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European Modular System for road freight transport – experiences and possibilities

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Abstract

The aim of this study was to evaluate Swedish and Finnish hauliers' experiences of using the European Modular System, EMS, which entails Sweden and Finland the use of longer and heavier vehicle combinations (LHV's). In short, EMS consists of the longest semi-trailer, with a maximum length of 13,6 m, and the longest load-carrier according to C-class, with a maximum length of 7,82 m, allowed in EU. This results in vehicle combinations of 25,25 m. The maximum length within the rest of Europe is 18,75 m. Thus, by using LHV's, the volume of three EU combinations can be transported by two EMS combinations. This study indicates that the use of LHV's according to EMS have positive effect on economy and environment, while not affecting traffic safety negatively.

Swedish hauliers have the possibility of using either the traditional 24 m road trains or 25,25 m LHV's according to EMS for national long distance transports. Experiences of using EMS vehicle combinations are mostly positive. LHV's according to EMS implies increased load area and flexibility compared to the 24 m road trains.

Since 2000, the Netherlands have been carrying out trials with LHV's according to EMS. The Dutch trials clearly indicate that it is possible to operate with LHV's on a limited road net and achieve a numerous positive effects regarding traffic safety, environment and economy.

Road freight currently accounts for approximately 45% of total transports (tonnes-km) within EU and the amount of transported goods is expected to increase by 55% from year 2000-2020. LHV's according to EMS is one way to deal with this issue.

Referat

Syftet med denna studie var att kartlägga erfarenheter från svenska och finländska åkerier som utnyttjar möjligheten att använda längre och tyngre fordonskombinationer enligt det europeiska modulsystemet, EMS. Det består i korthet av den i EU längsta tillåtna semi-trailern, maximal längd av 13,6 m, och den längsta lastbäraren enligt C-klass, maximal längd av 7,82 m. Detta ger fordonskombinationer med en totallängd av 25,25 m. Inom övriga Europa tillåts kombinationer av maximalt 18,75 m. Via EMS kan således två fordonskombinationer transportera lika stor volym som tre kortare EU-kombinationer.

Studien indikerar att det finns en rad positiva effekter såsom lägre transportkostnader, minskad miljöbelastning samtidigt som en förbättrad trafiksäkerhet kan förväntas.

Svenska åkerier har möjlighet att använda antingen en traditionell långtradare, 24 m lång, eller ett 25,25 m långt ekipage utfört enligt EMS. Resultaten i denna studie visar att åkerier är mycket nöjda med modulekipagen och att de framförallt uppskattar den ökade lastlängden och flexibiliteten. Valet av fordon styrs av godsets art och åkeriets verksamhet.

Nederländerna har bedrivit försök med modulekipage sedan år 2000 och erfarenheter därifrån är mycket goda. Försöken indikerar klart och tydligt att det är möjligt att använda modulfordonen på ett begränsat vägnät och fortfarande uppnå positiva effekter.

Vägtransport utgör för närvarande 45% av allt transportarbete (tonkm) inom EU och mängden transporterat gods förväntas öka med 55% från år 2000-2020. Längre och tyngre fordon enligt EMS kan vara ett sätt att möta detta behov.

Preface

This project has been initiated by the Transport and Materials Handling Committee of TFK and financed by the Swedish Road Haulage Associated, Volvo Trucks and Scania. Representatives from these organisations and the Swedish Road Administration have also contributed to the project via the reference group. We would like to thank them for their support as well as their commitment and contributions.

The project has been performed during the autumn and winter of 2006/2007 as a Master Thesis by Ingemar Åkerman and Rikard Jonsson, students at the Royal Institute of Technology, KTH, in Stockholm. Peter Bark has served as supervisor at TFK while Christer Lindh has been supervisor at KTH.

Members of the reference group have been:

Ulf Ehrning	Volvo 3P
Anders Lundström	Scania
Anders Lundqvist	Swedish Road Administration
Mårten Johansson	Swedish Road Haulage Association

Representatives from the Dutch authorities supplying information and establishing contact with Dutch hauliers:

Chris Kampfraath	Dutch Ministry of Transport, Public Works and Water Management
Eric de Kievit	Dutch Ministry of Transport, Public Works and Water Management, AVV Transport Research Centre

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Rolf Nordström and Gustaf Krantz	TFK

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Rolf Backman, Lars Ahrén	Ahréns Transport
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Niklas Reinholdt	Västberga Åkeri

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Marcel Pater	Dick Vijn Transport
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Henk van der Wal	Van der Wal Transport

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Stockholm in March 2007
TFK – Transport Research Institute

Peter Bark
Managing Director

We would finally like to thank our supervisors, Peter Bark and Christer Lindh, for their support. We would also like to thank TFK for giving us the opportunity to write this Master Thesis and everyone that has taken their time and contributed to the project. Thank You!

Ingemar Åkerman and Rikard Jonsson

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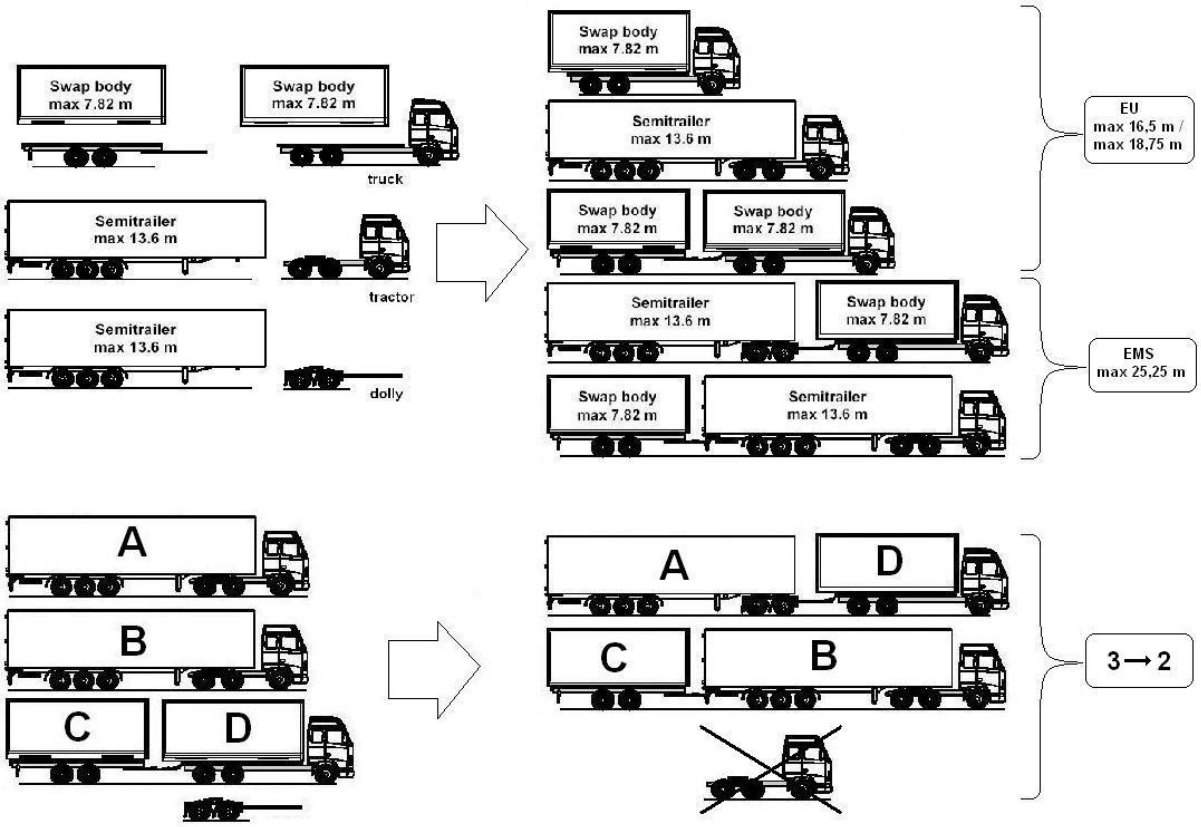
Summary

The aim of this study was to evaluate Swedish and Finnish hauliers' experiences of using longer and heavier vehicle combinations according to EMS. In short, it consists of combinations of the longest allowed semi-trailer, 13,6 m, and the longest allowed load carrier according to C-class, maximum 7,82 m. This results in vehicle combinations of 25,25 m and is known as the European Modular System, EMS.

In order to facilitate international transport and assure a fair level of competition, the European Union, EU, has legislated vehicle dimensions in a directive. No member state is allowed to deny use of the vehicles included in the directive. Sweden and Finland traditionally allow longer and heavier freight vehicles. When entering EU the nations wanted to keep their dimensions intact, rather than adopting the EU legislation. A Swedish adoption of the EU legislation would have led to a reduction of vehicle lengths from 24 to 18,75 m and GCW similarly from 60 to 40 tonnes. A report from TFK stated that this would cause an annual increase of transports costs by 20%, corresponding to 6,5 billion SEK. Further, large parts of the north Swedish forestry were in danger of becoming unprofitable. On the other hand, if Sweden and Finland were allowed to keep their then current legislation foreign hauliers had to purchase larger vehicles in order to stay competitive for transports in these countries.

In order to solve this, EU permitted each member state to use combinations of load carriers in the directive according to a modular concept. Sweden and Finland were allowed to combine one long and one short module, while the rest of EU only permits transports with either two short or one long module alternatively. By using EMS, the volume of three EU combinations can be transported by two EMS combinations. See figure below.



The study has been performed by conducting interviews with hauliers and authorities. Statistics and studies regarding the effects of vehicle dimensions on areas such as: traffic safety, environment and transport economy have been examined. The large-scale trial with increased vehicle dimensions in the Netherlands is discussed in a case study.

Results from this study indicate that the following generalized effects regarding increased vehicle dimensions according to EMS can be made:

Area	Most positive	Most negative	Result
Environment	Less fuel consumption per transported cargo unit.	May increase the market share of road transports	+
Economy, micro level	Reduced transports costs	Increased fuel consumption and maintenance per vehicle	+
Economy, macro level	More efficient transports, lower total costs	May need infrastructural adjustment	+
Congestion	Fewer vehicles transporting the same amount of goods	May increase the market share of road transports	+/-
Traffic safety	Fewer vehicles transporting the same amount of goods	Characteristics of the vehicles may increase the accident rate	+/-
Consequences on other transport modes	Facilitates intermodal transports	May increase the market share of road transports	+/-

Trial with increased vehicle dimensions proofs successful

Since 2000, the Netherlands have been carrying out trials with longer and heavier vehicle combinations according to EMS, (LHV's). Areas that have been closely monitored include traffic safety effects, economic and environmental consequences. The final trial involved 77 hauliers and some 150 LHV's. They were given access to the entire Dutch freeway system and each haulier was allowed to select ten routes outside of the freeway system. Worth noticing is that no infrastructural adjustments had to be made in order to carry out the trial.

Results from the trials indicated that, based on the preconditions used in the trials, 8000, corresponding to 7% of all regular heavy freight vehicles could be replaced by 6000 LHV's. This would have the following effects, annually:

- 1,8% reduced transports costs, corresponding to 216 million Euros.
- 4 fewer fatalities and 13 fewer injuries, corresponding to 9 million Euros.
- Positive effects on the environment, corresponding to 24 million Euros.
- 0,7% less congestion, corresponding to 10 million Euros.
- 0,05% increased road freight traffic, corresponding to 266 000 tonnes, and similar decrease of inland waterway by 0,2% and rail transports by 1,4%

The Dutch trials clearly indicate that it is possible to operate with LHV's on a limited road net and achieve a numerous positive effects regarding traffic safety, environment and economy. Further, the consequences on other modes of transports are marginal. Denmark and Norway are also interested in conducting similar trials with LHV's on the freeway system. The issue is debated in Germany and three states conduct trials, while the federal government remains negative towards increased vehicle dimensions.

Statistics indicate that there are currently approximately 1 million heavy freight vehicles performing long distance transports of pallet goods in Europe. These vehicles could be replaced by LHV's and this would, at best, result in 300 000 fewer vehicles.

Swedish experiences

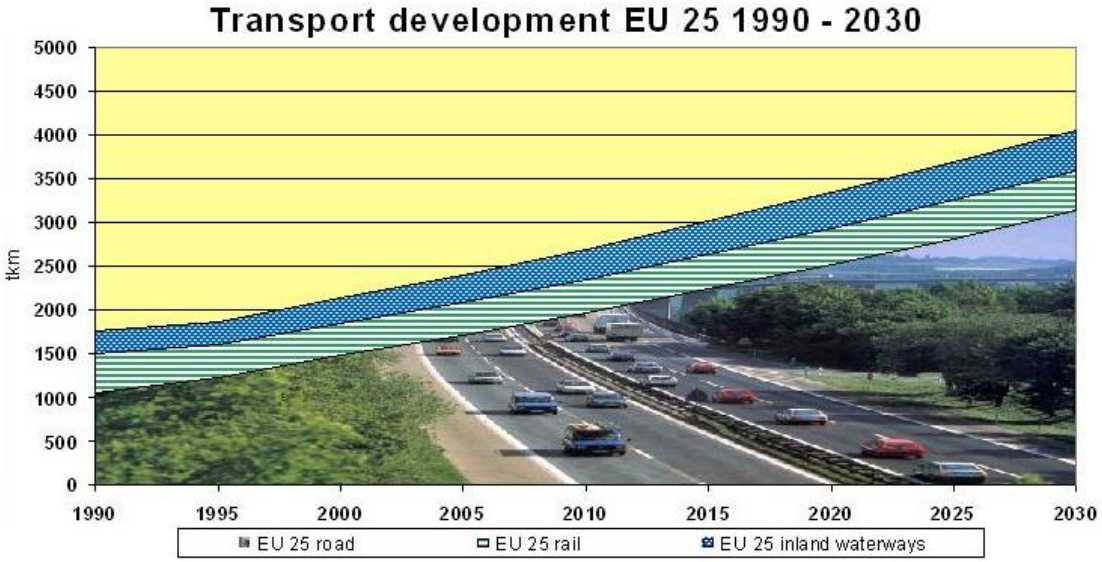
Swedish hauliers have the possibility of using either the traditional 24 m road trains or 25,25 m LHV's according to EMS for national long distance transports. Experiences of using EMS vehicle combinations are mostly positive. LHV's according to EMS implies increased load area and flexibility compared to the 24 m road trains. This study indicates that the following generalizations can be made:

- Hauliers performing **international** transports prefer EMS vehicles, thus using the same vehicles for all operations.
- Hauliers mainly transporting **volume sensitive goods** prefer EMS vehicles, which imply 8% added volume, corresponding to three bottom pallets.
- Similarly, hauliers mainly transporting relative **heavy goods** prefer 24 m road trains, as they weigh less, thus may carry some 2 extra tonnes of cargo without exceeding legislation.

