Number of tyres per axle based on the analysed vehicle layout
Cost tyres [€]	Cost per single tyre; estimated value
Diesel consumption [l/100km]	Simulated fuel consumption based on the specified tour and weight data and vehicle layout;
Fuel prices [€/l]	European average (EU28) between 31.07.2017 and 30.07.2018 without VAT; based on the Europe Oil Bulletin (European Commission, 2018)
AdBlue consumption [l/100km]	Standard value in relation to fuel consumption
AdBlue prices [€/l]	Estimated value
GCW [t]	Prime Candidate specific; see Appendix D
Tare weight [t]	Values either stated by participants for reference vehicles, or calculated with standard values for exemplary components if not stated by participants and for Prime Candidates
Payload [t]	Difference between GCW and Tare weight of the vehicle

Appendix D – Overview over Prime Candidates

Prime Candidate	Combination	GCW
1.1		50.000 t
1.2		50.000 t
1.3		42.000 t
1.4		42.000 t
2.1		46.000 t
2.2		46.000 t
2.3		40.000 t
3.1		74.000 t
3.2		70.000 t
3.3		68.000 t
3.4		71.500 t
4.1		68.000 t
4.2		68.000 t

4.3		68.000 t
4.4		68.000 t
4.5		66.000 t
4.6		80.000 t
4.7		74.000 t
5.1		86.000 t
5.2		86.000 t
5.3		86.000 t
5.4		92.000 t
5.5		98.000 t
6.1		92.000 t
6.2		92.000 t
6.3		93.000 t
6.4		93.000 t

Appendix E – Standard goods classification for transport statistics, 2007 (NST2007)

1	Products of agriculture, hunting, and forestry; fish and other fishing products
2	Coal and lignite; crude petroleum and natural gas
3	Metal ores and other mining and quarrying products; peat; uranium and thorium
4	Food products, beverages and tobacco
5	Textiles and textile products; leather and leather products
6	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials; pulp, paper and paper products; printed matter and recorded media
7	Coke and refined petroleum products
8	Chemicals, chemical products, and man-made fibers; rubber and plastic products ; nuclear fuel
9	Other non-metallic mineral products
10	Basic metals; fabricated metal products, except machinery and equipment
11	Machinery and equipment not elsewhere classified (n.e.c.); office machinery and computers; electrical machinery and apparatus n.e.c.; radio, television and communication equipment and apparatus; medical, precision and optical instruments; watches and clocks
12	Transport equipment
13	Furniture; other manufactured goods n.e.c.
14	Secondary raw materials; municipal wastes and other wastes
15	Mail, parcels
16	Equipment and material utilized in the transport of goods
17	Goods moved in the course of household and office removals; baggage and articles accompanying travellers; motor vehicles being moved for repair; other non-market goods n.e.c.
18	Grouped goods: a mixture of types of goods which are transported together
19	Unidentifiable goods: goods which for any reason cannot be identified and therefore cannot be assigned to groups 01-16.
20	Other goods n.e.c.

Source: Commission Regulation No 1304/2007; Unique classification for transported goods in certain transport modes

Appendix F - Terms and Definitions

Use case	• Use case describes an approach how one or more vehicle concepts are used in a defined road transport or in intermodal transport segment.
	• Use case indicates realistic/real daily operation of a logistics operator.
	  • A use case should be assigned to and defined for all of the following level of detail:
	    ▪ a specific transport type of route: Full-truck-load (main run), Full-truck-load (pre-carriage or onward-carriage), Less-than-truck-load, Source consolidation, Milk run; the type of transport route describes a typical route structure, which is determined by how many sources and how many sinks there are. It is not the entire distance that is taken into account (pre-carriage + main run + onward-carriage) but only one section (pre-carriage, main run or onward-carriage),
	    ▪ Commodities: determine the requirements of transport incl. handling by loading and unloading processes: e.g. bulk or liquids, pallet carrier, loading units, temperature guided transport, over size, general cargo, new cars, hazards goods,
	    ▪ Vehicles: scheduling, transport costs, transport weight and volume
	• The different level of details shall be consistent to each other to get a consistent use case

Test case	Scenario to be tested on physical vehicle
Scenario (cycle)	Mission profile with a certain vehicle
Mission profile	Speed/slope/payload as function of time or distance for a certain type of road, degree of congestion and elevation pattern
Trip	A vehicle traveling a defined trajectory from origin to destination (consists of one or more different mission profiles)
Daily operation	Set of trips in a day of operation (daily trips)
Annual operation	Number of operational days multiplied with daily operation (annual trips)
Market	Description of the road or intermodal transport segments based on the defined use cases. Giving emphasis to the volume of the use cases (e.g. tons, sales)

Drivers	Defining of relevant influence factors (e. g. according STEEP/PESTL – Sociological, Technological, Economic, Political, Legal) which influence the development of a market (e.g. increase of parcel market due to internet commerce; less bulk transport due to using of renewable energies replace fossil power plants; digitalisation of transport planning processes; 3-D printing; autonomous driving; decrease demand of fuels for the road transport market due to increase of new registered electric cars)
Vehicle concepts	Description of vehicle combinations: tractor, semi-trailer, trailer, lorries including standardized loading units like ISO container and swap bodies (source Falcon project: defined 6 groups, see the following slides 7-11)
Vehicle configuration	Main vehicle parameters: weight, mu, Cd*A, payload-capacity, EMG-power/torque
Logistics and logistics channel	• planning, execution and control of the movement and placement of people and/or goods and of the supporting activities related to such movement and placement, within a system organized to achieve specific objectives • the entire process of transferring products from producer to consumer, including storage, transport, transhipment, warehousing, material-handling and packaging, with associated exchange of information • network of intermediaries engaged in transfer, storage, handling and communications functions that contribute to the flow of goods
Logistics management	function of setting strategies for, planning, implementing and controlling the flow and storage of raw materials, in process stock, finished goods, and related information between the point of origin and the point of consumption for the purpose of meeting customer requirements
Supply Chain	• sequence of events, which may include conversion, movement or placement, which adds value • a system of entities being involved in producing, transforming and/or moving a product or service from suppliers to customers
Supply Chain Management	• organization, planning, control and execution of the products flow from development and purchasing, through production and distribution, to the final customer in order to satisfy the requirements of the market cost-effectively • includes flow of goods, information and payments1

