Road Freight Transport in Europe: Alternatives for Increasing Capacity

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Abstract Transport is a strategic sector of the European Union economy (about 5% of GDP) as it represents a significant source of jobs (5% of total employment), without forgetting its role in the proper implementation of the European single market. The volume of freight transport has grown in recent decades and is expected to continue to do so, with road freight transport contributing more than 75% of total inland freight transport in the European Union (EU) in 2020. Thus, more than three quarters (79%) of EU road freight transport in tonne-kilometres were carried by heavy goods vehicles with a maximum authorised mass above 30 tonnes. In addition, heavy-duty vehicles are responsible for about a quarter of the fuel consumption and greenhouse gas emissions of the transport sector in the EU. To reduce emissions, the EU has proposed an increase in transport efficiency which, among other strategies, includes better use of freight capacity and longer and heavier trucks. Currently, the dimensions and weights of trucks in international transport on European roads are regulated by Directive (EU) 2015/719. The European Commission allows EU members to test different dimensions than those proposed in the directive (without unfair competition) in order to study different alternatives for more efficient, greener and safer transport. The general situation of the EU and neighbouring countries in the field of road freight transport will be analysed, considering some alternatives such as those proposed in the Scandinavian countries, the United Kingdom and Italy, and their impact on costs and carbon footprint.

Keywords Heavy good vehicle · Large good vehicle · Sustainability

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1 Introduction

Nowadays organisations are facing economic, political, social, and technological changes increasingly faster. These changes have their origin in different aspects such as the globalisation of markets, uncertainty, high competitiveness, greater customer demand, concern for sustainability, and increased energy costs, among others [1]. Adapting to these changes has made both companies and supply chains increasingly competitive [2]. The competence in the logistics chain has revealed the importance of the logistics strategy as a generator of added value, a tool to satisfy customers and a facilitator of the achievement of business objectives. With the objective of generating value and obtaining competitive advantages over their rivals, companies seek greater efficiency and productivity in the different processes of the supply chain.

Therefore, the role and relevance of logistics in the strategic management of a company are increasing [3]. The generation of value and the search for competitive advantages make companies devote greater efforts to the design and organisation of logistics strategy. This has allowed in recent years a great development in logistics and transport, becoming one of the relevant areas of business management. Transport is an essential activity in the logistics strategy at the enterprise level, a competitive force in business, and an important contributor to the socio-economic and environmental development of countries [4–6]. Transport plays an essential role in development by providing people with accessibility to resources and markets, thus improving their quality of life, but doing so with the least possible environmental impact, which is sometimes difficult to implement [7, 8].

On the other hand, transport represents a relevant cost for most companies, around 10–20% of the total costs of a product [9, 10] and an important industry in all developed economies [11, 12]. Logistics accounts for 14% of the GDP of the European economy. Transport is a key sector of the economy: it accounts for more than 9% of the EU's gross value added (the EU's contribution to the economy). Transport services alone account for around €664 million and employ almost 11 million people. The costs associated with transport have increased significantly in recent years. The reasons are increase in the fuel price, greater distances travelled, reduction in delivery times, and lack of qualified personnel, among others. To reduce transport costs, many companies and institutions have promoted studies to improve utilisation and expand the available cargo capacity [13–15] in the different modes of transport.

The increase in load capacity (volume and weight) in the different modes of transport (road, rail, sea, and air) plays a fundamental role in the profitability of transport. The weight–volume ratio is very important in the planning of the occupation of the load capacity of the transport used since the volume is often exceeded before the weight that is transported [16].

In addition to the economic aspect of the more effective use of carrying capacity, there is a social facet related to the growing sensitivity towards sustainability and the climate impact of transport. Transport is the logistics operation with the greatest impact on the environment and the highest energy consumption, generating a large

part of the world's greenhouse gas (GHG) emissions [17, 18]. According to the International Energy Agency [19], transport accounts for 28.9% of total energy consumption globally, and generating almost 25% of CO_2 emissions, for which road transport accounted for 72% in 2020. To improve the sustainability of transport, especially road freight transport, it is essential to study the efficient use of load capacity [16]. Operating with empty or partially loaded trucks implies an inefficient use of the company's resources and, consequently, operating in an unsustainable way [20–22].

The United Nations adopted in 2015 the 2030 Agenda for Sustainable Development [23], an opportunity for countries and their societies to embark on a new path to improve the lives of all. It has 17 Sustainable Development Goals (SDGs), including climate change and environmental advocacy. Precisely Goal 13 expresses how the levels of emissions of carbon dioxide (CO_2) and other GHG emissions in the atmosphere increased to record levels in 2019. Climate change is affecting all countries on all continents and alternating national economies [23].