Volume sensitive goods are of higher value per volume unit than heavier goods. These are manufactured products intended for the final costumer. EMS vehicle combinations consume more fuel per vehicle and increased need for maintenances. These factors, combined with the characteristics of the cargo, should thus decide the hauliers' choice of vehicle.

Finnish hauliers have similar experiences regarding the use of EMS, due to similar preconditions and tradition as in Sweden. Finnish authorities also allow a 13,6 m full trailer, strictly not included in EMS. For this reason, 25,25 m vehicle combinations are more common in Finland. Both Swedish and Finnish hauliers claim that increased vehicle dimensions in the entire Europe would facilitate their operations.

Increased dimensions, a way to meet the increased demand of transports



According to the EU White Paper "European transport policy for 2010: Time to decide", there is a continuously increasing demand for transports within Europe. Road freight currently accounts for approximately 45% of total transports (tonnes-km) within EU. This White Paper was produced in 2001 with objective to achieve sustainable development for transports and proposed 60 measures. This paper has been updated and if all measures are taken, the amount of road freight is expected to increase by 55%, from year 2000-2020. In the mid-term review of the White Paper, focus was shifted towards improvements of all modes of transports. Increasing the vehicle dimensions according to EMS could be one way to achieve this.

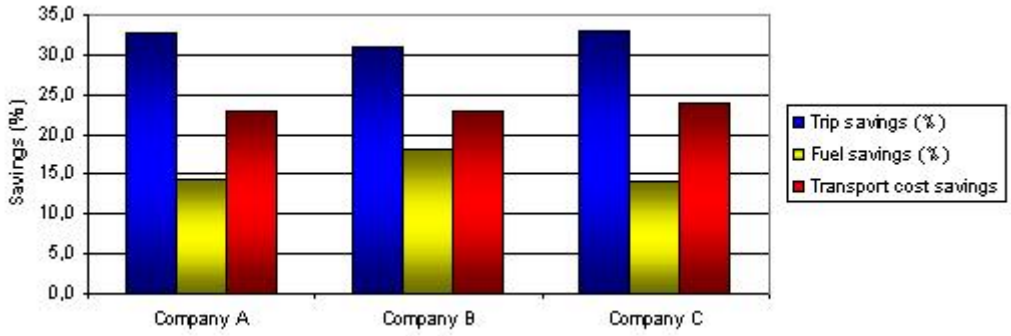
The issue of increased vehicle dimensions raises debate in Europe mainly due to four reasons:

- Are there any infrastructural limitations?
- Will the use of LHV's affect traffic safety negatively?
- Will the use of LHV's disadvantage other transport modes, thus transferring cargo from inland waterways and railways to road transports?
- Are there, hence, any negative environmental effects?

This study however indicates that these fears not necessarily have to be confirmed.

LHV's have positive effects on economy and environment

Several earlier reports have shown that increased vehicle dimensions according to EMS have positive effects on as well environment ("fuel savings") as economy ("transport costs savings"). This is based on the assumption that a decreased number of vehicles are needed for the same amount of transports if the dimensions of those vehicles are increased ("trip savings"). See figure below.



Infrastructure is mostly sufficient

The demand of increased vehicle dimensions is largest for long distance transports of volume-sensitive and high-valuable goods. These transports are mostly performed on larger transport routes, such as multi-lane freeways. Hence it is justified to assume that it is possible to allow LHV's on a limited road net, mostly consisting of larger transport routes. Some adjustments might be necessary, due to variations in infrastructure between Europe and Sweden/Finland.

Traffic safety is not negatively affected by increased vehicle dimensions

This study indicates that increased vehicle dimensions may have positive effects on traffic safety. This is due to larger vehicles lead to fewer vehicles in traffic. The number of vehicles is often considered to be the most significant parameter regarding traffic safety. According to the examined reports, there are no indications that the dimensions of the vehicles have an effect on the cause of the accidents. However, increased GCW affects the outcome of the accident. LHV's are preferably used on large, multi-lane, road, thus reducing the collision rate.

LHV's according to EMS facilitates intermodal transports

Increased vehicle dimensions correspond to more efficient road transports, which may have negative impact on other modes of transport regarding competition in the short perspective. One may however assume that other modes will develop in the long term. The White Paper also states the need of improvements for all kinds of transports. Further, EMS is assumed to facilitate intermodal transports, due to it involves increased use of standardized load carriers, already in wide-spread use within Europe.

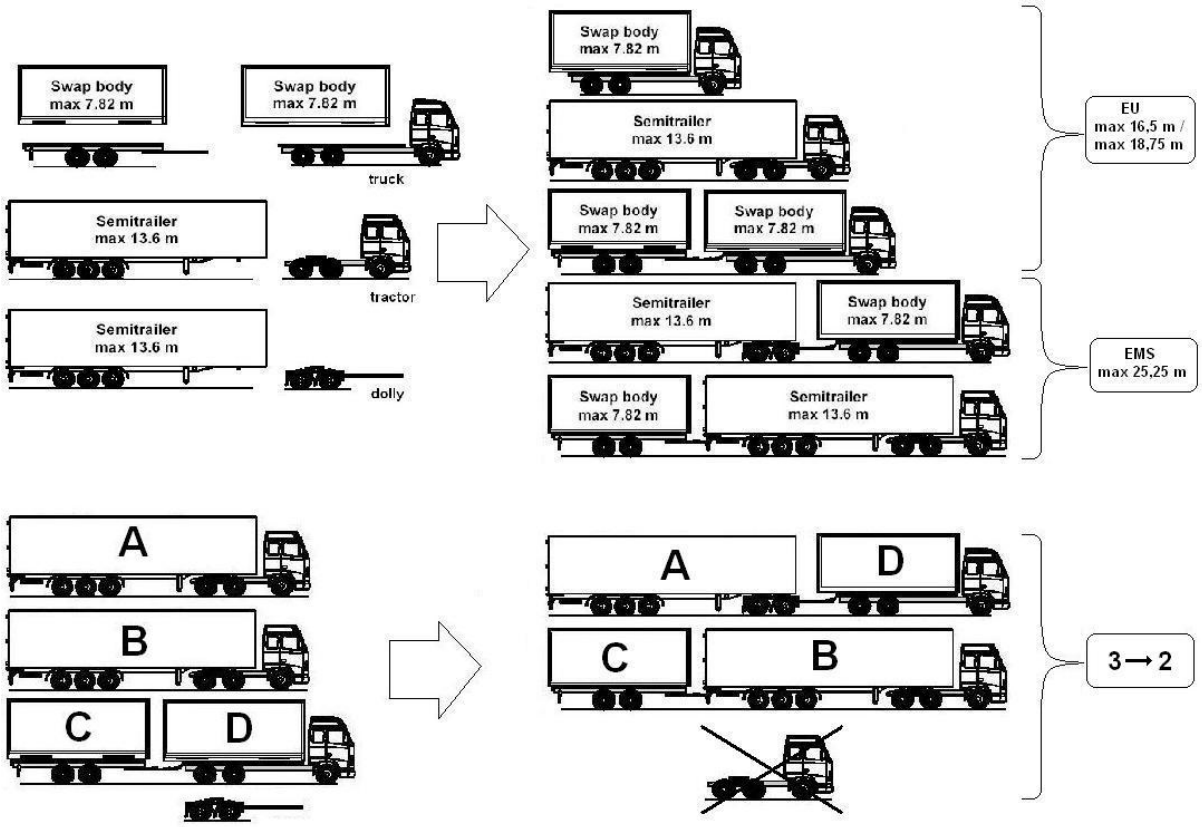
To sum this study up; increased vehicle dimensions according to EMS produces a number of positive effects for society, environment and transporting companies.

Sammanfattning

Syftet med denna studie var att kartlägga erfarenheter från svenska och finländska åkerier som utnyttjar möjligheten att använda längre och tyngre fordonskombinationer enligt modulsystemet. Det består i korthet av kombinationer av den i EU längsta tillåtna semi-trailern, 13,6 m och den längsta lastbäraren enligt C-klass, max 7,82 m. Detta resulterar i fordonskombinationer som mäter 25,25 m och kom att kallas European Modular System, EMS, eller modulsystemet.

För att underlätta internationella transporter och upprätthålla internationell konkurrens inom EU regleras fordonsdimensioner genom ett direktiv. Ingen medlemsstat får neka bruk av de i direktivet godkända fordonen. Sverige och Finland tillåter av tradition längre och tyngre fordonskombinationer för vägtransporter än övriga Europa. I samband med ländernas inträde i EU försökte de behålla sina större dimensioner istället för att anpassa sig till EU:s bestämmelser. En EU-anpassning av de svenska fordonen skulle ha inneburit att fordonslängden reducerades från 24 till 18,75 m och bruttovikten från 60 till 40 ton. En rapport från TFK visade att detta skulle medföra en ökning av transportkostnaderna med 20%, motsvarande 6,5 miljarder SEK per år. Vidare riskerade stora delar av det norrländska skogsbruket att bli olönsamt. Om Sverige och Finland å andra sidan fick behålla sina dimensioner skulle åkerier från övriga Europa behöva skaffa större fordon för att ha en chans att konkurrera på lika villkor vid transporter i dessa länder.

Lösningen blev att EU tillät varje medlemsstat att använda kombinationer av godkända lastbärare enligt modulkonceptet. Sverige och Finland fick tillåtelse att kombinera en kort och en lång modul medan övriga EU endast tillåter två korta, alternativt en lång modul. Via modulsystemet kan två fordonskombinationer transportera lika stor volym som tre EU kombinationer. Se bild nedan.



Denna studie har genomförts genom intervjuer med åkerier och berörda myndigheter. Tidigare rapporter angående fordonsdimensioners inverkan på olika områden, såsom trafiksäkerhet, ekonomi och miljö har sammanställts och diskuterats. De omfattande försöken med ökade fordonskombinationer i Nederländerna har behandlats i en separat fallstudie.

Utifrån de genomförda studierna kan följande generaliserade effekter antas gälla för ökade fordonslängder enligt modulsystemet:

Område	Mest positivt	Mest negativt	Resultat
Miljö	Mindre bränsleåtgång per transporterad godsenhet	Kan öka vägtransporternas marknadsandelar	+
Ekonomi, mikronivå	Lägre totala transportkostnader	Högre bränsleförbrukning och underhåll per motorenhet	+
Ekonomi, makronivå	Effektivare transporter, lägre totala kostnader	Kan finnas behov av infrastrukturella anpassningar	+
Trängsel	Färre fordon utför samma transportarbete	Kan öka vägtransporternas marknadsandelar	+/-
Trafiksäkerhet	Färre fordon utför samma transportarbete	Det enskilda fordonet kan ha en högre olycksrisk	+/-
Påverkan på övriga transportslag	Underlättar möjligheter för intermodala transporter	Kan öka vägtransporternas marknadsandelar	+/-

Framgångsrikt försök med ökade fordonsdimensioner

Nederländerna har sedan 2000 bedrivit försök med längre och tyngre fordonskombinationer enligt modulsystemet. Områden som studerades särskilt var inverkan på trafiksäkerhet, miljö och ekonomiska konsekvenser. Försöken omfattade som mest 77 åkerier och cirka 150 fordon. Dessa fick tillgång till hela det nederländska motorvägnätet och varje åkeri fick välja 10 rutter utanför motorvägnätet. Värt att notera är att det inte gjordes några infrastrukturella anpassningar för att bedriva försöken.

Baserat på samma förutsättningar som gällde under försöken fann man att 8000, motsvarande 7 % av alla konventionella tunga transportfordon skulle kunna ersättas av 6000 modulfordon. Detta skulle årligen medföra:

- 1,8 % lägre transportkostnader, motsvarande 216 miljoner Euro.
- 4 färre dödsfall och 13 färre skadade, motsvarande 9 miljoner Euro.
- Positiva miljöeffekter i form av minskade utsläpp, motsvarande 24 miljoner Euro.
- 0,7 % minskad trängsel, motsvarande 10 miljoner Euro.
- 0,05 % ökning av vägtransporter, motsvarande 266 000 ton, svarande mot en minskning av sjötransporter med 0,2 % och järnvägstransporter med 1,4 %.

Försöken i Nederländerna visar klart och tydligt att det är möjligt att införa ökade dimensioner för fordon enligt modulsystemet på ett begränsat vägnät och uppnå ett flertal positiva effekter gällande trafiksäkerhet, miljö och ekonomi. Vidare visas att överflyttning mellan transportslag är marginell. Danmark och Norge planerar också att utföra liknande försök med modulfordon på motorvägnätet. I Tyskland debatteras frågan och tre delstater bedriver försök medan den federala regeringen är negativt inställd till ökade fordonsdimensioner.

Statistik visar att det i Europa finns ca 1 miljon tunga lastbilar som transporterar pallastat gods över längre distanser och kan därmed vara utbytbara mot längre modulfordon. I bästa fall skulle detta innebära runt 300 000 färre lastbilar.