Logistics sectors	• Full truck load shipping • Consolidated cargo / Less-than-truck-load • Bulk goods / Silo • Special haulage* • Heavy haulage** • Courier / Express / Parcel *Special haulage: All types of shipping that cannot be handled with a standard vehicle or with a standard body, e.g. shipping of refrigerated and frozen goods, livestock transport, textile transport, tipper trucks, cement mixers. **Heavy haulage: All types of shipping involving non-standard dimensions and weights.
Source	Place of loading of a consignment
Sink	Place of unloading of consignment
Pre-carriage	Transport from source to a main run gateway
Main run	Part of the transport that covers main part of the overall distance - without transhipment; in-between pre-carriage and onward-carriage
Onward-carriage	Transport from a main run gateway onwards towards the sink or a further transhipment point
Loading unit	Unit of goods prepared for transport using loading tackles, e.g. . laden pallets, lattice boxes etc.
Loading tackles	Material that is used to pack transport goods an form a loading unit, e.g. Euro-pallets, lattice boxes, shrink foil, tapes etc.
Transport unit	Enclosed vessel that contains loading units, e.g. Semitrailers, Swap bodies, ISO containers, box bodies, tank silos etc.
Utilization	Degree to which a transport unit‘s capacity is used (tons, m^3, loading meters)
Shipping time	Time from pick up at source to drop-off at sink
Journey time	Part of shipping time for actual transportation (movement of goods) including loading, unloading, idle times and breaks
Multimodal Transport	Contains the transport of goods with at least two different transport modes (Hoffmann 2007, Peters 2006)
Intermodal Transport	Special case of multimodal transport. The freight is transported within the same loading unit during the whole transport with at least two different

	transport modes. During the transhipment, only the loading unit will be handled, but not the freight itself (Peters 2006, Hoffmann 2007)
Combined Transport (CT)	Special case of intermodal transport, “where the lorry, trailer, semi-trailer with or without tractor unit […] uses the road on the initial or final leg of the journey and, on the other leg, rail or inland waterway […].”(UIC 2017, p. 9) (see also Peters 2006, Hoffmann 2007). The CT can further be differentiated by the form of transport (accompanied or unaccompanied), geographical scope (domestic or international) or the type of transport chain (maritime or continental) (UIC 2017, p. 13)
Co-Modality	Describes “the optimal use and combination of different modes of transport” for an “optimal and sustainable utilization of resources […] and a high level of both mobility and environmental protection”.

Appendix G – Additional EUROSTAT tables

Table 5-1 Lorries and road tractors, by age [road_eqs_lorroa]

Lorries and road tractors, by age [road_eqs_lorroa]

Last update 06.04.18
Extracted o 05.09.18
Source of d Eurostat

UNIT Number
VEHICLE Road tractors

TIME	2013	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014	2014	2015	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016
GEO/AGE	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea
Belgium	45 000	9 993	10 191	12 970	4 340	7 506	44 693	9 624	9 264	13 896	4 420	7 489	44 851	10 044	9 858	12 608	4 862	7 479	45 749	10 890	10 903	11 229	5 179	7 548
Bulgaria	39 125	:	:	:	:	:	42 686	:	:	:	:	:	47 809	:	:	:	:	:	51 660	:	:	:	:	:
Czech Repu	7 626	144	317	1 264	5 901	:	6 621	89	180	899	5 453	0	5 283	67	153	551	4 512	0	4 488	83	84	378	3 943	:
Denmark	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	13 640	5 927	3 995	2 704	834	180
Germany (u	184 589	56 769	62 438	53 599	9 986	1 797	188 481	60 499	67 108	48 313	10 725	1 836	194 386	67 528	66 742	45 657	12 481	1 978	201 984	70 331	68 110	46 419	15 055	2 069
Estonia	10 241	1 237	1 029	4 667	2 826	482	10 583	1 291	1 486	4 331	2 969	506	10 813	1 160	2 068	3 821	3 221	543	11 365	1 273	2 106	3 565	3 792	629
Ireland	8 337	1 469	2 049	4 154	665	:	10 020	3 408	1 541	4 295	776	:	12 149	4 262	2 018	4 533	1 336	:	13 074	5 048	2 635	3 606	1 785	:
Greece	:	:	:	:	:	:	22 563	:	:	:	:	:	22 043	:	:	:	:	:	22 301	:	:	:	:	:
Spain	182 822	:	:	:	:	:	186 060	20 373	24 777	63 518	59 133	18 259	195 657	27 572	28 350	56 201	63 900	19 634	207 889	:	:	:	:	:
France	204 912	1	1	:	:	:	198 593	1	2	1	:	:	197 405	1	2	:	:	:	200 476	51 807	67 330	81 339	:	:
Croatia	8 010	799	1 687	3 405	2 119	:	8 662	1 069	1 109	4 251	2 233	:	9 329	1 353	1 573	4 070	2 238	95	10 443	1 735	1 991	4 287	2 325	105
Italy	149 563	11 403	34 331	42 302	61 527	:	:	:	:	:	:	:	:	:	:	:	:	:	162 092	19 359	28 986	34 636	79 111	:
Cyprus	1 682	20	98	475	1 038	51	1 658	22	85	359	1 145	47	1 637	16	52	296	1 209	64	1 805	10	65	353	1 297	80
Latvia	13 238	2 176	1 418	5 388	4 256	:	13 137	1 745	2 235	4 710	4 187	260	13 379	1 868	2 736	4 090	4 387	298	13 541	2 684	2 199	3 700	4 645	313
Lithuania	27 671	5 997	3 243	9 454	7 181	1 796	23 510	5 200	5 013	7 243	5 704	350	24 781	4 900	7 233	6 032	6 200	416	28 138	8 147	6 786	5 782	6 933	490
Luxembourg	4 726	1 238	1 758	1 465	265	:	4 602	1 243	1 887	1 187	285	:	4 502	1 409	1 760	1 026	306	:	4 516	1 621	1 472	1 115	307	:
Hungary	56 089	14 992	10 204	17 320	10 695	2 878	60 875	17 138	8 949	18 887	13 068	2 833	64 442	18 606	10 607	18 231	14 156	2 842	68 117	17 894	14 051	17 327	15 514	3 331
Malta	1 096	26	60	187	551	272	1 125	35	40	217	547	286	1 125	40	28	215	506	336	1 144	20	37	208	427	452
Netherlands	71 063	21 726	16 839	29 547	8 148	1 613	70 533	20 854	:	:	:	:	72 245	22 053	:	:	:	:	74 218	23 148	:	:	:	:
Austria	16 192	6 428	3 751	4 593	1 273	147	16 321	6 122	3 962	4 749	1 329	159	16 508	6 197	4 576	4 132	1 447	156	16 846	6 493	4 799	3 759	1 624	171
Poland	280 420	38 850	31 330	57 142	36 123	116 975	303 189	39 927	29 856	81 523	102 955	48 928	329 589	45 496	43 425	104 365	83 479	52 824	361 681	52 364	54 321	105 876	90 799	58 321
Portugal	31 374	3 853	4 498	12 641	9 565	817	37 312	4 965	5 019	13 353	12 784	1 191	39 286	6 483	5 277	12 968	13 264	1 294	41 175	7 824	6 023	11 673	14 192	1 463
Romania	84 947	6 805	6 907	33 727	37 508	:	94 206	8 134	10 178	33 243	42 651	:	105 760	10 695	13 157	34 726	47 182	:	:	:	:	:	:	:
Slovenia	9 638	1 555	2 090	4 879	936	178	10 162	1 834	2 784	4 489	879	176	11 326	2 480	3 310	4 419	928	189	12 981	3 149	3 564	4 892	1 175	201
Slovakia	27 561	:	:	:	:	:	28 429	:	:	:	:	:	29 928	:	:	:	:	:	31 016	:	:	:	:	:
Finland	11 984	905	1 079	4 620	4 490	890	12 439	859	1 102	4 245	5 198	1 035	12 882	695	1 348	3 634	5 889	1 316	13 656	823	1 371	3 318	6 524	1 620
Sweden	8 426	2 467	2 223	2 745	781	210	8 315	2 398	1 809	3 036	851	221	8 462	2 377	1 970	2 966	929	220	8 645	2 581	2 158	2 634	1 027	245
United King	:	:	:	:	:	:	:	:	:	:	:	:	128 771	35 082	48 629	31 474	10 293	3 293	134 341	39 161	46 640	33 607	11 445	3 488
Liechtenste	271	56	69	129	12	1	263	45	59	146	12	1	270	53	74	129	14	0	275	77	66	121	10	1
Norway	8 475	2 452	2 041	2 543	1 439	:	8 787	2 547	2 430	2 312	1 498	:	8 926	2 487	2 897	1 927	1 615	:	9 092	2 414	3 154	1 810	1 111	603
Switzerland	11 000	2 700	3 400	3 500	1 300	100	11 200	2 100	2 900	4 700	1 500	200	11 200	2 000	2 800	4 900	1 200	200	11 200	2 200	2 800	4 300	1 600	200
Former Yug	4 934	138	213	2 226	2 012	345	5 248	275	240	2 254	2 479	:	5 451	375	334	2 213	2 529	:	5 640	471	557	1 906	2 706	:
Turkey	180 229	41 589	40 785	52 643	27 956	17 256	197 218	32 398	58 081	53 596	36 137	17 006	214 893	33 525	69 380	50 637	42 927	18 424	225 599	25 870	63 928	64 154	50 559	21 088