Despite the fact that GHG emissions have fallen by around 6% in 2020 [24], due to movement restrictions and economic recessions resulting from the COVID-19 pandemic, this improvement is only temporary as global economy will recover from the pandemic and emissions will return to normal levels. In particular, the global transport sector is responsible for almost a quarter of GHG emissions, mainly CO_2, of which approximately 72% come from road transport [25]. In this sense, to realise a more optimal transport, it is essential to achieve a greater utilisation of the load capacity, which leads us to focus on the analysis of the percentage of volume and weight occupied as a system for measuring efficiency in the decision-making process [15, 16].

Cargo capacity concept has been studied from different perspectives and points of view (transport companies, customers, and government) which has led to a great diversity of opinions and results, without there being a standard model to calculate the most effective load capacity depending on the different situations of use [15, 16, 26]. One of the most used factors to determine efficiency of the freight transport is capacity utilisation (load factor), which relates the actual weight of goods to the maximum weight that can be transported [27]. This measure underestimates the actual use of the vehicle in sectors where utilisation is limited by volume and not by weight [28].

However, despite the importance of the concept of carrying capacity in the various logistics activities, most studies have focused on the analysis of the performance of the weight transported according to the type and age of the vehicles, without obtaining results on the economic and environmental consequences [29–34]. Based on data provided by Eurostat [35], the tonnes transported per vehicle are lower than the maximum allowed (EU average vehicle loads were 14.3 tonnes in 2020, with national loads of 13.5 and international loads of 15.9 tonnes) [35]: this is in many situations because lorries have a limited volume and cannot be filled more than the maximum permitted [28, 36].

Lumsden [37] states that long-distance road transport in Europe is very sensitive to load capacity measured on pallets as 2/3 of the total trips analysed were loaded to

at least 90%, while less than 20% of the same trips were loaded above 90% of the weight. The volume capacity used, on average, was 82%, and half of the transport is charged to 90%. And the average weight capacity used was 57%. A recent study in Spain [38] estimated that only 50% of vehicles with a maximum authorised mass of 40 tonnes are loaded with 32 tonnes or more. This is usually because many products occupy much more volume than weight, so that the lorries are not saturated in weight but in volume.

The purpose of this study is to analyse the contribution of increased volume, particularly lorry length, on the efficiency and environmental impact of road transport, proposing a solution based on existing trailers (or adapting them in a cost-effective way) without increasing the maximum weight transported.

The chapter is organised as follows. In Sect. 2, a brief compilation of the dimensions and weights permitted in Europe is shown, and in Sect. 3, the most common configurations of articulated vehicles and road trains in Spain are analysed. Then, in Sect. 4, the proposed solution is presented and justified. The chapter concludes with some conclusions and future developments.

2 Current Lorry Size and Weight Regulations in Spain and Other European Countries

2.1 Europe

Although there is an EU directive to harmonise the weights and dimensions of heavy goods vehicles (HGVs) for reasons of road safety and avoid damaging infrastructure [39] (amending [40]), there are some differences between them and even more if we include non-EU countries. This directive ensures that Member States cannot restrict the circulation of vehicles complying with these limits to carry out international transport operations within their territories and also aims to prevent national operators from benefiting from undue advantages over their competitors from other Member States when carrying out national transport.

However, as there are non-EU countries in Europe, they do not have to comply with these limits and [39] itself provides for derogations on maximum lengths to make HGVs more environmentally friendly by improving their aerodynamic performance or safer by adding extra space in the driver's cab. And exemptions on weights are also allowed for vehicles powered by alternative fuels (due to the higher weight of batteries in the case of electric vehicles). Thus, in a country's internal traffic, the dimensions and weights of lorries in the different European countries vary according to a multitude of circumstances: goods transported (mainly cars, timber and agricultural products), intermodal transport (containers), types of roads (number of lanes, motorways), and of course certain construction characteristics of the lorries (number of axles, refrigerated lorries).

There are very few differences in width and height between countries. The maximum permissible height is 4.0 m in most countries, except for some countries that

allow larger heights (4.2–4.5 m) for specialised lorries in transporting vehicles, cranes for removal of vehicles, or transporting containers approved for combined transport. And the maximum permissible width is 2.55 m except for some countries, which allow larger widths for refrigerated vehicles or for container transport. But although the length is broadly standard depending on whether we are talking about articulated vehicles (16.5 m) or road trains (18.75 m) in most European countries, there are significant differences when considering the transport of some goods, mainly cars. And there are some differences in the maximum authorised weight of articulated vehicles and road trains depending on the number of axles, the goods transported, the roads on which they travel, and above all whether the goods are transported in containers (Table 1).