Erfarenheter i Sverige

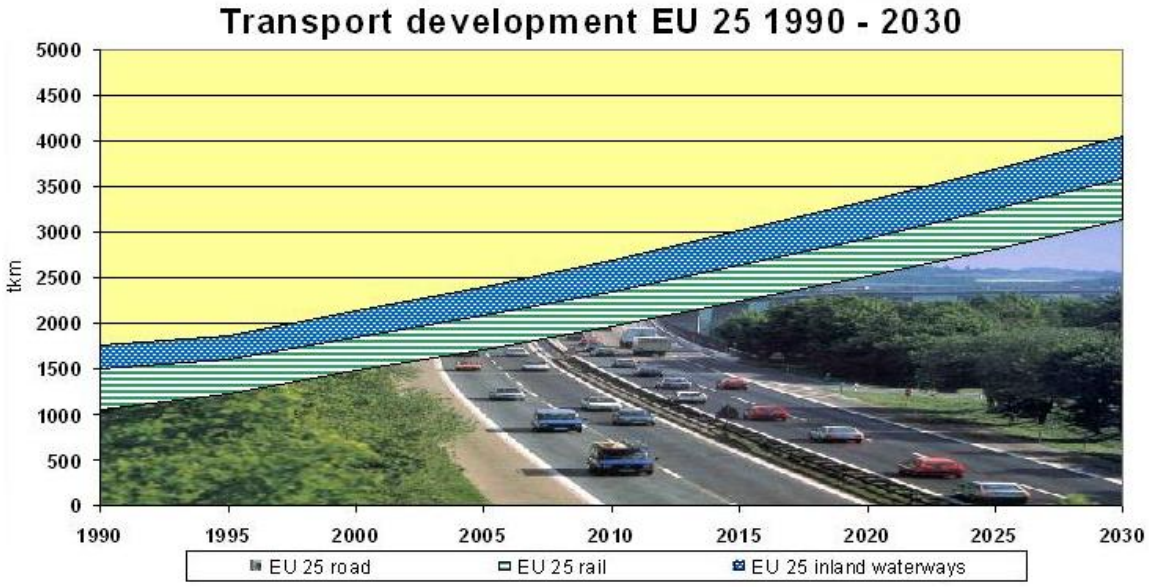
Svenska åkerier har alltså möjligheten att använda antingen traditionella 24 m eller 25,25 m fordonskombinationer enligt modulsystemet för fjärrtransporter i nationell trafik. Svenska åkeriers erfarenheter av modulsystemet är övervägande positiva. Systemet medför ökad volymkapacitet och en ökad flexibilitet jämfört med 24 m lastbilar. Utifrån de genomförda studierna kan följande generaliseringar göras:

- Företag som även utför **internationella** fjärrtransporter föredrar modulsystemet, då de kan utföra alla transporter med samma fordonsuppsättning.
- Företag som mestadels transporterar **volymkänsligt** gods föredrar modulsystemet, då det medför en volymökning på ungefär 8 %, motsvarande tre pallplatser.
- Företag som mestadels transporterar förhållandevis **tungt gods** föredrar 24 m fordon, då dessa har 2 ton lägre tomvikt och således kan lasta mer.

Volymkänsligt gods har högre värde per volymenhet än viktkänsligt gods. Detta då det ofta är färdigbearbetade produkter, nära slutkunden i flödeskedjan. Modulfordon har högre bränsleförbrukning per fordon än konventionellt 24 m-utförande och underhållsbehovet per fordonskombination är högre. Dessa faktorer viktat mot godsets volymvärde bör således avgöra åkeriers val av fordon.

Finländska åkerier har likvärdiga erfarenheter av användandet av modulsystemet eftersom förutsättningarna och historien är liknande den i Sverige. Finland har även tillåtit en 13,6 m släpvagn som i strikt mening inte omfattas av modulsystemet. Denna har medfört att användandet av 25,25 m fordon är vanligare i Finland. Svenska och finländska åkerier uppger att ökade fordonsdimensioner i hela Europa skulle effektivisera verksamheten ytterligare.

Ökade fordonsdimensioner, ett sätt att möta det ökade transportbehovet.



Enligt EU White Paper ”European transport policy for 2010: Time to decide” ökar behovet av transporter i Europa ständigt, och lastbilstransporter utgör för närvarande cirka 45 % av det totala transportarbetet (tonkm) inom EU. Denna vitbok togs fram 2001 med syfte att åstadkomma en hållbar utveckling inom transportsektorn och föreslog 60 åtgärder för detta. Denna vitbok har uppdaterats och om alla åtgärder vidtas förväntas mängden lastbilstransporter öka ytterligare med 55 % från år 2000 till 2020. I halvtidsöversikten av denna vitbok skiftades fokus mot en effektivisering av samtliga transportslag. Ökade fordonsdimensioner enligt modulsystemet är ett sätt att uppnå detta.

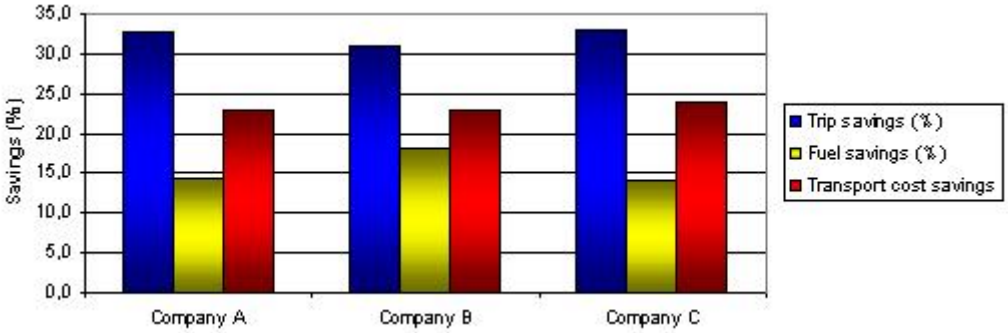
Frågan om ökade fordonsdimensioner väcker het debatt i Europa av främst fyra anledningar:

- Finns det begränsningar i infrastrukturen?
- Inverkar längre och tyngre fordonskombinationer negativt på trafiksäkerheten?
- Missgynnar dessa andra transportslag ur konkurrenssynpunkt och förflyttar därmed gods från inlandssjöfart och järnväg till lastbilstrafik?
- Medför dessa därmed negativa miljökonsekvenser?

Denna rapport visar dock att dessa farhågor inte nödvändigtvis behöver besannas.

Ökade fordonslängder medför positiva effekter för ekonomi och miljö

Flera tidigare rapporter har visat att användandet av längre fordonskombinationer enligt modulsystemet har positiva effekter på såväl miljön (”fuel savings”) som ekonomin (”transport costs savings”). Detta utifrån förutsättningen att ökade fordonsdimensioner innebär färre fordon som utför samma transportarbete (”trip savings”). Se bild nedan.



Infrastrukturen är generellt tillräcklig

Behovet av ökade fordonsdimensioner är störst för långväga transporter av volymkänsligt och högvärdigt gods. Dessa transporter utförs till största del på större transportleder, såsom flerfiliga motorvägar. Därmed är det befogat att anta att det är möjligt att tillåta längre fordon enligt modulsystemet på ett begränsat vägnät, främst bestående av just större transportleder.

Trafiksäkerhet påverkas inte negativt av ökade fordonslängder

Denna studie pekar på att längre fordonskombinationer kan ha en positiv inverkan på trafiksäkerheten. Detta om ökade fordonsdimensioner leder till ett minskat antal fordon på vägarna, vilket anses vara den starkast bidragande faktorn i olycksstatistiken. Enligt de undersökningar som studerats tyder ingenting på att dimensionerna på lastbilskombinationerna har med orsaken till olyckan att göra. Däremot inverkar fordonets bruttovikt negativt på utgången av olyckan. Längre och tyngre fordon kommer, i ett internationellt perspektiv, främst att trafikera större vägar med separerade körfält.

Intermodalitet främjas av modulsystemet

Ökade fordonsdimensioner innebär en effektivisering av vägtransporter vilket kan ha negativ inverkning på övriga transportslags konkurrenskraft i det korta perspektivet. På lång sikt kan man dock anta att övriga transportslag också effektiviseras. I White Paper påpekas att det krävs en effektivisering av samtliga transportslag för att möta det ökade behovet av transporter. Modulsystemet förmodas dessutom medföra en förbättring av de intermodala transporternas förutsättningar, då systemet bygger på ökad användning av standardiserade lastbärare som är vanliga i hela Europa.

Sammanfattningsvis visar denna studie att ökade fordonsdimensioner enligt EMS medför en rad fördelar för samhället, miljön och transportnäringen.

1 Introduction

The purpose of this study was to express experiences from hauliers using increased freight vehicle dimensions in Sweden and Finland, which allow longer and heavier vehicles than in the rest of the nations within the European Union, EU. Today most of the countries in the EU has limited the length of vehicle combinations to a maximum of 18,75 m according to the EU directive 96/53. The gross weights are also in general limited to 40 tonnes, while 44 tonnes are allowed for intermodal transports. As opposed to the rest of Europe, Sweden and Finland has a long history of using long freight vehicle combinations. The nations' current use of vehicle combinations of 25,25 m and 60 tonnes is enabled through the use of the European Modular System, using the same vehicles and load carriers as used in EU, but according to a modular concept.

1.1 Background

Until 1968, there was no limit regarding vehicle length in Sweden, and some vehicle combinations were over 30 m long. In 1968, Swedish authorities decided to limit the maximum vehicle length to 24 m. One of the reasons for 24 m was the demand of carrying three twenty foot equivalent units, TEU. Within this limit, a vehicle combination could carry three TEU, either three short or one long and one short (3x20 ft or 1x20 + 1x40 ft) load carrying units; a sort of modular concept. In 1973, discussions were held in regard to limit vehicle length to 18 meters, similar to most European countries at the time. Studies were performed, mainly concerning traffic safety and the conclusion was to maintain the current legislation.

Contrary to the length legislation, the allowed gross combination weight, GCW, in Sweden has increased in steps, thanks to improved infrastructure and increasing demand. In 1974, GCW was increased from 37 to 51,4 tonnes. In the 1990s, a lot of old bridges were reinforced, thus enabling increased GCW to 56 tonnes (1990) and finally 60 tonnes (1993).

In most of the countries in Europe, both vehicle dimensions and GCW have increased. Road-trains went from 18 to 18,75 m (1996). Semi-trailer combinations similarly from 15,5 to 16,5 m. GCW has increased slightly more. First from 28 to 38 tonnes, and presently 40 tonnes is the weight limit within EU (44 tonnes for indivisible load carrier in intermodal transports, e.g. 40 ft container). A number of countries also allow vehicles with GCW between 40 and 50 tonnes.

At the time of Sweden's entry in the EU, the discussion regarding vehicle dimensions once again arose. As a member state, Sweden would be forced to adopt the same legislation as the rest of EU, according to EU Council directive 85/3 (1985). Vehicle length would decrease from 24 to 18 m and GCW from 60 to 40 tonnes. This was met with great resistance, and studies showed that Sweden would lose up to 6,5 billions SEK (*Nordström, et al, 1994*) due to higher transport costs. Further, emissions of CO_2 and NO_x would increase. Also, the Swedish forest industry would suffer greatly, and the forest areas in the northern parts of the country would become unprofitable.

A compromise was settled, allowing Swedish hauliers to use longer vehicle combinations, while at the same time giving foreign hauliers the possibility of competing on similar conditions. This was achieved by something called the European Modular System, EMS. EMS is basically the idea of combining one long and one short load carrier into modules, while all vehicles and load carriers individually are allowed according to EU Council directive 96/53 (1996).

Directive 96/53 legislates vehicle dimensions for international transports within Europe. The directive state maximum length and weight oblige each member nation to allow motor vehicles and load carriers complying with the directive. However, each nation may allow vehicle combinations deviating from the directive for national traffic. A number of countries allow vehicles with higher GCW than stated in the directive, while Sweden and Finland are currently the only nations allowing longer vehicles for national transports. These vehicles are not allowed in other member states. By combining load carriers complying with the directive, vehicle combinations up to 25,25 m are allowed in Sweden and Finland according to "*a modular concept*", which also is mentioned in the directive. This way, by coupling and de-coupling modules, hauling companies may operate with the same vehicles in Sweden and Finland as well as in the rest of the EU.

EMS consists of a number of transport vehicle modules complying with directive 96/53.These vehicle and load carriers are combined with one of two coupling units to produce a number of freight vehicle combinations. The modules and units used are shown in *figure 1.1* below.

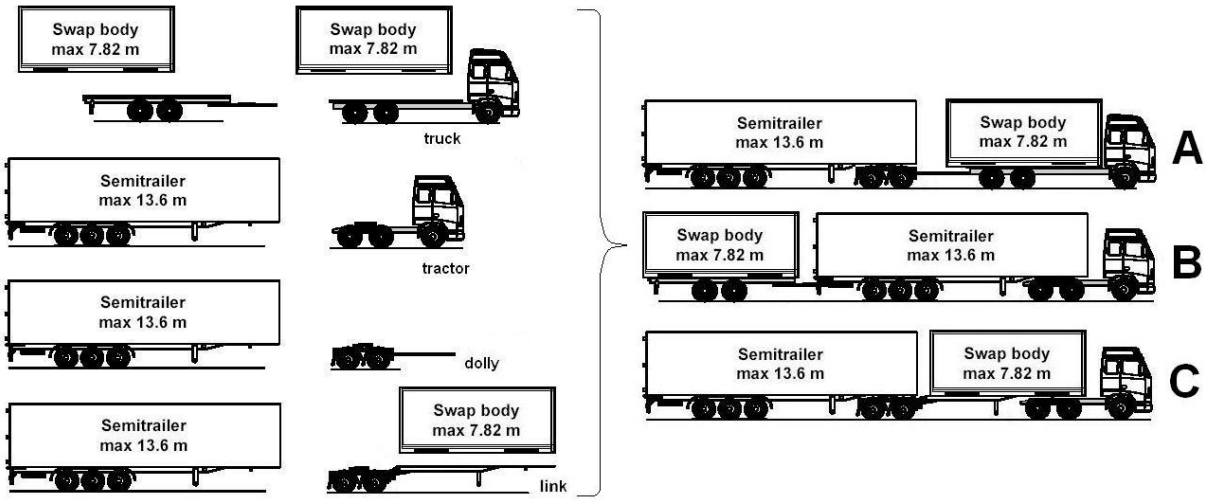


Figure 1.1: Units used within the European Modular System.

Note that the load carriers are not listed explicitly in the directive; rather they are the results of the limitations. The dolly and link are not listed at all. Also note that the shorter load carrier does not have to be a swap-body. It may be a rigid load carrier permanently attached to the frame of a truck or a trailer of the same frame.

In order to deal with the issue of increased demand for transports, EU produced a White Paper called "European transport policy for 2010: time to decide" (2001). One of the main objectives was

"*To strike a balance between economic development and the quality and safety demands made by society in order to develop a modern, sustainable transport system for 2010.*".