Special value:
: not available

UNIT Number
VEHICLE Goods vehicles <= 3.5 tonnes

TIME	2013	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014	2014	2015	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016
GEO/AGE	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea
Belgium	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Bulgaria	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Repu	405 575	:	:	:	:	:	:	:	:	:	:	:	425 142	:	:	:	:	:	425 142	:	:	:	:	:
Denmark	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	397 001	96 144	63 493	114 365	112 224	10 775
Germany (u	2 100 000	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Estonia	57 420	5 687	5 230	16 633	19 574	10 296	61 232	6 146	7 209	15 564	21 356	10 957	65 986	7 149	8 905	14 780	23 276	11 876	71 435	8 282	9 619	14 765	25 676	13 093
Ireland	:	:	:	:	:	:	288 129	46 817	36 034	142 536	62 742	:	299 737	61 341	33 577	132 046	72 773	:	310 291	78 699	34 978	110 496	86 118	:
Greece	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Spain	:	:	:	:	:	:	4 506 916	194 983	321 550	1 243 128	1 839 513	907 742	4 519 096	253 610	278 104	1 038 840	1 988 957	959 585	4 544 462	290 530	270 394	818 355	2 141 170	1 024 013
France	6 232 061	712 171	1 082 414	1 749 205	2 688 271	:	6 270 839	701 452	1 094 484	1 699 969	2 774 934	:	6 257 419	666 811	1 048 390	1 686 029	2 856 189	:	6 204 927	604 835	993 887	1 673 389	2 932 816	:
Croatia	:	:	:	:	:	:	:	:	:	:	:	:	107 381	14 680	10 149	34 322	40 031	8 119	116 001	17 223	13 575	31 508	44 652	9 043
Italy	3 318 991	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	3 431 207	:	:	:	:	:
Cyprus	97 245	1 889	8 083	22 236	42 334	22 703	93 381	1 485	6 093	20 602	41 466	23 735	92 726	1 916	3 870	19 945	40 205	26 790	94 673	2 355	2 642	18 086	41 974	29 616
Latvia	45 923	:	:	:	:	:	50 047	4 649	5 245	12 780	22 016	5 357	53 421	4 714	6 760	12 368	23 705	5 874	53 266	4 496	7 491	11 932	23 938	5 409
Lithuania	80 739	:	:	:	:	:	55 676	:	:	:	:	:	57 345	:	:	:	:	:	59 293	:	:	:	:	:
Luxembourg	27 635	6 246	7 738	8 429	5 223	:	28 521	6 275	8 271	8 471	5 505	:	29 668	6 942	8 307	8 574	5 815	:	31 138	7 722	8 220	8 999	6 196	:
Hungary	359 686	28 903	39 459	104 173	163 914	23 237	371 278	31 982	30 149	105 397	177 918	25 832	386 629	39 189	35 186	93 008	196 457	22 789	404 204	47 941	37 338	87 402	201 092	30 431
Malta	32 456	1 243	1 852	4 369	13 082	11 910	33 054	1 394	1 473	5 096	12 477	12 614	33 085	1 434	1 830	5 185	11 458	13 178	33 731	1 084	1 925	4 980	9 944	15 798
Netherlands	815 169	161 052	150 678	282 475	245 569	35 704	814 954	154 426	:	:	:	:	828 383	157 081	:	:	:	:	852 632	177 115	:	:	:	:
Austria	355 214	93 330	78 177	104 408	64 774	14 525	365 686	91 343	79 927	111 871	67 832	14 713	375 163	91 968	86 173	110 357	71 794	14 871	387 786	96 387	89 154	110 862	75 951	15 432
Poland	2 334 415	66 653	261 484	415 298	981 847	838 287	2 399 323	137 492	247 445	501 607	812 937	699 842	2 447 764	149 191	209 710	490 176	852 838	745 849	2 515 751	15 886	155 818	520 738	878 066	945 243
Portugal	1 164 962	32 054	100 140	256 783	566 699	209 286	1 259 725	42 689	85 982	249 372	601 350	280 332	1 224 821	53 729	61 770	229 337	597 154	282 831	1 221 913	60 753	54 670	204 395	595 140	306 955
Romania	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Slovenia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Slovakia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Finland	387 674	22 336	35 564	82 602	137 203	109 969	400 396	21 438	38 579	76 121	151 499	112 759	414 295	22 294	38 216	73 503	161 547	118 735	430 717	25 348	34 236	73 901	169 305	127 927
Sweden	484 387	115 636	102 800	136 959	102 123	26 869	499 962	106 021	110 116	151 928	105 403	26 494	514 443	111 073	126 269	135 450	115 839	25 812	533 005	125 134	119 140	151 499	111 035	26 197
United King	:	:	:	:	:	:	:	:	:	:	:	:	3 627 473	673 877	709 002	1 102 438	1 007 152	135 004	3 775 884	724 262	761 102	1 047 945	1 097 909	144 666
Liechtenste	2 476	437	556	664	648	171	2 510	389	576	755	620	170	2 577	417	615	752	637	156	2 688	450	628	821	625	164
Norway	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	480 962	65 389	87 509	154 292	148 805	24 967
Switzerland	319 000	80 000	67 000	85 000	71 000	16 000	329 200	57 000	79 100	95 000	81 100	17 100	341 000	51 000	86 000	115 000	73 000	16 000	352 500	59 700	85 900	104 100	85 400	17 400
Former Yug	23 372	:	:	:	:	:	:	:	:	:	:	:	33 237	1 663	2 276	8 292	21 006	:	34 669	1 677	2 599	8 422	21 971	:
Turkey	2 933 050	405 378	615 210	1 034 878	605 800	271 784	3 062 479	258 685	754 127	999 972	752 437	297 258	3 255 299	308 175	733 908	951 989	945 863	315 364	3 442 483	359 617	581 708	996 860	1 147 587	356 711