Directive 97/27/EC [43] sets out provisions for the masses and dimensions of vehicles and also certain requirements relating to manoeuvrability. In the case of some semi-trailers, the manoeuvrability requirements will be deemed to be met by virtue of their dimensions.

2.2 Typical HGV Configurations in Spain

Articulated Vehicle The overall length of semitrailer tractor + semitrailer is 16.5 m in Spain (as in most European countries), so the semi-trailer can have a maximum length of 13.6 m (12 m from the kingpin) and a useful width of approximately 2.5 m. In order not to exceed the maximum overall height of 4 m, the semi-trailer is usually around 2.9–3 m (it can be slightly extended depending on tyre configurations). Therefore, we have approximately 33.7 m^2 of usable floor space and around 95–100 m^3 of volume for most models. This means that 33 euro pallets are usually transported (although it could be as many as 34).

Road Train The total length of a road train is 18.75 m, which allows an overall load dimension of 15.65 m for rigid drawbar trailers. Considering the same height and width dimensions, we obtain a usable area of approximately 39 m^2 and a volume of around 115 m^3. And a capacity of around 38 euro pallets.

Euro-Modular System (EMS) Since December 2015, road trains of up to 25.25 m and 60 tonnes have been allowed to operate in Spain, although their use is restricted to obtaining an authorisation to circulate. The EMS ('European Modular System') is a modular combination provided for in European legislation (Directive 2002/7/EC [44] amending Directive 96/53/EC [40]) which is made up of transport elements common in Europe, assembled in such a way as to form homogeneous units and optimise transport capacity: a 'carrier' lorry (7.82 m) pulling a semi-trailer across a platform (13.6 m) and a tractor unit with semi-trailer (13.6 m) plus trailer (7.82 m). Therefore, for the EMS, loading volume is approximately 156 m^3, loading area is about 53 m^2, and the maximum number of pallets (without re-assembly) is 52 pallets.

Table 1 Permissible maximum dimensions and weights of lorries in Europe

Country	Weights (in tonnes)			Length (in metres)	
	Road train		Articulated vehicle 5 axles and +	Road train[a]	Articulated vehicle
	4 axles	5 axles and +			
Albania	36	40	44	18.75	16.50
Armenia	36	36	36	20	20
Austria/Estonia /Germany	36	40/44	40/44	18.75	16.50
Azerbaijan	36	42	44	20	20
Belarus	38/40	40/42	42/44	20	24
Belgium	39	44	44	18.75	16.50
Bosnia-Herzegovina	36/38	40/42	42/44	18.75	16.50
Bulgaria /Liechtenstein /North Macedonia /Poland /Switzerland	36	40	40	18.75	16.50
Croatia	36	40	40/44	18.75	16.50
Czech Republic	32	48	48	18.75	16.50
Denmark[b]	38	44	44	18.75	16.50
Finland[c]	36	44	44	34.50	23
France	38	40/44	40/44	18.75	16.50
Georgia/Romania /Serbia	36	40	40/42	18.75	16.50
Greece	38	40/42	40/42/44	18.75	16.50
Hungary	36/38	40	40/42	18.75	16.50
Ireland	36	42/46	44/46	18.75	16.50
Italy	40	44	44	18.75	16.50
Latvia	36	40	40/42/44	18.75	16.50
Lithuania	36	40/42	40/44	18.75	16.50
Luxembourg	44	44	44	18.75	16.50
Malta /Moldova /Montenegro / Slovenia /Turkey	36	40	40/44	18.75	16.50
Netherlands	40	50	50	18.75	16.50
Norway	39	46–50	46–50	19.50	17.50
Portugal	37	44	44	18.75	16.50
Russia	36	40/44	40/44	20	20
Slovakia	40	40	40	18.75	16.50
Spain	36/38	40	42/44	18.75	16.50
Sweden	38	40[d]	44	25.25	24
Ukraine	38/44	40/44	40/44	22	22
United Kingdom	36/38	40/44	40/44	18.75	16.50

Adapted from International Transport Forum [41, 42]

[a]Road train specialised in the carriage of cars (loaded): 22 m (Ireland, Slovenia), 21.75 m (Romania), 21 m (Croatia, Montenegro, Serbia), 20.75 m (Czech Republic, Lithuania, Moldova), 20.55 m (Spain), 20.35 m (France); specialised road train: 20 m (Georgia); lorry with two trailers: 22/24 m (Hungary); road train with two trailers: 22.00 m (Turkey); heavy goods vehicle specially designed for the transport of timber: 24 m (Norway)

[b]Six-axle: 50 t; seven-axle or more: 56 t

[c]Five-axle: 44 t; six-axle: 56 t; seven-axle: 60 t; eight-axle: 64–68 t (restrictions for ADR), 69–76 t (not for ADR)

[d]On some roads, the permissible maximum weight is 74 t

2.3 Potential Benefits

Despite being a practical solution to reduce costs and emissions, longer and heavier vehicles (HLVs) often get a bad rap for being unsafe or requiring large infrastructure investments. HLVs [also known as toll doubles, eco-combis, high-capacity transportation (HCT), road trains, super trucks, or mega trucks] are trucks that are longer and heavier than the legal dimensions of a country.