The paper presents 60 measures for increased transport efficiency, many of them focuses on increasing the share of rail- and sea-transports. However, if all measures are taken, the amount of road transports is still expected to increase by 38% to 2010. This number has been revised and today EU predicts a 55% increase in demanded transport capacity from year 2000 to 2020, as shown in *figure 1.2* below.

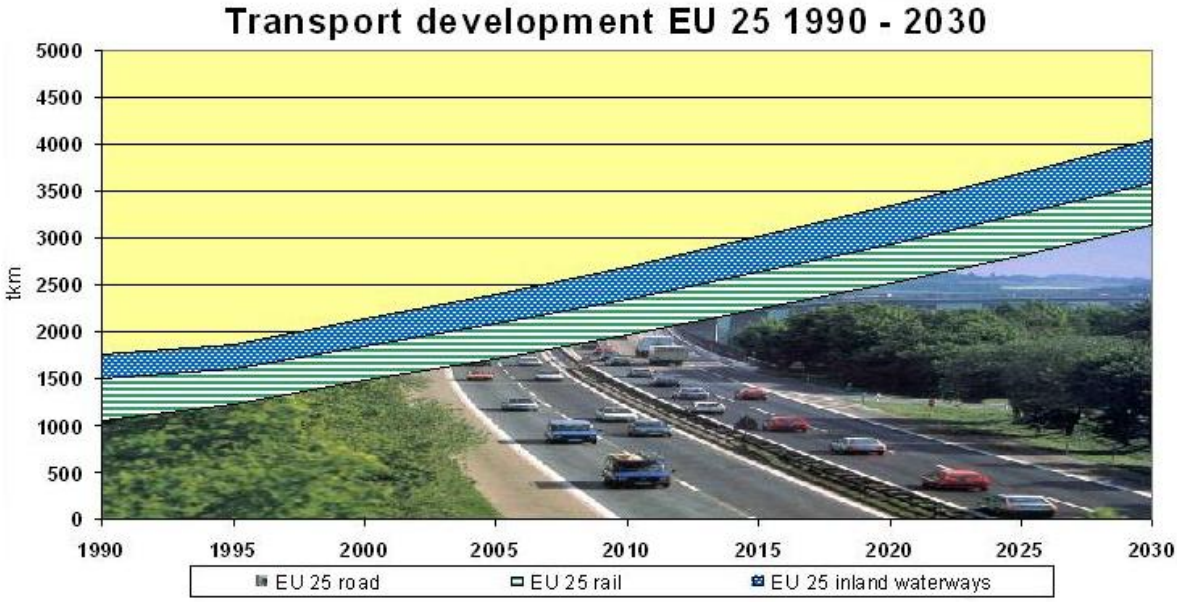


Figure 1.2: Goods transport development in EU25 1990-2030

Optimising transport efficiency for all modes of transports is stressed in the EU W*hite Paper - mid-term review* (*2006*). A large introduction of LHV's based upon EMS could be one such measure to optimise road transports efficiency while facilitating intermodal transports.

1.2 Objective, scope and limitations

The objective of this study is to evaluate experiences regarding the use of 25,25 meters EMS vehicles in Sweden, Finland and the Netherlands. Further, the effects of increased vehicle dimensions on traffic safety and economy are examined. Finally, the trials with longer and heavier vehicles carried out in the Netherlands are also given a thorough examination.

As this is an area with ongoing development, the report does not discuss any events or activities taking place after December 31, 2006.

1.3 Problems

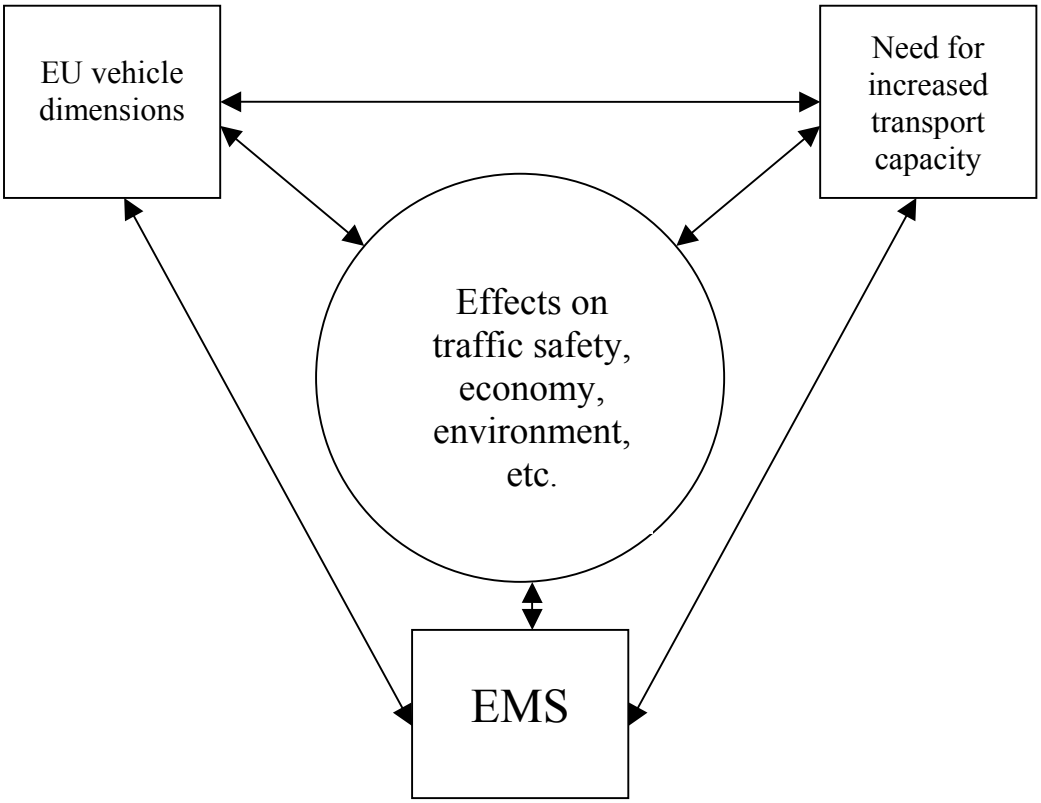


Figure 1.3: Problem description

Figure 1.3 above describes one complexity of this study and how different areas are affecting each other. On one hand, there is the EU-legislation, which is supposed to facilitate international transports and maintain a level of fair competition between nations. On the other hand, there is a need for increased transport capacity, where a legislation allowing increased vehicle dimensions is one solution. These two combined gave birth to a third entity; EMS. All three of these independently, and combined, have different effects on several areas, which are to be discussed in this report.

1.4 Reading guidelines

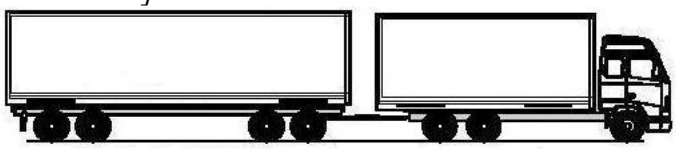
For the reader who is unfamiliar with this subject a more detailed description of EMS is found in the *Appendix*.

The reader who is only seeking new results is kindly directed to *chapters 3* and *4*, while *chapters 5-9* is a summary of earlier reports within this subject. *Chapter 10* includes the authors own comments.

1.5 Definitions

24 m Swedish road train
Road train consisting of a *truck* and a *full trailer* used since many years back. Not allowed in international traffic due it is deviating from *EU Council Directive 96/53*. In Finland this combination measures 22 m.

24 m Swedish road train. [Source: Rosenlunds Åkeri]

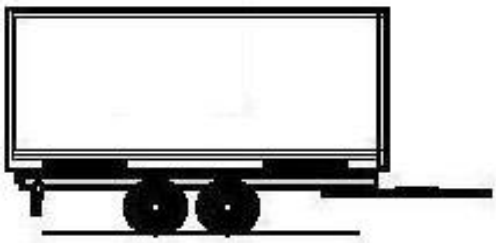


A-class load carrier
Load carriers according to ISO or CEN-standard, based on the frame of a 40 ft ISO container. There are three different types; A1219, A1250 and A1360 according to CEN standard, e.g swap-bodies. The number represents the load carrier's front to end length in cm. A-class also involves the 40 ft ISO container.

B-double / B-train
A combination with a truck, link and a semi-trailer. See *Module C*.

C-class load carrier
Load carriers according to ISO or CEN-standard, based on the frame of a 20 ft ISO container. There are three different types of swap-bodies; C715, C745 and C782. The number represents the swap-body's front to end length in cm. C-class also involves the 20 ft ISO container.

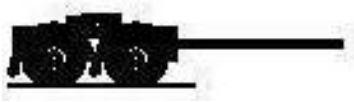
Centre-axle trailer
Trailer suited for the CEN-standard *C-class* load carrier, equipped with a stiff draw-bar. Also named cart or jigg.



Centre-axle trailer [Source: Plieger]

Combined transports
Transports using at least two different transport modes, e.g. road and rail transports. Also called *intermodal transports*.

Dolly
A trailer used as a steering axle when coupled via a fifth wheel to a semi-trailer. Along with a truck, forming the vehicle combination *Module A*



Dolly [Source: Närko]

EMS
Abbreviation for the European Modular System.

EU
Abbreviation for European Union.

EU15
Common term for the 15 nations that were EU-members in 1995 and comprises of:
Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom

EU directive 85/3
Directive produced in 1985 in order to facilitate international transport by setting "a least common standard" regarding vehicle dimensions, axle load, GCW, etc for all member states.

EU directive 96/53
Update of *directive 85/3*. The directive legislates the dimensions of vehicles for international traffic in EU.

GCW
Abbreviation for Gross Combination Weight, the total weight of a vehicle combination.

General Cargo
Often palletized goods for industrial use like machinery, tools, equipments and consumables like food, electronics, clothing, etc, etc.

GVW
Abbreviation for Gross Vehicle Weight, the total weight of a vehicle.

Intermodal transport
See *combined transport*.

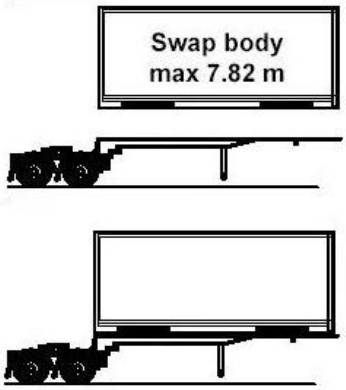
ISO container
Standardized load carriers, measuring 20, 40 or 45 ft in length and 8 ft in width, used for inter modal transports. ISO = International Organization for Standardisation.

ISO container [Source: Dancontainer]

Jigg
A common name for the *centre-axle trailer*

LHV
Abbreviation for Longer and Heavier Vehicles. In this report referred to vehicle combinations longer and heavier than regular EU-combinations of 18,75 m and 40/44 tonnes.

Link
In this report referred to a vehicle used to couple a semi-trailer to a tractor while at the same time carrying a CEN-standard *C-class swap-body* or a permanent load area according to the same frame, forming a *Module C* vehicle combination.



Link [Source: Parator]

Load carrier
A permanent or removable unit suited to carry load, e.g. a container, swap-body, semi-trailer or trailer.

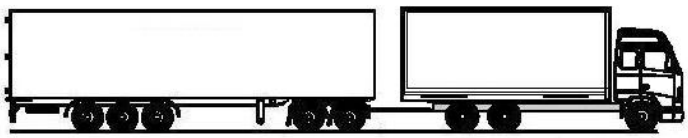
LZV
"Langere en Zwaardere Vrachtautocombinaties", Dutch abbreviation for *LHV*

Modular Concept
Introduced in the article 4.4b in the directive 96/53, in fact enabling the use of EMS.

Module A

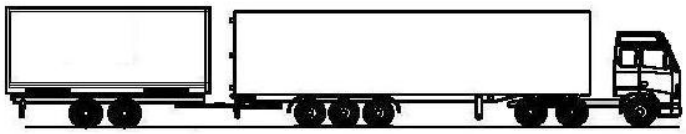
In this report referred to as the EMS combination of truck, dolly & semi-trailer.

Module A [Source: Henk v.d. Scheur]



Module B

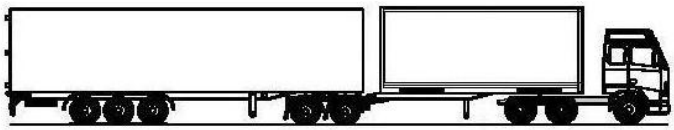
In this report referred to as the EMS combination of tractor, semi-trailer & jigg.



Module B [Source: Ahréns Åkeri]

Module C

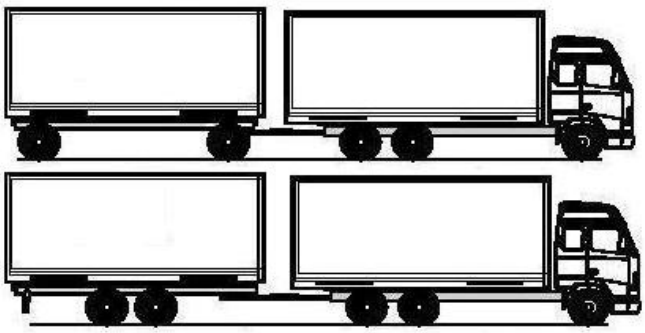
In this report referred to as the EMS combination of tractor, link & semi-trailer. Often called B-double or B-train.



Module C [Source: Stoltzes transport]

Road train

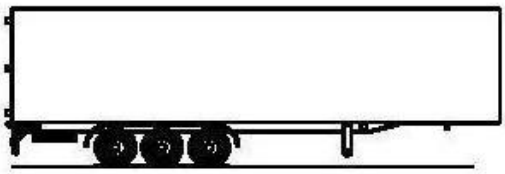
In this report referred to as the EU vehicle combination consisting of a truck and a short trailer, resulting in a maximum combination length of 18,75 m.



Roadtrain [Source: Brandes]

Semi-trailer

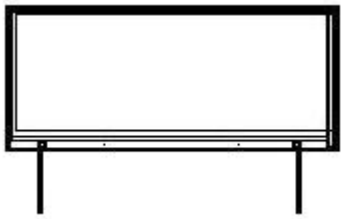
A trailer used in such a fashion that the front end rests upon a tractor, link or dolly. Semi-trailers may have different dimensions, of which some are according to *A-class*. Maximum length allowed within the *EU-directive 96/53* is approximately 13,6 m.