Special value:
: not available

UNIT Number
VEHICLE Goods vehicles > 3.5 tonnes

TIME	2013	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014	2014	2015	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016
GEO/AGE	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea	Total	Less than 2	From 2 to 5	From 5 to 1	From 10 to	Over 20 yea
Belgium	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Bulgaria	348 834	:	:	:	:	:	369 189	:	:	:	:	:	396 582	:	:	:	:	:	405 217	:	:	:	:	:
Czech Repu	187 864	:	:	:	:	:	:	:	:	:	:	:	221 650	:	:	:	:	:	221 650	:	:	:	:	:
Denmark	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	28 326	5 452	4 784	9 664	6 116	2 310
Germany (u	531 000	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Estonia	24 521	393	436	3 216	6 397	14 079	24 807	455	516	3 008	6 653	14 175	24 974	462	617	2 682	6 791	14 422	25 417	474	656	2 205	7 244	14 838
Ireland	:	:	:	:	:	:	19 731	3 489	2 882	9 550	3 810	:	19 143	3 867	2 414	8 593	4 269	:	19 366	5 078	2 409	7 102	4 777	:
Greece	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Spain	:	:	:	:	:	:	332 568	7 320	16 017	74 016	120 279	114 936	332 422	9 831	13 434	63 902	127 266	117 989	335 018	12 644	11 727	53 079	136 304	121 264
France	348 715	32 009	46 230	102 950	167 526	:	344 215	29 116	46 947	98 838	169 314	:	337 159	27 554	49 150	88 791	171 664	:	334 162	30 711	45 593	84 550	173 308	:
Croatia	130 547	11 671	16 194	41 819	60 863	:	132 045	13 048	10 260	44 591	64 146	:	29 473	1 181	1 394	7 223	13 654	6 021	30 229	1 491	1 469	6 643	14 391	6 235
Italy	619 035	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	587 501	:	:	:	:	:
Cyprus	10 142	100	509	2 334	5 202	1 997	9 407	59	327	1 897	5 410	1 714	9 473	53	244	1 558	5 809	1 809	9 826	91	132	1 362	6 265	1 976
Latvia	33 976	:	:	:	:	:	20 021	548	826	3 150	7 082	8 415	19 198	501	920	2 760	6 781	8 236	17 260	491	880	2 309	6 406	7 174
Lithuania	34 628	:	:	:	:	:	20 493	:	:	:	:	:	20 770	:	:	:	:	:	21 965	:	:	:	:	:
Luxembourg	5 298	731	1 107	1 706	1 754	:	5 311	807	1 073	1 694	1 737	:	5 404	784	1 162	1 643	1 816	:	5 594	873	1 141	1 712	1 868	:
Hungary	46 874	1 956	2 811	9 783	19 652	12 672	46 258	2 060	1 984	9 757	20 037	12 420	45 166	2 412	2 284	8 700	20 982	10 788	44 757	2 663	2 666	7 771	20 397	11 260
Malta	9 830	181	269	1 005	4 174	4 201	9 920	188	186	1 207	3 899	4 400	9 941	133	293	1 346	3 365	4 804	10 463	112	233	1 270	2 751	6 097
Netherlands	65 046	10 221	12 294	20 693	17 203	8 349	63 356	9 176	:	:	:	:	62 436	8 992	:	:	:	:	62 155	9 729	:	:	:	:
Austria	53 346	9 972	10 429	16 851	12 014	4 080	52 908	9 904	9 612	17 658	11 832	3 902	52 352	10 067	9 718	17 013	11 778	3 776	52 582	10 578	9 936	16 087	12 274	3 707
Poland	627 649	15 759	27 932	63 217	213 095	307 646	638 104	14 940	19 255	101 597	184 829	317 483	650 612	17 081	19 318	99 410	185 173	329 630	663 904	17 817	19 914	95 496	186 444	344 233
Portugal	50 111	897	2 584	8 945	23 097	14 588	51 562	1 145	2 049	8 651	24 446	15 271	49 112	1 435	1 510	7 918	23 753	14 496	47 386	1 698	1 425	6 830	23 146	14 287
Romania	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Slovenia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Slovakia	288 436	:	:	:	:	:	293 118	:	:	:	:	:	302 455	:	:	:	:	:	308 952	:	:	:	:	:
Finland	:	:	:	:	:	:	137 285	6 300	10 508	31 210	60 545	28 722	141 197	5 479	11 183	28 001	63 673	32 861	145 779	6 280	10 408	25 428	66 341	37 322
Sweden	66 807	13 561	12 589	17 756	12 849	10 052	67 313	13 119	11 728	19 192	13 492	9 782	67 599	12 898	12 141	19 367	13 824	9 369	68 749	14 522	12 543	18 208	14 244	9 232
United King	:	:	:	:	:	:	:	:	:	:	:	:	360 695	50 780	76 206	110 415	103 210	20 084	365 397	58 912	76 102	100 417	108 737	21 229
Liechtenste	339	35	60	124	94	26	336	30	60	13	80	30	331	36	61	121	82	31	323	38	61	115	80	29
Norway	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	68 759	7 175	10 510	15 194	22 854	13 026
Switzerland	41 700	8 100	9 400	11 900	8 600	3 700	41 900	5 800	8 800	14 300	9 400	3 600	41 800	6 000	8 500	14 300	9 500	3 500	41 900	5 800	8 500	14 300	9 800	3 500
Former Yug	6 795	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Turkey	575 721	39 544	40 594	124 215	188 651	182 717	576 510	28 726	54 092	112 081	193 280	188 331	589 426	35 158	61 786	91 706	204 863	195 913	599 735	34 968	57 025	78 765	217 034	211 943

Table 5-2 Lorries (excluding light goods road vehicles), by permissible maximum gross weight [road_eqs_lornum]

Lorries (excluding light goods road vehicles), by permissible maximum gross weight [road_eqs_lornum]