By consolidating the load of many vehicles into a combination of high-capacity vehicles, HLVs can reduce carbon emissions and cost per unit of cargo transported: an individual LHV could reduce carbon emissions by 15–40%, a 33% reduction in its costs, and a 70% drop in fuel consumption and CO_2 emissions. There are also some positive effects on driver shortages; consolidating the load of many trucks into one allows transportation operators to operate with less manpower and potentially use the improved margins to pay better wages to skilled drivers.

3 Longer Articulated Vehicles: Similar Studies in Europe (Italy and the United Kingdom)

According to Article 4 of [40], a Member State may permit, through its national territory, the circulation of certain combinations of vehicles differing from maximum values of masses and dimensions set out in Annex I thereto, provided that this does not significantly affect international competition in the transport sector. This is enabled by a special permit, which is issued by the relevant state authorities.

The circulation of megatrucks is already allowed in European countries; however, a large part of these have applied this measure within the framework of pilot experiences to study and evaluate the impact of their implementation on traffic safety, infrastructure, emissions, costs, and transport. Sweden was the first country to implement gradually EMS systems, and subsequently the Netherlands. Also, Denmark, Finland, Belgium, Germany, Norway, and other European countries belong to the group of countries that have been gradually introducing this kind of transport. According to [45], the current studies are

- Sweden: Pioneer in the use of vehicles that exceed the limits of the regulations, it allows since 2009, in the north of the country, the use of trucks of 90 tonnes and 30 m long, for the transport of wood [46]. Up to 64 tonnes are currently allowed and 74 tonnes and 34 m long trucks (truck with two trailers) are being tested.
- The Netherlands is currently testing the use of 32 long truck trains with good results, which will soon allowed for usage.
- Denmark: Currently, the vehicle maximum authorised weight is 48 tonnes.
- Finland: It is similar to Sweden, but it is possible to use a complete trailer of 13.6 m long by train truck of 25.25 m, although it is not foreseen in the directive but cannot be used in international transport. In 2013, following a change in

legislation, the use of vehicles with the maximum authorised weight of 76 [47] was authorised. And they allow vehicles of 34.5 m since January 2019.
- Germany: Since 2017, trucks with a weight of 40 tonnes and a length of 25.25 m have been allowed to circulate, and the possibility of increasing the maximum gross weight to 44 t is being analysed [45].
- Norway: Norwegian regulations since January 2020 allow the circulation of vehicles 24 m long and up to 60 tonnes [45].

3.1 Progetto Diciotto (Italy)

With the publication in September 2021 of Decree Law number 121/2021 [48], the experiment known as Progetto Diciotto [49] (P18), developed by ANFIA (Associazione Italiana Filiera Industria Automobilistica) and several transport companies, has been put into operation. In 2009, the project began, which sought to increase the efficiency of road freight transport by increasing the length of articulated trucks from 16.50 m to 18 m (including towing devices), thus increasing their capacity in terms of volume (the maximum total mass remains at 44 tonnes).

P18 has shown that there are no problems in daily use and allows to reduce the number of commercial vehicles. In fact, an articulated truck of 18 metres, a metre and a half more than before (trailer of 15.1 m), can transport 37 euro pallets instead of the 33 of the 16.5 m (see Fig. 1). The experimental phase [50] after 10 million real kilometres, particularly on medium-length routes (200–600 km), proved that 18-m lorries have proven to be suitable for the transport of light and bulky goods loaded on pallets or in bulk, which can take advantage of the additional space available by staying within the legal limits of the maximum transportable weight (e.g. light food, packaging, toilet/household paper, household appliances, etc.).

In addition, allowing cargo saturation, saving on average 12% the number of trips, reducing fuel consumption per unit of goods transported, and consequently in CO_2 emissions has demonstrated to improve transport efficiency. In terms of driving comfort and manoeuvrability, for 74% of drivers there are no differences between the vehicles of the Progetto 18 and the traditional ones, except in some restricted parking lots, and they did not find manoeuvrability problems. In terms of safety, 83% perceived the same safety and 7% even better compared to 16.50-m trailers. When it comes to safety, only 6% of drivers believe that overtaking manoeuvres while driving a P18 vehicle is more difficult.