Semi-trailer [Source: PNO]

Swap body

A load-carrier able to be loaded and unloaded on *trucks*, *jiggs* and rail-road carriages. In this report swap-body is referred to as the CEN-standard *C-class* load carriers of 7,15, 7,45 and 7,82 m.



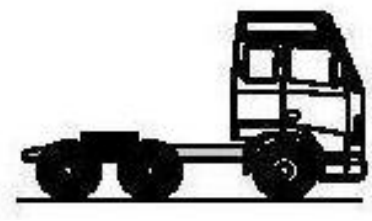
Swap body [Source: 3Sgroup]

TEU

Twenty-foot equivalent ISO container. 1 TEU equals a 20 foot container, 2 TEU equals 1x40, or 2x20 foot container. TEU-containers may be used within EMS.

Tractor

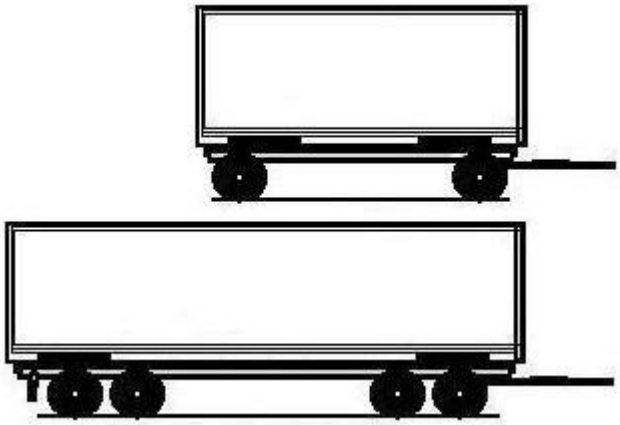
A motor vehicle able to tow semi-trailers and links. The tractor is equipped with a "fifth wheel" where a link or semi-trailer is connected; the tractor thus has no load-carrier.



Tractor [Source: Scania]

Trailer (full trailer)

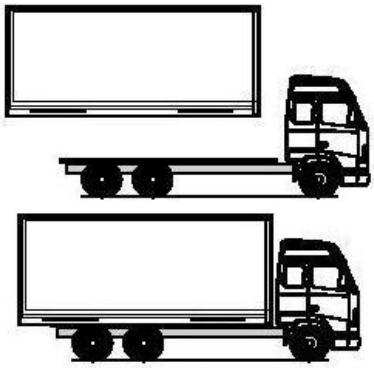
A load carrier with a draw-bar and axles in the front and rear. Maximum length according to *96/53* is 12 m. Full trailers are frequently used in Sweden and Finland, but are today not so common in EU, due to the length limit of 18,75 m.



Trailer(full trailer) [Source: Schmitz]

Truck

A motor vehicle that will carry the load (rigid) or a load carrier (swap-body). Trucks can be equipped with towing devices to enable towing of trailers and dollies. Also at times called lorry.



Truck [Source: Scania]

2 Method

This study is based upon information gathered using the following methods:

- Literature survey
- Interviews
- Inquiry
- Case study

The main part of this study is based on interviews with a number of hauliers and authorities whose activities are in connection with the project.

An inquiry was used to gather more quantitative information.

2.1 Literature survey

Since this is a subject not covered extensively by researches, there is not a lot of present literature. However, a number of reports have been examined and statistics are collected and discussed.

2.2 Interviews

This study has been carried out by conducting several interviews with a number of hauliers and also some authorities, closely connected to the subject. The hauliers were located in Sweden, Finland and the Netherlands while there have been interviews conducted with authorities in Sweden and the Netherlands.

Twelve Swedish, one Finnish and four Dutch hauliers were interviewed.

The Swedish hauliers were selected with regards to their location, size, main activity, and number of EMS-vehicles. The focus was on companies performing long distance transports, both nationally and internationally. Also larger companies were preferred, in order to include a large number of vehicles.

In order to carry out the interview on location, hauliers in the Stockholm region were preferred. Four hauliers outside of Stockholm were interviewed: one in Västerås and three in the Helsingborg region. These interviews were still carried out on location. Four interviews were conducted via telephone.

2.3 Inquiry

As a complement to the interviews, an inquiry was produced, in order to achieve more quantitative results.

The hauliers were selected from a list, received from the Swedish Traffic Register, containing over 500 hauliers having at least one dolly registered. As a reference, there are approximately 2500 dollies in traffic in Sweden.

The focus of the inquiry was on hauliers with long distance transport as main activity. As the scope of the inquiry was to complement the results of the interview in a wider perspective, focus was on hauliers with 25-100 employees. To be able to get carry the inquiry out in an effective way only hauliers with an e-mail address were selected.

The topics of the inquiry focused on the use and experiences of using the EMS.

The inquiry was sent to 134 Swedish hauliers and 23 were received.

2.4 Case study

A case study regarding the Dutch trial with LHV's, LZV-proef, is discussed in *chapter 4*.

The aim of the case study is to show-case that LHV's are able to operate properly within tight restrictions and still have positive effects on the economy as well as on traffic safety, environment, and congestion.

3 Experiences of using EMS

EMS vehicle combinations of 25,25 m have been used in Sweden and Finland since November 1, 1997. The Netherlands have carried out extensive trials using EMS vehicles since 2000 in two different trials. A thorough description of EMS is found in the *Appendix*.

The following experiences have been compiled by interviewing a total of 17 hauliers in Sweden, Finland and the Netherlands. Answers from 23 hauliers taking part in the inquiry have also been taken into account. A total number of more than 3000 vehicles are covered by the interviews in this study.

Primarily the scope of the interviews and inquiry were to analyze hauliers' experiences of using EMS vehicle combinations. Further, the answers were compared to statistics, other reports and literature within the subject.

Regarding experiences of using EMS this study asks several questions:

- Is the transported goods volume or weight sensitive?
- What types of goods are transported?
- Are there any economic benefits?
- On what routes are EMS vehicles used?
- Are there modal shifts from train to road?
- Experiences regarding how traffic safety is affected?
- In what kind of operations are LHV's used?

Generally all hauliers within this survey using EMS vehicles are very pleased with them. First and foremost they are very pleased with the extra loading area. Secondly hauliers appreciate the extra flexibility the EMS gives them due to the standardized load carriers facilitating intermodal transports. Each of the EMS combinations also has the possibility of decoupling one of the trailers, thus resulting in a shorter vehicle suited for delivery and pick-up in towns, cities, etc. The ability to perform international transports with the same units is also much appreciated and a main reason for using EMS.

The main complaint regarding EMS vehicles was the increased need for maintenances. Hauliers however consider that the advantages are overcoming this drawback.

3.1 Sweden

Swedish legislation regarding vehicle dimensions is less strict than the general legislation within EU. Swedish hauliers also have the possibility of using traditional 24 m vehicles which are able to carry more weight, since the 24 m vehicle's lower weight unloaded. This is of great use for cargo of high weight, while not being very voluminous. A common approach among Swedish hauliers is thus to use the 24 m vehicle combinations for heavier goods and the 25,25 m vehicle combinations for voluminous goods in national transport.

Since there is little, or none, statistics regarding how common the 25,25 m vehicles are this study has tried to answer this question. According to the Swedish Association of Road Haulage Companies there are roughly 20 000 heavy trucks suited for long distance transport

of general cargo in Sweden. Further there are roughly 20 000 semi-trailers and full trailers respectively while there are nearly 2500 dollies used in traffic. If all the dollies are assumed to be used in a Module A, this combination would account for 12,5% of all long distance transports in Sweden. Additionally there are Module B & C combinations, but these are however not as common. A fair assumption is thus that 10-15% of all long distance transports are performed using a LHV according to EMS. The remainder is performed with shorter combinations, and especially by using 24 m road trains. The hauliers interviewed state a slightly higher number, maybe due to these companies' own extensive use of EMS.

Generally all Swedish hauliers within this study using EMS vehicles are very pleased with them. First and foremost they are very pleased with the extra loading capacity. Since the hauling business operates with low economic margin and there is a high degree of competition, the possibility to increase the income per trip without increasing the cost too much is more than welcome. Secondly hauliers appreciate the extra flexibility the EMS produces. Hauliers truly believe that the use of EMS facilitate the use of intermodality. This is due to the standardized load carriers facilitating intermodal transports. Each of the EMS combinations also has the advantage of the possibility of decoupling one of the trailers. This way, a shorter delivery vehicle is created. The Swedish hauliers taking part in this study performing international transports state that their own operations would be greatly facilitated if LHV's were allowed in the entire Europe. This would allow them to use LHV's all the way, as opposed to today, when they have to stop and de-couple.

3.2 Finland

One Finnish haulier and a number of Swedish hauliers partly operating in Finland have contributed to the conclusions regarding Finnish hauliers view on EMS. The results and findings regarding Finland are similar to the ones in Sweden. This is much due to the two nations' similar history of LHV's.

The Finnish and Swedish legislation differs somewhat. In Finland it is, although not mentioned in the directive and contrary to Sweden, possible to run a 13,6 m full trailer within 25,25 m. This is very appreciated by Finnish hauliers performing national transport since the trailer weight less than a semi-trailer with dolly, thus enabling more and heavier cargo load. The trailer is also somewhat easier to maintain than a semi-trailer and dolly. This is probably the reason why the 25,25 m vehicle combinations are more common in Finland than Sweden. These trailers are however not allowed in international transport. Just like Swedish hauliers, the Finnish haulier performing international transports feel they would benefit greatly if allowed to use LHV's in the entire Europe.

3.3 The Netherlands

The Dutch trials with EMS vehicles and Dutch hauliers' experiences are covered extensively in *chapter 4*. One interesting difference, which is due the set-up of the trial, is that the Dutch hauliers struggled to pin-point the most profitable route for their LHV's. This is also due to the larger differences between the 16,5/18,75 m combinations used in the Netherlands, compared to Swedish 24 m "regular" vehicles. Hauliers in Sweden, operating with both EMS and "regular" vehicle combinations choose their preferred vehicle depending on the characteristics of the cargo rather than selecting the longest route with full load.

3.4 The characteristics of using EMS

3.4.1 Volume sensitive rather than weight sensitive

Of great interest is whether transports are volume or weight sensitive. Here volume sensitive means cargo with rather low density. This result in the loading space is being filled before the cargo exceeds the maximum weight restriction. Weight sensitive, on the other hand, means that the load exceeds the maximum weight restriction before the loading space is entirely filled.

According to Swedish truck manufacturer Volvo, "general cargo" is the dominating cargo transported on long distances (>250 km). General cargo is often volume sensitive and of quite high value compared to its weight. This type of cargo is often transported to wholesalers, supermarkets, department stores etc. Examples of products are: electronic devices, groceries, flowers, etc. Another major type of cargo is parts used in production by manufacturing companies with short lead-times. Thus the time factor is also of great importance to the costumer.

Transport Industry	Long Distance (> 250 km)	Regional (50 - 250 km)	Local (< 50 km)	Sum %
1 General Cargo 2 Transport of containers & trailers 3 Industrial transports	28,1%	4,1%	0,9%	33,1%
4 Consumer goods/retail, wholesale 5 Daily commodities, grocery & food	14,5%	3,0%	0,7%	18,2%
6 Agricultural products & material	*7,1%*	3,4%	1,0%	11,5%
7 Building & Construction	*6,4%*	7,6%	5,5%	19,5%
8 Forest Paper & Cork 9 Petroleum & Chemicals 10 Ore, coal, mining	6,4%	3,7%	1,3%	11,4%
11 Service transports 12 Waste & recycling	1,3%	2,4%	2,6%	6,3%
Sum	63,8%	24,2%	12,0%	100,0%

Table 3.1: Distribution of field of operations for new trucks. (Volvo Trucks)

Table 3.1 above shows the distribution of different transport segments over three different distance classes. The numbers are drawn from factory new trucks and for what kind of operation the truck has been equipped when sold. All the numbers are taken from Swedish truck manufacturer Volvo and comprise all trucks with a GVW of over 10 tonnes. The table clearly indicates that heavy trucks are mainly used, in long distance transport and cargo with high value, i.e., characteristics well suited for the EMS. Vehicles suited for long distance transports account for 63,8% out of all heavy trucks. Vehicles suited for general cargo accounts for 28,1 %-units out of those 63,8%.

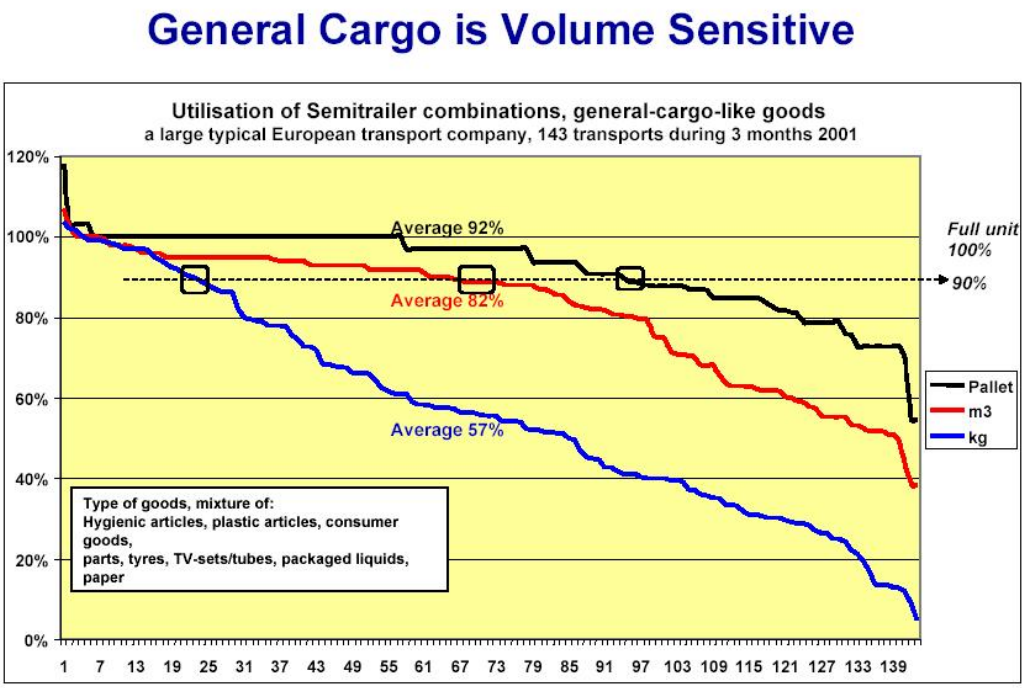


Figure 3.2: Utilisation of trucks (Volvo Trucks)

"Long distance road transport in Europe is most sensitive to a truck's load capacity measured by number of pallets or volume. These trucks are seldom fully loaded by weight" (Lumsden)

A further investigation of "general cargo" shows that the average utilised volume capacity is 82% for a typical European transport company, while the average utilised weight capacity was only 57%. Another interesting result is that the average pallet capacity reached 92%, meaning loading length is of great importance. See *figure 3.2* above.