Last update 06.04.18
Extracted oı 05.09.18
Source of dε Eurostat

UNIT Number

TIME	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014
GEO/WEIGI	Total	From 3 501	From 7 501	From 12 001	Over 40 000	Total	From 3 501	From 7 501	From 12 001	Over 40 000
Bulgaria	348 834	:	:	:	:	369 189	:	:	:	:
Czech Repu	187 864	103 438	18 054	66 372	:	:	:	:	:	:
Denmark	:	:	:	:	:	:	:	:	:	:
Germany (ui	531 000	:	:	:	:	:	:	:	:	:
Estonia	24 521	8 028	4 693	11 549	251	24 807	8 044	4 693	11 795	275
Ireland	:	:	:	:	:	19 731	:	:	:	:
Spain	:	:	:	:	:	332 568	57 161	82 803	192 454	150
France	348 715	23 500	66 331	258 810	74	344 215	23 008	63 794	257 346	67
Croatia	130 547	:	:	:	:	132 045	:	:	:	:
Italy	619 035	141 731	133 552	3 227	340 525	:	:	:	:	:
Cyprus	10 142	6 566	1 452	1 931	193	9 407	4 711	1 199	3 487	10
Latvia	33 976	5 705	3 820	24 451	:	20 021	5 323	3 580	11 027	91
Lithuania	34 628	13 780	9 025	11 804	19	20 493	8 499	5 047	6 724	8
Luxembourg	5 298	:	:	:	:	5 311	:	:	:	:
Hungary	46 874	12 582	12 763	21 510	19	46 258	11 852	12 582	21 799	25
Malta	9 830	7 334	621	1 865	10	9 920	7 469	612	1 827	12
Netherlands	65 046	:	:	:	:	63 356	:	:	:	:
Austria	53 346	6 649	6 078	40 602	17	52 908	6 444	5 791	40 657	16
Poland	627 649	284 175	233 386	107 824	2 264	638 104	233 604	205 204	197 043	2 253
Portugal	50 111	14 928	7 757	27 426	:	51 562	15 174	8 064	28 322	2
Slovakia	288 436	:	:	:	:	293 118	:	:	:	:
Finland	:	:	:	:	:	137 285	50 287	9 784	76 523	692
Sweden	66 807	7 151	7 158	52 390	108	67 313	7 075	6 867	53 240	131
United King	:	:	:	:	:	:	:	:	:	:
Liechtenstei	339	33	14	292	0	336	33	12	291	0
Norway	:	:	:	:	:	:	:	:	:	:
Switzerland	41 700	4 900	3 300	33 400	0	41 900	5 100	3 200	33 600	0
Former Yug	6 795	:	:	:	:	:	:	:	:	:
Turkey	575 721	156 945	70 487	347 398	891	576 510	152 148	71 440	351 952	970

TIME	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016
GEO/WEIGI	Total	From 3 501	From 7 501	From 12 001	Over 40 000	Total	From 3 501	From 7 501	From 12 001	Over 40 000
Bulgaria	396 582	:	:	:	:	405 217	:	:	:	:
Czech Repu	221 650	121 127	21 594	78 929	0	221 650	121 127	21 594	78 929	:
Denmark	:	:	:	:	:	28 326	:	:	:	:
Germany (ui	:	:	:	:	:	:	:	:	:	:
Estonia	24 974	8 008	4 680	12 010	276	25 417	8 091	4 708	12 325	293
Ireland	19 143	:	:	:	:	19 366	:	:	:	:
Spain	332 422	58 010	82 427	191 834	151	335 018	59 211	82 625	193 027	155
France	337 159	22 426	60 684	253 978	71	334 162	22 045	58 377	253 670	70
Croatia	29 473	10 186	4 701	14 395	191	30 229	10 023	4 875	15 150	181
Italy	:	:	:	:	:	587 501	137 337	131 239	3 471	315 454
Cyprus	9 473	4 677	1 223	3 571	2	9 826	4 783	1 248	3 795	0
Latvia	19 198	5 011	3 383	10 714	90	17 260	4 275	2 953	9 942	90
Lithuania	20 770	8 590	5 385	6 787	8	21 965	8 708	6 048	7 201	8
Luxembourg	5 404	:	:	:	:	5 594	:	:	:	:
Hungary	45 166	11 154	12 067	21 920	25	44 757	10 677	11 440	22 617	23
Malta	9 941	7 530	605	1 798	8	10 463	7 820	623	2 012	8
Netherlands	62 436	:	:	:	:	62 155	:	:	:	:
Austria	52 352	6 274	5 599	40 466	13	52 582	6 168	5 408	40 993	13
Poland	650 612	239 152	206 840	167 349	37 271	663 904	240 337	83 060	36 655	2 253
Portugal	49 112	14 143	7 722	27 245	2	47 386	13 333	7 496	26 555	2
Slovakia	302 455	:	:	:	:	308 952	:	:	:	:
Finland	141 197	51 111	9 960	79 370	756	145 779	51 977	10 126	82 801	875
Sweden	67 599	6 931	6 611	53 905	152	68 749	6 797	6 331	55 435	186
United King	360 695	171 056	20 183	162 049	7 407	365 397	170 637	21 092	167 208	6 460
Liechtenstei	331	32	10	289	0	323	31	9	283	0
Norway	:	:	:	:	:	68 759	24 463	3 535	38 850	1 911
Switzerland	41 800	5 100	3 200	33 500	0	41 900	5 200	3 100	33 600	0
Former Yug	:	:	:	:	:	:	:	:	:	:
Turkey	589 426	150 331	74 212	363 835	1 048	599 735	150 758	75 508	372 336	1 133

Table 5-3 Lorries, by type of motor energy [road_eqs_lormot]

Lorries, by type of motor energy [road_eqs_lormot]

Last update 19.04.18
Extracted or 05.09.18
Source of da Eurostat

UNIT Number
VEHICLE Goods vehicles <= 3.5 tonnes

TIME	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016
GEO/MOT_	Total	Petroleum p	Liquefied pe	Diesel	Electricity	Other	Alternative E	Petrol (exclu	Diesel (excl	Bioethanol	Biodiesel	Compressed	Liquefied na	Hybrid elect	Hybrid diese
Bulgaria	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Repu	425 142	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Denmark	397 001	549 186	:	4 201 807	:	:	:	:	:	:	:	:	:	:	:
Germany (u	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Estonia	71 435	12 693	0	58 614	17	:	128	12 689	58 614	:	:	111	0	4	0
Ireland	310 291	:	:	:	77	65	146	648	309 497	:	:	4	:	:	:
Spain	4 544 462	489 247	1 838	4 049 422	2 946	237	5 793	488 793	4 049 393	:	2	743	27	454	29
France	6 204 927	126 741	215	6 023 555	26 429	26 212	54 631	126 306	6 023 466	356	:	:	1 419	435	89
Croatia	116 001	4 420	:	110 540	65	973	1 041	4 420	110 540	:	:	3	:	:	:
Italy	3 431 207	:	:	:	:	:	130 071	202 759	3 098 377	:	:	:	:	:	:
Cyprus	94 673	4 861	0	89 802	1	9	10	4 856	89 802	0	0	0	0	5	0
Latvia	53 266	2 292	166	49 713	11	1 080	1 261	2 292	49 713	0	0	4	:	0	0
Lithuania	59 293	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Luxembourg	31 138	1 111	77	29 784	102	64	243	:	:	:	:	:	:	:	:
Hungary	404 204	20 265	1	382 482	94	1 213	1 457	20 265	382 482	0	2	147	0	0	0
Malta	33 731	1 201	0	32 489	25	16	41	1 201	32 489	0	0	0	0	0	0
Netherlands	852 632	:	15 720	:	:	:	:	26 134	806 254	:	:	2 992	:	:	:
Austria	387 786	18 078	2	366 284	1 467	998	3 424	18 078	366 284	:	:	957	:	0	0
Poland	2 515 751	615 824	171 152	1 673 992	411	51 956	225 935	615 824	1 673 992	1	0	2 414	1	:	:
Portugal	1 221 913	11 889	609	1 209 213	176	0	811	11 861	1 209 213	0	0	26	0	28	0
Slovakia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Finland	430 717	26 602	0	403 567	248	217	548	26 595	403 567	5	:	78	0	7	0
Sweden	533 005	52 111	7	470 031	1 552	4 033	10 861	52 055	470 031	4	0	5 265	0	56	0
United King	3 775 884	128 432	:	3 634 591	4 987	228	13 076	128 217	3 634 566	:	:	6 581	:	215	5
Liechtenstei	2 688	628	0	2 033	5	12	27	627	2 033	0	0	10	0	1	0
Norway	480 962	31 798	:	446 144	2 568	58	3 020	31 798	446 144	:	:	394	:	0	0
Switzerland	352 500	62 800	0	286 000	700	1 000	3 400	62 800	286 000	0	0	1 700	0	0	0
Former Yug	34 669	6 700	543	27 372	6	1	550	6 700	27 372	:	:	:	:	:	:
Turkey	3 442 483	93 756	82 801	3 257 630	130	8 096	91 097	93 756	3 257 630	:	:	70	:	:	:

Special value:
: not available

UNIT Number
VEHICLE Goods vehicles > 3.5 tonnes

TIME	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016
GEO/MOT_	Total	Petroleum p	Liquefied pe	Diesel	Electricity	Other	Alternative E	Petrol (exclu	Diesel (excl	Bioethanol	Biodiesel	Compressed	Liquefied na	Hybrid elect	Hybrid diese
Bulgaria	405 217	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Repu	221 650	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Denmark	28 326	:	:	341 453	:	:	:	:	:	:	:	:	:	:	:
Germany (u	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Estonia	25 417	5 985	0	19 398	0	:	34	5 985	19 398	:	:	34	0	0	:
Ireland	19 366	28	:	:	1	5	7	:	19 331	:	:	1	:	:	:
Spain	335 018	3 617	26	329 698	66	65	1 703	3 617	329 681	:	0	1 521	25	0	:
France	334 162	138	8	332 948	90	629	1 076	136	332 846	:	:	:	349	2	:
Croatia	30 229	49	:	30 150	:	30	30	49	30 150	:	:	:	:	:	:
Italy	587 501	:	:	:	:	:	1 378	3 323	582 800	:	:	:	:	:	:
Cyprus	9 826	9	0	9 817	0	0	0	9	9 817	0	0	0	0	0	:
Latvia	17 260	1 226	37	15 472	0	523	562	1 226	15 472	0	0	2	:	0	:
Lithuania	21 965	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Luxembourg	5 594	33	2	5 429	:	130	132	:	:	:	:	:	:	:	:
Hungary	44 757	515	0	44 211	0	18	31	515	44 211	0	0	13	0	0	:
Malta	10 463	34	0	10 421	0	8	8	34	10 421	0	0	0	0	0	:
Netherlands	62 155	:	292	:	:	:	:	870	60 660	:	:	204	:	:	:
Austria	52 582	90	0	52 439	1	4	53	90	52 430	:	:	48	:	0	:
Poland	663 904	29 037	8 296	609 976	619	15 655	24 891	29 037	609 976	0	0	321	0	:	:
Portugal	47 386	6	10	47 356	0	2	24	6	47 340	0	0	12	0	0	:
Slovakia	308 952	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Finland	145 779	2 025	1	143 446	1	211	307	2 025	143 446	65	:	30	0	0	:
Sweden	68 749	871	6	66 847	0	182	879	871	66 824	44	0	647	0	0	:
United King	365 397	1 863	:	362 837	402	25	697	1 863	362 755	:	:	195	:	0	:
Liechtenstei	323	3	0	320	0	0	0	3	320	0	0	0	0	0	:
Norway	68 759	3 236	:	65 184	2	81	339	3 236	65 178	:	:	256	:	0	:
Switzerland	41 900	300	100	41 500	0	0	200	300	41 500	0	0	100	0	0	:
Former Yug	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Turkey	599 735	6 730	91	587 813	:	5 073	5 192	6 730	587 813	:	:	27	1	:	:

Table 5-4 Road tractors by type of motor energy [road_eqs_roaene]

Road tractors by type of motor energy [road_eqs_roaene]

Last update 19.04.18
Extracted on 05.09.18
Source of da Eurostat

UNIT Number

TIME	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016
GEO/MOT_	Total	Petroleum p	Liquefied pe	Diesel	Electricity	Other	Alternative E	Diesel (excl	Bioethanol	Biodiesel	Compressed	Liquefied na	Hybrid diese
Belgium	45 749	237	:	41 756	3	:	3 753	3 753	:	:	:	:	:
Bulgaria	51 660	:	:	:	:	:	:	:	:	:	:	:	:
Czech Repu	4 488	18	:	4 444	:	:	26	26	:	:	:	:	:
Denmark	13 640	:	:	:	:	:	:	:	:	:	:	:	:
Germany (u	201 984	88	:	201 279	1	633	705	705	:	:	39	32	:
Estonia	11 365	54	0	11 309	0	:	2	2	:	:	2	0	0
Ireland	13 074	4	:	13 070	:	:	0	0	:	:	:	:	:
Greece	22 301	:	:	:	:	:	:	:	:	:	:	:	:
Spain	207 889	1 219	35	206 305	4	24	365	365	:	0	135	167	0
France	200 476	1	2	200 144	1	51	331	331	:	:	:	277	:
Croatia	10 443	63	:	10 346	:	34	34	34	:	:	:	:	:
Italy	162 092	154	:	:	:	:	362	362	:	:	:	:	:
Cyprus	1 805	3	0	1 802	0	0	0	0	0	0	0	0	0
Latvia	13 541	0	4	13 529	0	8	12	12	0	0	0	:	0
Lithuania	28 138	9	1	28 120	:	8	9	9	:	:	:	:	:
Luxembourg	4 516	1	:	4 440	:	75	75	75	:	:	:	:	:
Hungary	68 117	80	0	67 865	1	166	172	172	0	0	5	0	0
Malta	1 144	1	0	1 140	0	3	3	3	0	0	0	0	0
Netherlands	74 218	28	20	:	:	:	:	:	:	:	116	:	:
Austria	16 846	2	0	16 842	0	1	2	2	:	:	1	:	0
Poland	361 681	1 629	2 087	354 112	61	3 709	5 940	5 940	0	0	82	2	:
Portugal	41 175	0	42	41 116	0	1	59	59	0	0	16	0	1
Romania	:	:	:	:	:	:	:	:	:	:	:	:	:
Slovenia	12 981	1	8	12 970	0	2	10	10	:	:	0	:	:
Slovakia	31 016	:	:	:	:	:	:	:	:	:	:	:	:
Finland	13 656	12	0	13 641	0	2	3	3	0	:	1	0	0
Sweden	8 645	8	0	8 592	0	14	31	31	10	0	7	0	0
United King	134 341	1 116	:	132 561	291	338	643	643	:	:	12	:	0
Liechtenstei	275	0	0	275	0	0	0	0	0	0	0	0	0
Norway	9 092	176	0	8 911	0	5	5	5	:	:	0	0	0
Switzerland	11 200	0	0	11 200	0	0	0	0	0	0	0	0	0
Former Yug	5 640	353	105	5 181	:	1	106	106	:	:	:	:	:
Turkey	225 599	447	13	224 377	:	722	775	775	:	:	40	:	:

Table 5-5 Semi-trailers, by permissible maximum gross weight [road_eqs_semit]

Semi-trailers, by permissible maximum gross weight [road_eqs_semit]