3.2 High-Volume Semi-Trailer Trial (the United Kingdom)

The Department for Transport [51] proposed an increase of 2.05 m in the length of semi-trailers and a maximum length of 18.75 m for articulated vehicles (allowing 30 standard UK pallets to be transported on one trailer instead of 26; see Fig. 2) within the existing weight limit of 44 tonnes gross vehicle weight (offering more efficiency

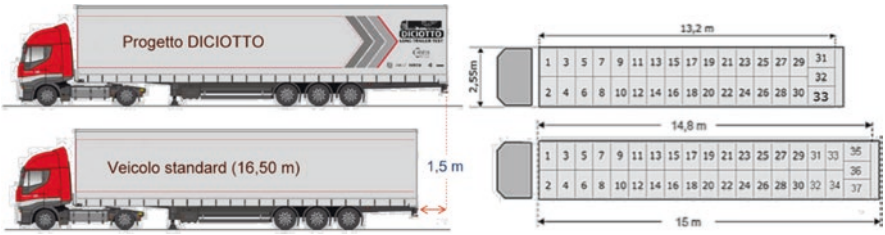

Fig. 1 Comparison between the P18 truck and the traditional one. (Taken from [50])

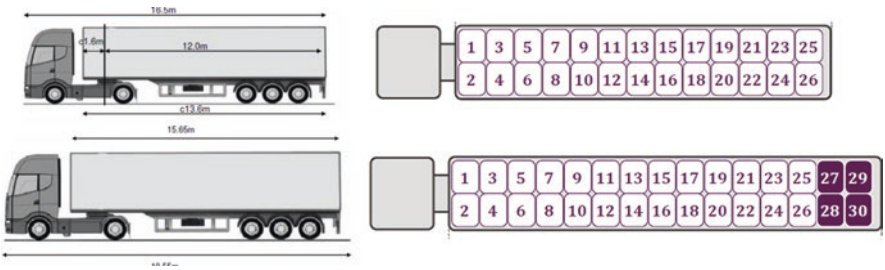

Fig. 2 Comparison between the LST truck and the traditional one. (Taken from [51, 52])

and fewer truck trips for goods limited by volume rather than weight). This will not involve vehicles longer than those on British roads as the current maximum allowable length for a rigid vehicle/trailer combination with drawbar is already 18.75 m.

The project began in 2009, with the main objective of analysing whether the introduction of these high-volume semi-trailers would generate general economic (more efficient freight transport, equal amount of cargo in less travels, etc.), environmental (local air pollution and carbon reduction), and land social benefits (positive benefit on congestion, reduction of accidents, noise, and infrastructure costs).

Testing with longer semi-trailers (LST) began in 2012, and until the end of 2019, the results of the trial indicated that [53, 54]

- It reduced, on average, 1 in 12 trips, saving between 54 and 60 million vehicle-kilometres.
- Showed reduction in emissions of 48,000 tonnes of CO_2 and 241 tonnes of NOx.
- LSTs have been involved in approximately 53% fewer collisions and personal injury victims than the average GB HGV.

Given these results, they have considered that they have enough data, and although initially it was planned that the tests would run until 2027, it is being considered to put an end to it and its use is approved, with certain limitations, this year; even a new variant of 48 tonnes is being thought.

4 Conclusions

The challenges faced by the transport and logistics sector worldwide include increase in demand and costs, reduction in emissions, and lack of drivers, making a series of measures necessary to improve the efficiency of the sector. One of these possible improvements is the efficient utilisation of truck capacity. In this sense, different alternatives are being proposed that allow to extend the length of the trucks especially if they are saturated in volume and not in weight.

An increase in the size of trucks means an increase in the capacity of the load and with it a decrease in the trucks that are necessary to transport the same amount of cargo, reducing congestion, accidents, consuming less fuel, and emitting less CO_2 than conventional vehicles per unit of cargo transported.

With respect to future developments, we are developing a pilot study, together with transport and industrial companies, in which a new alternative for trucks is proposed. Our approach considers the possibility of a truck in which the tractor–trailer combination is 20.5 m long, while maintaining the same maximum load limitation of 40 tonnes as at present. This solution, with a trailer of 18.75 m long, would allow 10 more euro pallets to be transported, which would be very efficient for routes that are not saturated in weight but in volume. This would have less impact on existing infrastructures and, given its manoeuvrability, would require little investment in infrastructure.

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