- 2/3 trips was loaded with at least 90% pallets.
- Half of the trips filled at least 90% of the volume.
- Only 1 out of 6 trips used more than 90% of the weight.

The data-set for this analysis is gathered from five different Dutch hauliers performing international transports. Nearly 150 trips where cargo was measured in pallets, volume and weight were recorded. The study clearly indicates that it is more likely to reach the maximum volume capacity (82%) before exceeding the weight restriction (57%); the cargo is thus being volume sensitive. This shows that volume, and also number of pallets, is a far more restricting factor than the weight capacity. There is thus a greater need for increased dimensions rather than weight.

Every company interviewed for this study performs general cargo transports on long distances. Thus, volume, or load length, is supposed to be the major restricting factor for this kind of cargo. This argument is supported by the majority of the companies. However, only one of the hauliers performed operations (flower transports) such that they never reached the weight restriction. This indicates the diversity of the hauling business, and the need for flexible solutions. It is however believed that the business will continue developing towards volume-sensitive cargo.

Although the majority of the hauliers taking part in this study claim volume being the most important factor, it appears weight at times is the limiting factor. In Sweden, hauliers have the possibility of using the conventional 24-meter combination for the heavier goods and national, long-distance transports. This combination is approximately 2 tonnes lighter than a 25,25-m combination according to EMS, hence giving the possibility to load 2 extra tonnes of cargo. The two lengths thus have become complements to each other. The 24 m road train is however not allowed for international transports, limiting its efficiency.

The added volume is where the hauliers find the greatest benefits of using EMS vehicle combination. A 25,25-m vehicle combination has, compared to a conventional 24 m vehicle, an additional loading length capacity of 1,25 meter, corresponding to three pallets.

For LHV's according to EMS the weight restriction exceeds volume restriction for cargo of density at roughly 250 kg/m^3. Thus, if the cargo has density of more than 250 kg/m^3, the weight restriction will be exceeded before the vehicle is fully loaded and vice versa. This is also a well-known fact among hauliers. For cargo exceeding 250 kg/ m^3 the transport buyer, in general, has to pay per kilo. The number is calculated from the loading weight capacity of roughly 38 tonnes and the loading volume capacity of 150 m^3. One might think that this is a relative low figure but keep in mind that general cargo consists of a lot of packing material to protect the high-valued cargo. Also cargo destined for its final costumer, such as refrigerators, washing machines and chips, contains a lot of air.

3.4.2 What kind of volume?

As stated above, hauliers claim volume is of greater importance than weight. Volume however is made up of length, width and height. When trying to evaluate the importance between the factors determining volume, the authors came to the conclusion that it is actually the type of cargo that sets the limits. One haulier may actually experience different limiting factors with each transport, even though he is using the same vehicle combination. Thus this is an area where it is not possible to deliver a unified answer. This is also the area where the answers in the inquiry varied the most.

The most frequent answer to the inquiry-question "*Which are the advantages of operating with EMS vehicle combinations?*" were "Three extra pallets". Also "Need for long goods" was mentioned in two cases, i.e. cargo not possible to transport in an ordinary trailer.

3.4.3 Increased flexibility

When operating on an increasingly competitive market, hauliers are forced to optimize their operations in order to increase profit, while cutting expenses. Flexibility is a key in modern logistics in order to accommodate different needs from costumers with a limited number of vehicles and load carriers.

EMS vehicles offer an increased flexibility. This is due to EMS is built up from units standardized and used within EU, making it easy to implement them in the companies' businesses. This is extra beneficial for companies performing both long distance transports as well as distribution transports. Each of the EMS combinations has the advantage of the possibility of decoupling one of the trailers, thus resulting in a shorter vehicle suited for delivery and pick-up in towns, cities, etc.

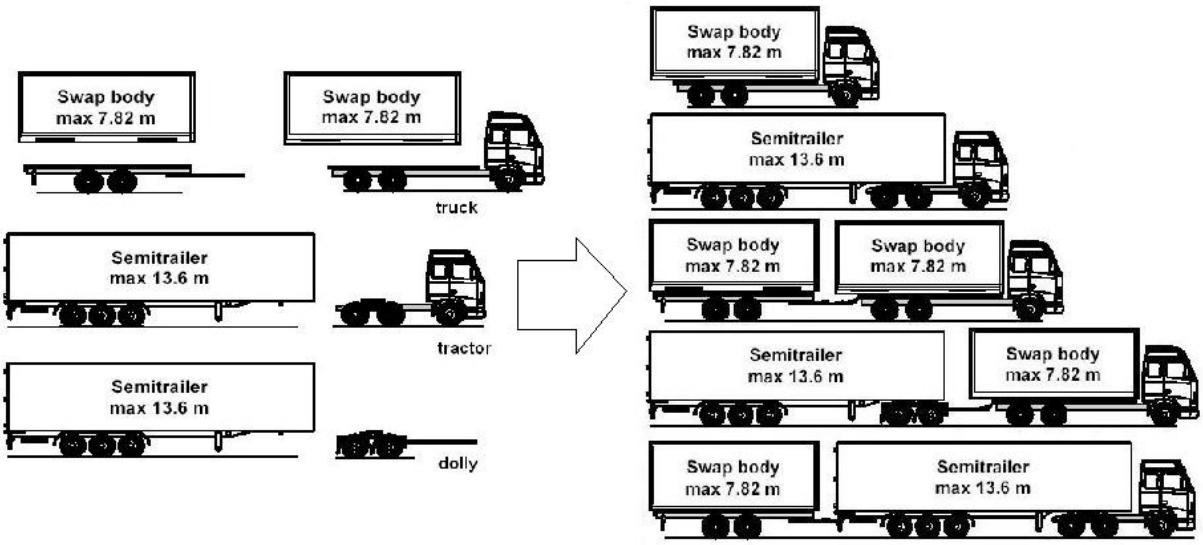


Figure 3.3: Possible combinations within EMS. Note that the C-class load carrier can be a rigid as well as a swap body

The left part of *figure 3.3* above shows the units the EMS is built up from. From these, five different combinations can be achieved, which are shown in the right part of the figure and could be the optimal configuration for different types of operations. Here, only Modules A and B are shown. In *chapter 3.4.7*, the flexibility advantages of using Module C are more thoroughly discussed.

All hauliers interviewed and inquired states that the extra flexibility the EMS vehicles offer is of great benefit. This is both for companies performing national and international traffic. Companies performing national transport appreciate the possibility of decoupling a trailer to perform distribution transport as stated above. Further, companies performing international transports take advantage from the possibility of using LHV's while transporting in Sweden and decouple the combination at some location in the south of Sweden when continuing to the continent.

Standardized load carriers also facilitate the possibilities of combined transports. This also adds to flexibility when examining the entire transport chain. Haulier view on EMS and intermodal transports are discussed in *chapter 3.4.5* below.

Chapter 3.5 below discusses four examples of how four different hauliers are using EMS to its fullest potential, fitting their operations. This is a way of showcasing the flexibility of the EMS and how it is used in order to fit the four companies' daily operations.

3.4.4 On what roads are the EMS used?

The infrastructure varies between nations as well as in nations. Sweden and Finland have a tradition of long and heavy vehicles, and the road net has been built to satisfy those demands. This is not the present situation in the far more dense populated parts of Central Europe. Still, the majority of the longer and heavier vehicles are used for long-distance transports, hence using larger roads, as freeways. In Sweden and Finland, there are no limitations for the use of LHV's on certain road, unless general bans of freight traffic.

The 25,25 m combinations are mostly used in long distance transport on routes that are quite fixed. In Sweden this means that most of the roads travelled are motorways and main roads. Towns and city centres are avoided as far as possible, due to long vehicles are quite difficult to manoeuvre in narrow crossings, bends and turnabouts, etc. There are also city centres with limited over-all length, like Stockholm City.

A common procedure is to decouple the dolly and semi-trailer and use the truck as a distribution vehicle when unloading in city centres.

No haulier interviewed stated any difficulties driving EMS vehicle combinations in Sweden, and the majority also claimed it would already today be possible to operate with LHV's on larger roads on the continent.

3.4.5 Hauliers view on intermodality

Most of the Swedish hauliers interviewed and inquired have a rather negative view on using combined traffic for their own business although positive to the idea of intermodality. In fact they state that there is no reason to use road transport for its own sake. Rather, they are looking for possibilities to cut costs all over their business and using intermodal transports is one way of doing this.

The main stated reason for this negativity is due to the hauliers feeling an uncertainty regarding reliability when using railway for cargo transports. Secondly they feel that using the railway is inflexible. A third problem stated by the hauliers, especially in the Stockholm area, is that the loading and unloading spot is somewhat ill-placed. The spot is rather inaccessible and its locations, relatively close to the city center, lead to freight vehicles having to travel through Stockholm during the most traffic intense hours of the day.

On the bright side, hauliers actually using the railway are rather positive but yet again feel vulnerable to the unreliability. The railway is mostly used for heavy goods of quite low value. Also time is not really a decisive factor for this cargo. The transports are booked in advance and the haulier disposes a number of slots on certain departures and has to confirm within a certain time before departure whether the spots are going to be used or not.

3.4.6 Hauliers view on traffic safety when using EMS

No haulier interviewed stated that EMS vehicle combinations of 25,25 meter and 60 tonnes affects traffic safety negatively. In fact, they claim EMS vehicles are more stable and safe to drive. Nor have Dutch hauliers any complaints. The Dutch drivers stated that it was marginally more difficult driving 25,25 m vehicles compared to 18,75 meter. Keep in mind that Dutch drivers have little, or none, experience of driving LHV's.

Some of the hauliers are sceptical towards the safety aspects of Module B. However, the companies actually using that combination have no negative experiences regarding traffic safety, although they admit that load distribution is of greater importance for the stability.

All hauliers agree that since the use of LHV's leads to less number of vehicles being used, a wide spread use of LHV's increases traffic safety.

3.4.7 Hauliers view on different EMS combinations

The most common combination in Sweden and Finland is by far Module A. According to the Swedish Traffic Register, there are roughly 2500 dollies registered in Sweden by over 530 companies. In Sweden Module C is the second to most used combination, while Module B is the second to most used combination in Finland.

The main reason Module A is the most common is due to the fact that it is very similar to a standard Swedish 24 m combination (and Finnish 22 m). There were already a large number of trucks in traffic in Sweden and Finland and hauliers only had to couple a dolly and semi-trailer to the truck in order to attain a 25,25 m combination. The truck needs no modification and can be used with a dolly and any semi-trailer as well as a standard trailer as before. It is considered easy to drive and tests performed by Volvos show that this is a very stable combination, see *chapter 5.1.4*.

The main disadvantage with the Module A is that it is quite heavy thus lowering the loading capacity regarding total weight. A 25,25 m combination is some 2 tonnes heavier than a similar 24 meters combination, thus meaning the shorter combination is better suited for transporting heavy goods.

Only one of the hauliers in this study had extensive experience of using Module B, in depth described as Company B in *chapter 3.5.2*. They are however very pleased with the combination due to it suits their operations well.

Module B is often considered unstable and inflexible and needs to be loaded more carefully since it is less stable than other combinations. Also, the semi-trailer used for this combination has to be equipped with a coupling device thus making the combination less flexible than the Module A, which the haulier can combine from any semi-trailer.

Module C is not that common in Sweden but is considered, both by trials and drivers' experiences, to be a very stable combination. On the downside, the combination is said to be rather difficult to manoeuvre in narrow loading and unloading areas, especially when reversing.

Some manufacturers are promoting links with adjustable lengths. Due to a larger wheelbase, heavier cargo can be carried with the link extended. This innovative combination is a very flexible solution. When coupled to a tractor, the vehicle can be used as a city-distribution vehicle with a C-class load carrier, as well as for long distance transport when coupled to a semi-trailer, then forming a Module C. However, hauliers have so far taken a hesitating stance toward this vehicle. This is mostly due to its rather high price-tag but also because there are some concerns regarding problems with the adjustable length. Hauliers in general try to keep maintenance costs down and there is a fear that the vehicle will cause a lot of problems, especially in the winters with snow and ice interfering with the sliding device.

The innovative solution with the adjustable link is pictured in *figure 3.5* below:

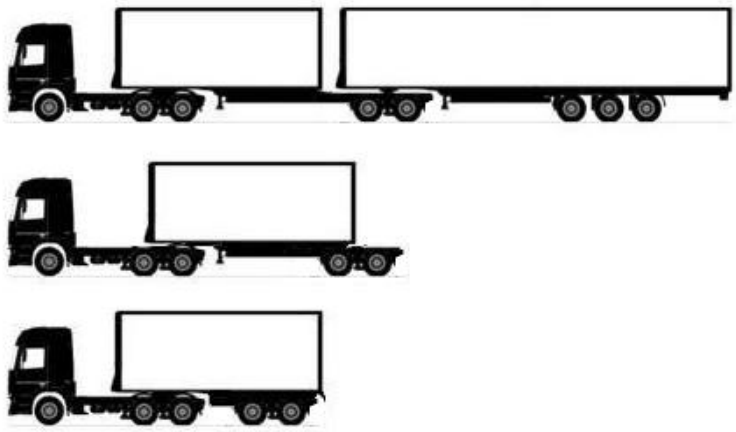


Figure 3.5: Schematic view of the adjustable link

3.4.8 Negative attitude towards width restriction

There is a debate between Swedish and Finnish hauling companies and authorities regarding restrictions in vehicle width. Directive 96/53 states 2,55 m as maximum width for all load carriers, except for temperature-controlled load carriers, which may be 2,60 m. These have to be equipped with thicker (45 mm) walls, and the aim is to achieve 2,50 m inner width for all kinds of load carriers.