Last update 06.04.18
Extracted o 05.09.18
Source of d Eurostat

UNIT Number

TIME	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016
GEO/WEIG	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000
Bulgaria	38 202	:	:	:	:	41 099	:	:	:	:	45 271	:	:	:	:	49 794	:	:	:	:
Czech Repu	49 752	:	:	:	:	52 183	:	:	:	:	53 815	:	:	:	:	53 826	:	:	:	:
Denmark	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	480 310	:	19 705	330 366	130 239
Germany (u	292 116	18 565	14 598	238 170	20 747	300 875	24 657	14 650	244 187	23 012	300 895	:	:	:	:	323 431	:	:	:	:
Spain	246 400	:	:	:	:	247 277	10 922	13 887	219 545	2 923	254 005	11 206	13 793	225 962	3 044	262 941	11 474	13 717	234 568	3 182
France	325 036	4 056	18 130	299 939	2 911	328 314	3 846	18 301	303 328	2 839	331 077	3 646	18 571	306 067	2 793	335 311	3 447	18 969	310 152	2 743
Croatia	9 940	:	:	:	:	10 258	:	:	:	:	10 842	1 041	173	9 313	315	11 927	1 017	188	10 369	353
Italy	98 043	24 589	:	:	73 454	:	:	:	:	:	:	:	:	:	:	105 481	25 135	:	:	80 346
Cyprus	7 420	:	:	:	:	7 475	:	:	:	:	7 522	:	:	:	:	7 640	:	:	:	:
Latvia	15 234	:	:	:	:	14 960	106	263	13 126	1 465	15 394	96	247	13 583	1 468	14 850	75	202	13 224	1 349
Lithuania	31 168	14 136	15 663	1 353	16	25 256	17 312	6 933	1 000	11	25 565	14 338	6 700	4 508	19	27 855	11 629	6 622	9 579	25
Netherlands	131 890	:	:	:	:	135 689	:	:	:	:	142 977	:	:	:	:	149 030	:	:	:	:
Austria	29 360	1 193	1 362	25 878	927	30 659	1 177	1 324	27 194	964	32 441	1 173	1 261	29 017	990	33 797	1 174	1 274	30 297	1 052
Poland	298 380	21 042	42 819	234 519	:	321 289	35 374	29 272	256 643	:	342 161	21 918	43 521	276 722	:	371 755	36 562	30 155	305 038	:
Romania	82 276	454	601	2 244	78 977	:	:	:	:	:	96 645	:	:	:	:	:	:	:	:	:
Slovenia	7 615	:	:	:	:	8 095	:	:	:	:	8 984	:	:	:	:	9 933	:	:	:	:
Slovakia	251 217	:	:	:	:	262 781	:	:	:	:	22 217	:	:	:	:	24 452	:	:	:	:
Finland	28 601	26 614	1 436	420	131	30 799	2 975	26 730	637	457	31 974	3 247	27 570	667	490	33 164	3 420	28 429	748	567
Sweden	26 036	551	1 122	8 911	15 452	26 096	547	1 118	9 322	15 109	26 573	543	1 102	9 551	15 377	27 796	544	1 072	10 287	15 893
Liechtenstei	328	26	28	266	8	329	25	29	268	7	344	26	31	280	7	353	42	36	286	9
Norway	:	:	:	:	:	15 021	:	:	:	:	15 813	:	:	:	:	16 418	251	521	3 567	12 079
Switzerland	16 200	5 800	7 900	2 300	200	16 200	5 700	8 000	2 500	200	16 700	5 700	8 000	2 700	200	16 800	5 700	8 100	2 900	200
Turkey	231 352	11 100	9 871	202 452	7 929	256 996	10 582	9 820	228 168	8 426	280 081	10 248	9 808	251 186	8 839	297 275	10 096	9 726	268 328	9 125

Special value:
: not available

UNIT Thousand tonnes

TIME	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016
GEO/WEIG	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000	Total	20 000 kg o	From 20 00	From 30 00	Over 40 000
Bulgaria	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Repu	1 071	:	:	:	:	1 210	:	:	:	:	1 371	:	:	:	:	1 380.776	:	:	:	:
Denmark	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Germany (u	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Spain	6 451	:	:	:	:	6	0	0	6	0	7	0	0	6	0	6 942	44	290	6 436	172
France	8 974	33	356	8 465	120	9 148	30	362	8 638	118	9 295	27	372	8 779	117	9 475	25	382	8 938	130
Croatia	252	:	:	:	:	264	:	:	:	:	290	5	3	269	13	313	5	3	290	15
Italy	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Cyprus	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Latvia	440.95	:	:	:	:	433.99	1.09	5.24	375.19	52.46	446.85	0.98	4.93	388.37	52.67	432.69	0.75	4.01	379.14	48.78
Lithuania	619.1	211.8	356.8	49.7	0.8	475.8	296.7	146	32.6	0.5	535.8	245.2	144.9	144.6	1.1	654.7	198.4	147.6	307.3	1.4
Netherlands	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Austria	974	11	36	876	51	805	7	26	732	40	857	7	24	785	41	897	7	25	822	43
Poland	8 277	252	1 070	6 955	:	7 089	278	1 732	5 079	:	9 786	831	1 275	7 680	:	9 815	920	1 917	6 978	:
Romania	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Slovenia	234 148	:	:	:	:	250 034	:	:	:	:	278 584	:	:	:	:	309 550	:	:	:	:
Slovakia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Finland	523	469.98	32.9	14.44	5.71	557	32	490	18	17	573	33	504	18	18	595	35	518	21	21
Sweden	835	4	20	263	547	838	4	20	277	537	855	4	19	284	546	898	4	18	309	567
Liechtenstei	8.71	:	:	:	:	8.75	:	:	:	:	9.16	:	:	:	:	9.53	0.17	0.68	8.36	0.32
Norway	:	:	:	:	:	499	:	:	:	:	527	:	:	:	:	549	6	75	413	53
Switzerland	356	62	208	77	9	365	62	211	82	10	375	62	214	87	11	382	63	213	94	12
Turkey	1 000	48	43	875	34	1 000	41	38	888	33	1 000	37	35	897	31	1 000	34	33	902	31

Table 5-6 Trailers, by permissible maximum gross weight [road_eqs_trail]

Trailers, by permissible maximum gross weight [road_eqs_trail]