Sweden and Finland used to have a 2,60 m width limit for all kind of load carriers before entering EU. One might consider 5 cm not being a great issue, but the hauliers claim loading pallets are far more complicated with the tighter limit. As the width of pallets measure 0,8 m and are stocked three in a row, this leaves just a 10 cm margin. Further worsening the situation is that pallets at times are not loaded properly and cargo may protrude beyond the outer limit of the pallet, leaving almost no margin of space. In the worst case, this may cause a drop of pallet load capacity by 1/3, as pallets only can be arranged two by two.

Deviations from the directive may become contra-productive in that it will obstruct international transports. Trying to stick with the directive will also facilitate inter modal transports. Of greatest importance is an international harmonization of legislation.

3.4.9 Increased need for maintenance

A-class and C-class load carriers according to EMS are very common on the European market, therefore a relative cheap investment. An EMS vehicle combination however consists of three vehicles, instead of two, thus increasing the needs, and costs, for maintenances.

There are also technical problems with the Electronic Brake System, EBS. The system is not configured to handle more than two separate vehicles. Hauliers, as well as manufacturers, are well aware of the problem. In practice, two of the vehicles are controlled by EBS, while the third have ordinary pneumatic brakes. In both Module A and B, the truck, or tractor, and semi-trailer are controlled by EBS, while the third vehicle (dolly or centre-axle trailer) has pneumatic brakes. These have to be adjusted properly, which demands maintenances. This flaw is however not considered to affect traffic safety.

The current market is small, since LHV's are used only in Sweden and Finland. Manufacturers claim that the EBS-system will be configured to handle three units within a year.

3.5 Four hauliers and their implementations of EMS.

In this chapter, four different hauliers, and their implementation of EMS vehicles are presented. The focus is on how EMS has positive effects on the companies' logistic efficiency.

3.5.1 Company A

Company A is located in the Stockholm region. Their main business is day-time short-distance distribution transport within the Stockholm region for a number of different clients. Because of this their main fleet consist of distribution trucks. Most of the trucks are equipped with C-class swap-bodies, enabling them to switch load carrier. The company also have a number of semi-trailers used to transport large amount of goods to certain costumers located in the outskirts of the Stockholm area. To make the most use of their load-carriers, the trucks are coupled to a dolly with a semi-trailer for transports during the nights. This way the separate units has become a 25,25 m vehicle combination, Module A. This vehicle combination is used to transport goods to a location halfway between Stockholm and Gothenburg to meet another vehicle, driving from Gothenburg, and the load carriers are switched. This is enabled by the standardized load carriers and the swap bodies. This way Company A will have their truck and a semi-trailer back in the morning ready for another day of distribution transports in Stockholm!

The reason for using the semi-trailers as opposed to conventional Swedish trailers is that the company mainly transport volume sensitive goods and rarely reaches the maximum loading weight. Another reason is the added flexibility. Company A is a good example of the added possibilities the EMS presents. The Company keeps most of its fleet in action almost 24 hours a day.

3.5.2 Company B

Company B is located in a large city in the middle part of Sweden. They offer a wide variety of transport services including conditioned transports, especially equipped trucks for fast loading and unloading dedicated for transport to and from Arlanda airport and also transports with extra security for very high valuable goods.

The company also has daily deliveries from Helsinki, Finland to Arnhem in the Netherlands, via a hub in Helsingborg, Sweden. These are the transport services this example will focus on. When the possibility of using EMS vehicle combination was presented, Company B saw the advantages right away. The cargo from Helsinki is volume sensitive and always exceeds the loading capacity of a small load carrier, like C782. Thus, Company B are using 13,6 m semi-trailer for these transports. In cases the semi-trailer is completely filled, a centre-axle trailer with a C782, coupled to the semi-trailer, is used to handle the surplus cargo, forming a Module B. Since LHV's are not allowed in Denmark and Germany, they are decoupled at a hub in Helsingborg, Sweden. As Module B consists of standardized load carriers, new combinations are easily arranged, eligible for the remaining transport on the continent. If possible, Company B would, of course, use the LHV's all the way.

A minor case-study, performed by a student at Malmö University, shows the fuel savings for the company. The fuel consumption of four vehicles, performing 12 round-trips each on the route Helsinki-Helsingborg, has been recorded. 92% of the trips were performed with the Module B configuration, while the rest was regular tractor & semi-trailer.

Table 3.6 below shows the figures. Also, note that two Module B combinations exceeds the load capacity of three semi-trailer combinations, even further increasing the "fuel/cargo-unit"-rate.

Fuel consumption, on average	
Module B	3,56 l/10km
Tractor & semi-trailer (regular)	3,07 l/10km
Consumption for three "regulars"	9,21 l/10km
Consumption for two Module B	7,12 l/10km
Difference	2,09 l/10km
Mutation	22%

Table 3.6 Fuel consumption for a number of trips recorded at Company B, (Svensson, 2004)

Company B has found a way to compensate the daily fluctuation in cargo on a given route without having to use a complex system of different vehicles. Luckily for Company B it seems that the route between Helsinki and Helsingborg is fairly balanced cargo-wise. Otherwise, a situation where all the centre-axle trailers would end up in Helsingborg could occur. That would mean that some of the transport to Helsinki would have to be performed with a lesser amount of cargo, or in the worst case empty, causing the company to lose money. Thus Company B is quite dependant on keeping the route balanced in the future as well.

3.5.3 Company C

Company C is located in the south part of Sweden and performs general cargo transports between Scandinavia and Western Europe. For transports in Europe, Company C utilises both of the most common vehicle combinations on European roads; road-trains or semi-trailers.

All routes from Europe to Scandinavia passes the headquarter in southern Sweden, where the vehicle units are re-arranged into 25,25 m EMS-combinations as far as possible.
Company C has a number of customer and clients, and may have as many as 10-15 different clients in the same transport. Although most of the cargo is considered "volume sensitive", one of Company C's best abilities is to combine different kinds of cargo in order to maximize the volume of cargo, while not exceeding the weight restrictions. This way, Company C hardly ever reaches the maximum allowed weight, neither in Sweden, nor in EU.

For transport with origin and destination within Sweden, Company C uses EMS vehicle combinations whenever possible and needed considering the amount of cargo. These transports are carried out using a Module A. This way they are also able to use the truck as a distribution vehicle in towns and cities. Company C is a perfect example of how the EMS vehicle where intended to be used, "three becomes two" and greater flexibility for the company.

3.5.4 Company D

Company D is a major general cargo haulier with activity all over Sweden. They have a large number of trucks and load carriers. Their main vehicle combination is Module A. Even though company C has a big fleet of its own, they frequently lease other, smaller, hauliers to perform their transports. This is facilitated due to that they use standardized load carriers according to EMS.

Similar to Company A the explanation to why they prefer EMS vehicle combinations instead of regular Swedish 24 m vehicles is that they mainly transport volume sensitive goods. The cargo of a full vehicle combination seldom weighs more than 16 tonnes.

The company has organised their operation in such a fashion that the trucks are dedicated to certain routes while the load carriers are used wherever needed. This way the company makes good use of the most expensive units, namely the truck and driver. The trucks are used almost 24 hours a day while the empty load carriers may be stationary for some time before being deployed again. This also means that a certain truck may transport several different load carriers during one day at one certain route. Thus, a high level of standardization is of great importance, making sure each load carrier is compatible with each truck.

4 Case study: Dutch trials with LHV's – LZV-proef

This chapter discusses the results of the trials with vehicles of larger dimensions in the Netherlands. The Netherlands is a relative small country with high population density and also a large amount of transportations, as the port of Rotterdam is one of the worlds' largest. Together with the port of Amsterdam it handles a large share of all cargo transported to and from Europe. The Netherlands also has a long history of trade and transports and has thus evolved as a major logistic centre for the entire Europe.

The Netherlands has conducted large-scale trials in two phases with 25,25 m and 60 tonnes vehicle combinations, LZV's (Dutch for LHV), since 2000. Compared to the current legislation, which sets maximum vehicle length to 18,75 m and maximum allowed vehicle weight to 50 tonnes, this is a noticeable difference in vehicle dimensions. In the second phase of the trials, 77 hauliers with roughly 150 vehicles took part.

There were major monitoring of the trials, performed by Arcadis and TNS Nipo Consult, on commission of the Dutch Ministry of Road and Waterways. The second trial was also found to be successful and in November, 2006 when the second trial was scheduled to end, authorities decided to prolong the trial for another year. This in order to gather even more experiences and to fine-tune the legislation should the Netherlands decide to allow LZV's on a permanent basis.

4.1 Background and aim of the trial

The Netherlands is a country with a high level of transports and Dutch hauliers have for a long time requested increased vehicle dimensions, both regarding length and weight. Politicians however were restrictive and referred to the EU directive 96/53, with regard to vehicle dimension.

The question remained and hauliers now referred to the fact that Sweden and Finland had adopted 25,25 m and 60 tonnes as they became member states in EU, according to a "modular concept", EMS, which is mentioned vaguely in directive 96/53. Also, the directive mentions that the member states should be given the possibility of a trial period in order to adopt vehicle dimension deviating from those laid in the directive.

In 1999 a limited trial was launched with longer and heavier vehicles, LZV's. The first trial began in December 1999 when parts of the port in Rotterdam were allowed for 15 LZV's. The trial ended in mid-2003 and since the trial went very well a second trial was launched in January 2004. This time the entire motorway net was allowed as well as 20 km leading to and from the motorways. A maximum of 100 haulage companies and 300 LZV's were to participate in the trial. Each participating haulier was allowed to select 10 routes which had to be approved by authorities responsible for the trial and the desired road.

The aim of the trials was to evaluate the use of longer and heavier vehicles in terms of effects on transport efficiency, environment, congestion and traffic safety. Further, it was considered a large and decisive step towards a permanent allowance of LZV's, which could reduce the already stressed traffic situation.

4.2 Preparations for the trials

When conducting a large-scale trial, it is of great importance setting well-suited restrictions in order to perform a successful test without risking negative reactions from the public opinion.

As in all democracies, the public has the final word, and even if transporting companies shares great benefits from increased vehicle dimensions, it would not be possible introducing this if the general opinion is negative. Areas like environmental effects and traffic safety hence are becoming major issues, requiring satisfying answers. Also, as the Netherlands´ previous legislations stated 18,75 m as maximum vehicle length, the view of fellow road-users is of great importance.

A number of restrictions were set. The first is the basic one:

- Companies may operate with longer and heavier vehicles, LZV's, with maximum length 25,25 m and maximum weight 60 tonnes.

This is the same legislation as is currently used in Sweden and Finland.

4.2.1 Restrictions regarding roads

The Netherlands has, as mentioned, a remarkable high population density, implementing infrastructure not always being adopted for large vehicle combinations. This lead to the second restriction:

- LZV's can only be used on a limited road net.

Further, the country has one of the world's largest shares of roads per square meter land, and the freeway system is well built out. As larger vehicle combinations are to be used for longer distance transports, it would be unsuitable restricting the road net too much. The third restriction came clear:

- LZV's may be used on the entire freeway system.

It is however obvious that the vehicles not exclusively can operate only on the freeway system. Logistic centres often are located in a close vicinity of freeways but another restriction was needed.

- LZV's may operate on ordinary roads within 20 km from the freeway system.
- Small towns and city centres are still excluded.

These, in fact, led to hauliers involved in the trials, were offered to choose 10 routes. This followed the same procedure as for "exceptional transports", i.e. even longer and heavier vehicles with special one-time permits. Here, another number of restrictions were set, sometimes different from the "exceptional transports":d

- Each haulier was able to choose 10 routes.
- The routes had to be separated from bicycle lanes.
- Railroad crossings were not allowed for LZV's if trains were allowed to run more than 40 km/h.

Also, the local road keeper had to approve each chosen route. This to make sure LZV's could pass bridges, turnabouts, etc.

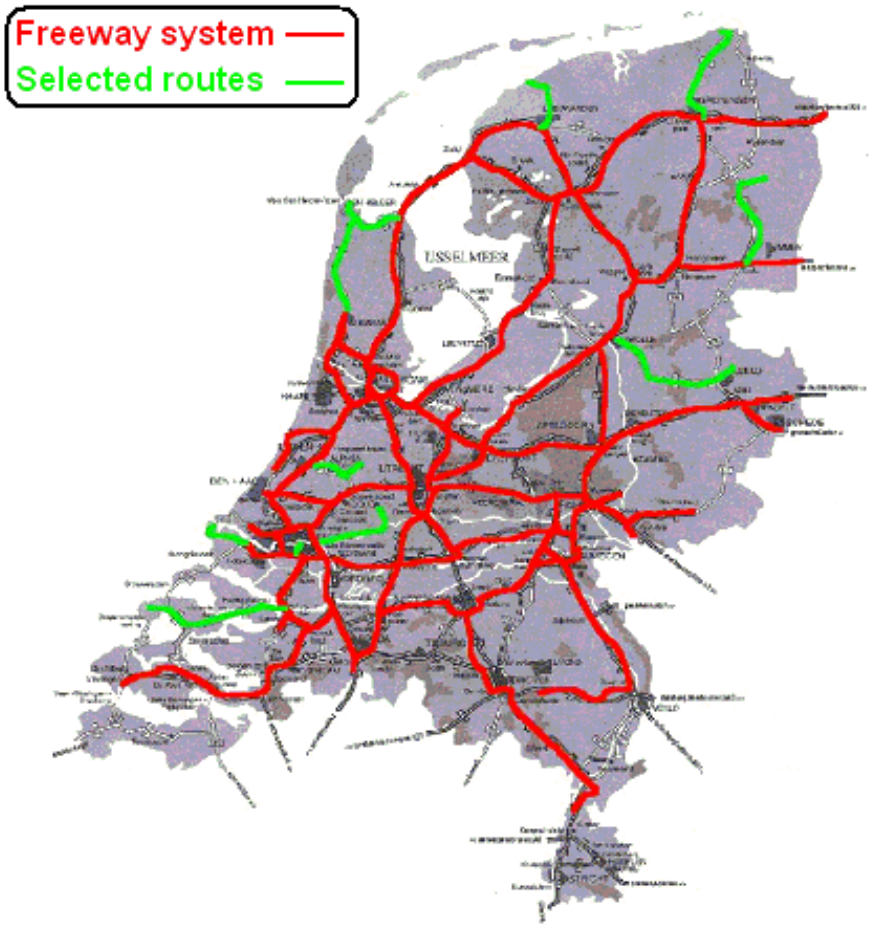


Figure 4.1: The Dutch freeway system and one haulier's selected routes, (Chris Kampfraath)

4.2.2 Restrictions regarding participants

Further, restrictions had to be made regarding the number of participants and vehicles during the trial. The lower the number, the more difficult it would have been to draw conclusions from the trail. Too many participants would have made the administration unforeseeable and could also have a negative impact on traffic safety.