Last update 06.04.18
Extracted o 05.09.18
Source of d Eurostat

UNIT Number

TIME	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016
GEO/WEIG	Total	750 kg or le	From 751 to	From 3 501	Over 10 000	Total	750 kg or le	From 751 to	From 3 501	Over 10 000	Total	750 kg or le	From 751 to	From 3 501	Over 10 000	Total	750 kg or le	From 751 to	From 3 501	Over 10 000
Belgium	:	:	:	:	:	:	:	:	:	:	315 424	:	:	:	:	:	:	:	:	:
Bulgaria	19 833	:	:	:	:	20 014	:	:	:	:	20 548	:	:	:	:	19 838	:	:	:	:
Czech Repu	345 742	:	:	:	:	374 050	:	:	:	:	405 908	:	:	:	:	423 373	:	:	:	:
Denmark	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	11 934 224	10 077 463	1 169 144	563 553	124 064
Germany (u	4 941 949	:	:	:	:	4 996 571	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Estonia	80 083	62 508	9 796	347	7 432	85 427	58 017	10 593	351	16 466	90 684	61 451	11 544	406	17 283	96 383	64 955	12 633	354	18 441
Spain	161 447	:	:	:	:	165 878	337	130 173	3 111	32 257	172 505	346	133 889	3 068	35 202	180 657	358	137 906	3 058	39 335
France	1 093 131	273 203	768 743	5 018	46 167	1 111 820	285 753	775 226	4 889	45 952	1 130 802	298 536	781 666	4 718	45 882	1 155 939	313 619	791 681	4 609	46 030
Croatia	23 320	:	:	:	:	25 015	:	:	:	:	26 115	1	7 964	9 669	8 481	27 367	1	8 477	9 988	8 901
Italy	249 065	3 524	1 538	3 271	243 497	:	:	:	:	:	:	:	:	:	:	259 920	738	1 428	3 168	254 586
Cyprus	7 514	:	:	:	:	7 919	:	:	:	:	8 299	:	:	:	:	8 669	:	:	:	:
Latvia	47 110	:	:	:	:	49 635	36 460	9 510	238	3 427	52 244	38 537	10 190	219	3 298	50 236	37 165	9 869	189	3 013
Lithuania	22 401	823	8 242	5 682	7 654	14 709	671	6 651	2 897	4 490	14 962	694	7 096	2 873	4 299	15 141	923	7 257	2 991	3 970
Hungary	403 662	247 053	39 755	58 696	58 158	409 473	246 031	41 624	59 321	62 497	412 533	244 687	43 523	59 253	65 070	420 928	247 117	46 029	57 931	69 851
Malta	1 425	19	10	124	1 272	1 538	19	10	130	1 379	1 677	19	11	130	1 517	1 783	19	11	130	1 623
Netherlands	964 889	:	:	:	:	970 962	:	:	:	:	979 377	:	:	:	:	989 453	:	:	:	:
Austria	662 236	330 663	246 226	19 227	66 120	680 052	336 140	256 002	19 161	68 749	698 712	342 290	265 629	19 142	71 651	717 625	348 709	275 697	19 065	74 154
Poland	632 443	:	472 982	145 938	13 523	634 340	:	473 650	91 891	68 799	636 051	:	474 287	147 463	14 301	641 602	:	477 812	148 957	14 833
Romania	221 832	189 107	21 822	:	10 903	:	:	:	:	:	251 445	:	:	:	:	:	:	:	:	:
Slovenia	17 635	:	:	:	:	18 612	:	:	:	:	19 831	:	:	:	:	21 237	:	:	:	:
Slovakia	:	:	:	:	:	:	:	:	:	:	250 675	:	:	:	:	253 288	:	:	:	:
Finland	894 501	781 043	85 792	373	27 293	929 805	794 818	106 118	330	28 539	957 058	806 373	120 854	356	29 475	982 984	814 482	137 691	369	30 442
Sweden	817 257	372 171	417 529	776	26 781	845 609	392 398	425 172	717	27 322	877 081	414 497	433 956	688	27 940	911 130	438 107	443 837	653	28 533
Liechtenstei	2 887	647	1 756	44	440	2 770	698	1 908	35	129	2 718	641	1 923	27	127	2 805	651	1 998	28	128
Norway	:	:	:	:	:	1 012 673	:	:	:	:	1 049 751	:	:	:	:	1 087 433	549 657	517 475	1 162	19 139
Switzerland	247 200	58 600	174 800	2 700	11 200	255 200	59 300	182 100	2 600	11 200	262 900	60 400	188 800	2 500	11 200	271 000	77 600	180 000	5 000	8 300
Former Yug	8 298	254	2 262	5 600	182	8 424	:	:	:	:	6 536	:	:	:	:	8 161	:	:	:	:
Turkey	11 277	695	2 075	851	7 656	11 418	673	2 154	822	7 769	11 778	663	2 395	818	7 902	12 087	660	2 644	818	7 965

Special value:
: not available

UNIT Thousand tonnes

TIME	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016
GEO/WEIG	Total	750 kg or le	From 751 to	From 3 501	Over 10 000	Total	750 kg or le	From 751 to	From 3 501	Over 10 000	Total	750 kg or le	From 751 to	From 3 501	Over 10 000	Total	750 kg or le	From 751 to	From 3 501	Over 10 000
Belgium	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Bulgaria	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Repu	421	:	:	:	:	502	:	:	:	:	544	:	:	:	:	524.12	:	:	:	:
Denmark	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Germany (u	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Estonia	419.6	24.61	9.38	1.71	383.9	619.35	38.88	17.59	2.7	560.18	657.55	41.59	19.3	2.65	594.01	513.89	31.38	11.27	9.54	461.7
Spain	757	:	:	:	:	0	0	0	0	0	0	0	0	0	0	1 005	0	95	11	899
France	1 594	95	817	24	658	1 616	101	835	24	656	1 635	109	849	23	654	1 668	116	823	22	707
Croatia	149	:	:	:	:	158	:	:	:	:	176	0	14	44	118	179	0	14	44	121
Italy	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Cyprus	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Latvia	81.62	:	:	:	:	83.37	14.96	11.22	1.22	55.97	83.65	16.09	12.21	1.11	54.24	79.37	15.91	12.32	0.97	50.18
Lithuania	165.7	0.5	14.5	44.1	106.6	98	0.4	11.9	22.4	63.3	94	0.4	12.7	22.4	58.5	93.6	0.4	13	23.7	56.5
Hungary	2 090.881	132.455	63.619	454.665	1 440.142	2 215.37	132.35	67.39	459.66	1 555.96	1 713.15	89.81	45.04	318.76	1 259.54	1 831.38	91.47	49	312.86	1 378.05
Malta	45.67	0.002	0.03	0.08	44.81	49.56	0	0.03	0.88	48.64	54.87	0.002	0.03	0.88	53.96	58.89	0.002	0.03	0.88	57.97
Netherlands	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Austria	2 332	191	349	135	1 657	1 827	144	264	96	1 323	1 909	149	278	96	1 386	1 981	154	294	96	1 437
Poland	3 177	:	851	380	1 946	6 362	:	1 338	672	4 352	3 251	:	1 185	1 150	916	7 682	:	1 908	4 472	1 302
Romania	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Slovenia	159 742	:	:	:	:	173 005	:	:	:	:	194 235	:	:	:	:	215 227	:	:	:	:
Slovakia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Finland	1 153.6	368.28	117.06	2.76	665.45	1 232	399	134	2	697	1 276	403	147	2	724	1 323	407	162	2	752
Sweden	1 139	180	332	4	622	1 171	191	342	4	635	1 211	202	352	3	652	1 255	215	365	3	671
Liechtenstei	4.36	:	:	:	:	4.57	:	:	:	:	4.593	:	:	:	:	4.75	0.31	2.65	0.12	1.67
Norway	:	:	:	:	:	1 114	:	:	:	:	1 164	:	:	:	:	892	515	9	368	0
Switzerland	431	29	248	13	141	446	29.2	262	12.2	142.7	459	30	275	12	143	474	41	278	35	120
Former Yug	8 298	40	1 735	837	5 686	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Turkey	1 000	62	184	75	679	1 000	59	189	72	680	1 000	56	203	70	671	1 000	54	219	68	659