- Maximum 100 companies could participate in the trial.
- Maximum number of vehicles was set to 300.
- No company was allowed to have more than 10 LZV's.

These restrictions were considered fair, while still producing the needed amount of statistic materials.

Hauliers were informed via ads in press in the Netherlands and were given the possibility to apply. Hauliers had to choose between "longer" or "longer and heavier" vehicles. Either 25,25 meters, while not exceeding the 50 tonnes set as maximum weight in the Netherlands, or 25,25 m with a total weight of 60 tonnes. Each haulier also got to choose no more than 10 separate routes as mentioned above.

Finally, regarding the collection of statistic materials, each participant had to deliver data regarding transported cargo, fuel consumption, investment costs, etc., during the trial.

4.2.3 Restrictions regarding drivers

The most important action taken to maintain traffic safety was a demand for a certain certificate for the driver operating the LZV. The drivers had to have at least 5 years experience of driving articulated vehicles and not have his or her driver license suspended, withdrawn or declared invalid during the last three years.

- LZV-drivers have to attain a certain certificate

This included a two-day course, including both practical and theoretical tests. Also, this lead to participating companies designated their most experienced drivers for this purpose.

4.2.4 Restrictions regarding vehicles

The main restriction regarding vehicle dimensions is already stated above:

- The vehicle combination may be up to 25,25 m long and weigh up to 60 tonnes.

All LZV's have to comply with a number of rules regarding manoeuvrability:

- Each LZV may have no more than two hinge-points.
- Each LZV must be able to circulate a roundabout with a radius of 14,5 m and an inner radius of 6,5 meter. This corresponds to a swept path of 8 m.
- Each LZV-combination has to pass tests regarding stability, braking and lane-change.

Due to the increased weight of the vehicles, it was considered necessary to implement a restriction regarding engine power as well as brakes:

- Each LZV has to be equipped with Anti Blocking Brakes, ABS.
- Each LZV has to have an engine producing at least 420 Hp.

In order to maintain a high safety level it is considered necessary to adopt a number of safety devices to protect fellow road-users:

- Each LZV has to be equipped with front side protection system.
- Each LZV has to be equipped with side-panels.
- Each LZV has to be equipped with anti splash and spray facilities on all axles.

Due to the LZV's increased dimensions it is considered necessary to improve the driver's field of vision:

- Each LZV has to be equipped with extended rear-view facilities such as mirror or camera.

Finally, in order to avoid serious accidents it was stated:

- Dangerous goods and fluids are not allowed to be transported by LZV's.

4.3 Dutch hauliers' experiences from the trial

The authors of this report have visited and conducted interview with four participating hauliers, which are presented below.

4.3.1 Haulier A, container traffic

The first haulier was located just south of Rotterdam and their main business was container transport between the Rotterdam harbour and the rest of the Netherlands. They primarily used a B-double carrying three TEU. The B-double was specially designed since there was no fitting trailer available on the market when trials began.

The haulier used their LZV in their regular daily operation. One problem the haulier ran into was overload. In general a 20 foot container weighs approximately 15 tonnes making it impossible to transport three containers while at the same time stay within 60 tonnes GCW since the truck and B-double weighs roughly 20 tonnes unloaded. Therefore there was a need of a more precise planning which containers the LZV's should transport. The standard tractor and container-trailer weighs approximately 18 tonnes making it possible in most cases to load two 20 ft containers while staying within 50 tonnes GCW. Hence, this haulier insisted on even further increased GCW, as long as extra axles are added to the vehicle.

Another problem for this haulier were transports to the port of Antwerp, Belgium. The port is located approximately 20 km from the Dutch border. Since Belgium does not allow vehicles longer than 18,75 m the haulier had to detach one container at the border while delivering two to the port and returning to pick up the last one. Still the haulier claimed this was more effective than having two vehicles performing the same operation.

4.3.2 Haulier B & C, general cargo

Two hauliers main business was general cargo transport, using a truck and dolly with a semi-trailer. One of them mainly focused on national transports while the other mainly focused on international transport.

Haulier B used their LZV's in their longest routes, from the north to the south-west of the Netherlands, where it was considered to be most efficient. At times they suffered from lack of cargo meaning that the LZV had to perform the transport not fully loaded. This was due to transports of a lot of seasonal goods as well as contractors are used to order "regular loads", i.e. a full semi-trailer. Efforts are needed to deal with this problem, but will, most likely, be easier if LZV are allowed on a more permanent basis.

Haulier C performs international transports between Western and Eastern Europe and has routes like the Netherlands-Poland, NL-Kazakhstan and also NL-Spain. The LZV´s are used for national transports, where one of the major contractors is a large insulation manufacturer. The haulier considers LZV´s are optimal for transporting insulation as it is cargo with very low density.

Both haulier B and C preferred Module A, as the only investment needed is the dolly. There were no difficulties experienced when driving the vehicle, but there were, however, some narrow loading areas, where the vehicle had problems to operate.

Haulier C also fell victim to the limited road restrictions in two cases. One of the desired destinations was located well within 20 km from the freeway, but some 100 meters of the way there went through a small village, hence not allowed for LZV's. The destination could still be reached by driving a detour, but then the distance became longer than the 20 km allowed during the trial. The haulier had low understanding for this, because regular freight traffic was still allowed to travel through that specific village.

In the other case, the haulier had to drive a detour of 5 km in order to avoid a rail-road-crossing.

4.3.3 Haulier D, in-house logistics

The last company was a wholesale business in sanitary fitting, heating, electrical and installation material, and handled all their logistic activities in-house. Their logistics department thus transported goods from the company's major warehouse to their regional warehouses, retailers and also to construction sites. They preferred using a shorter truck with two centre-axle trailers and swap-bodies. Regularly they use a truck with one trailer in order to stay within the 18,75 m regulation. When being able to use 25,25 m vehicle combination they just added one extra trailer.

The only investment needed was coupling devices on some of the trailers, which was considered fairly cheap.

The characteristics of the trial suited haulier D perfect, as nearly all of their 27 regional warehouses are located in large shopping areas close to freeways. With 10 routes, 9 of these could be served by LZV, while the last route led from the major warehouse to the nearest freeway, actually not more than 500 m away.

One issue for the company, however not LZV-related, is that the cargo-flow is mainly one-way; from the major warehouse. This means that nearly 50% of the trips are performed empty.

4.3.4 Common experiences

All hauliers were, in general, very pleased with the trials and had no problems driving the LZV's. Their main complaints concerned the restrictions in the trials. The main issue was not being able to cross railroad tracks or operate on roads not separated from bicycle lanes. There was also a wish to be able to operate with a higher total weight.

Due to the trial being time limited some of the hauliers found it difficult fully implementing the increased possibilities in their current operations. Two different approaches to implementing the LZV's were observed. Some hauliers used them as regular combinations in their daily operations while others pin-pointed routes were LZV's were used most efficiently. This is an effect of the differences in logistic activities, fluctuations in amount of cargo, etc.

In some cases LZV's could not be used due to restrictions in the desired routes. This results in a less effective use of the LZV's, as well as, in some cases, less effective logistic activities.

Hauliers, of course, appreciated the extra volume and the added flexibility the EMS provides.

The drivers did not state any difficulties driving the longer vehicles, although the increased dimensions required a slightly different style of driving. Each driver was required to attend a two days course and a test in order to receive a certificate allowing them to LZV's.

4.4 Results

Dutch authorities found that the results of the first trial were very positive and thus a second, expanded trial was launched. The second trial was also found to be successful and in November, 2006 when it was scheduled to end, authorities decided to prolong the trial for another year. This in order to gather even more experiences and to fine-tune the legislation should the Netherlands decide to allow LZV's on a permanent basis.

The company ARCADIS was engaged to evaluate the trial, and produced a report called Monitoringsonderzoek Vervolgproef LZV (*Arcadis, 2006*). The report is based upon statistics from 66 companies and 100 LZV's. The results are displayed for four different scenarios while this report will discuss two of them.

Scenario I is the same conditions as used during the trials. 25,25 m and 60 tonnes used on a limited road net.

Scenario II is similar to Swedish and Finnish legislation, 25,25 m and 60 tonnes but without limits in the used road net. LZV's are also allowed to perform transports of dangerous goods.

The remaining two scenarios, not discussed in this report, are similar to Scenario II, but with different allowed weight restriction, 50 and 70 tonnes.

4.4.1 General results

It is assumed that 6000 LHV-combinations would replace 8000 regular vehicle combinations (Scenario I) and 11000 LVH's replacing 16000 regular (Scenario II) while still producing the same amount of transported cargo. Based on the preconditions used in the trial the number of travelled kilometres were reduced by 7% (Scenario I). If legislation corresponding to Scenario II would be used the number of kilometres would be reduced by 14%.

The total amount of freight vehicles with GCW over 20 tonnes in the Netherlands at the start of the trials were roughly 200000. A reduction in number of vehicles by 1% (2000/200000) however resulted in 7% less travelled km. It was believed that 7-26% of all freight vehicles with a GCW of over 20 tonnes could be replaced by LZV's. Thus the reduction of km could be even greater.

4.4.2 Intermodal effects

The report concluded that there will appear a limited modal shift towards road transports. The report states an increase of road transports by 0,05-0,1%, while inland waterways decreases 0,2-0,3% and railroad transport decreases 1,4-2,7%. The decrease in railroad transport may seem considerable, but this is in fact due to railroad transport not being used very extensively in the Netherlands. In contrast to Sweden, inland waterway transport is the dominant transport segment in the Netherlands, road transports excluded.

	Scenario I	**Scenario II**
Δ Inland waterway	-188 kt	-357 kt
	-0,2%	-0,3%
Δ Railway transports	-78 kt	-148 kt
	-1,4%	-2,7
Δ Road transports	+266 kt	+505 kt
	+0,05%	+0,1%

Table 4.2: Intermodal effects in thousand tonnes (kt) and % (Arcadis, 2006)

These figures are based upon inquiry results performed during the trial. Both participating and non-participating hauliers were inquired about intermodal effects. The report stresses that the figures are not to be seen as significant, due to the low number of inquiries.

4.4.3 Traffic safety effects

The report states that there are no reasons to assume that LHV's are having a negative impact on traffic safety. On the contrary, there are reasons to believe that road safety in fact will increase. The report claims that the number of fatal accidents will decrease by 4 to 7, likewise the number of injuries will decrease by 13 to 25 annually. This conclusion is based on the Dutch Centrum voor Energiebesparing's (CE) findings that there occur 16 fatal injuries and 53 injuries per billion vehicle kilometres. Based on the preconditions used in the trial the number of travelled kilometres were reduced by 7%. As the total number of travelled kilometres decreases, so will the number of accidents.

By November 1, 2006, when the trial was supposed to end, only one accident involving a LHV had occurred during two years of trial. The report claims that "this accident was not related to the specific characteristics of LHV's", (*Arcadis, 2006*), meaning the accident would still have occurred if there had been a conventional vehicle instead of the LHV. In comparison, there are roughly 33000 traffic accidents each year in the Netherlands, (*Eurostat*).

4.4.4 Congestion

Congestion effects were evaluated in the report regarding the trials. It is stated that congestion give rise to as much as 850 million Euro annually in increased expenses for the Dutch society, due to increased travel times. The report concluded that congestion would decrease by 0,7-1,4%.

4.4.5 Environment

The reduction of number of vehicles resulted in an annual reduction of mileage by 7%, or 242 million less vehicle km. Further, this would lead to a total reduction of fuel consumption by 36 million litres. The slightly higher fuel consumption per vehicle for LHV's is taken into account. With Scenario II, the reduction of annual mileage would reach 14%, thus resulting in even larger fuel savings.

When powering a heavy vehicle over 20 tonnes, a Euro 3 diesel engine, is producing 814 g/km of CO_2, 6,1 g/km of NO_x, and 0,1 g/km of PM_{10} and $PM_{2,5}$. When applied to the estimated reduction of trucks made in the evaluation of the Dutch trials, this would lead to a total reduction as listed in *table 4.3.*

Emission	**Scenario I**	**Scenario II**
Savings (1000 kg)		
NO_x,	-1477	-2800
$PM_{10}/PM_{2,5}$	-24	-46
CO_2	-197052	-373669
Savings (%)		
NO_x,	-1,9	-3,7
$PM_{10}/PM_{2,5}$	-1,2	-2,3
CO_2	-3,0	-5,7

Table 4.3: Reduction of emissions.

Please note that the reduction in percent is valid for road freight in general in the Netherlands, thus spanning all freight vehicles in the nation. The reduction actually associated with the number of trucks in the trial would thus probably be higher.

4.4.6 Economic effects

Listed in the *table 4.4* below are the accumulated economic savings from the trial. It is stated in the report that there might be a less than optimal use of the load capacity if LZV's are allowed permanently. The load capacity is however believed to be used more efficiently after some time of use. No expected time-table is presented.

	Scenario I	**Scenario II**
Reduced emissions	-23	-46
Traffic safety	-9	-18
Reduced congestion	-10	-18
Operations costs	-216	-409
Total	**-259**	**-491**

Table 4.4: The economic savings of the trial, macro level (million Euros) (Arcadis, 2006)

As seen in *table 4.5* the major economic savings for the hauliers are reduced fixed costs, mainly due to less number of vehicles. Also the fuel cost is reduced significantly.

	Scenario I	Scenario II
Variable costs		
Fuel	-53	-100
Maintenances	-12	-23
Tires	-4	-8
Fixed costs		
Drivers salaries	-86	-164
Other fixed costs	-147	-278
Total	**-216**	**-409**
Total (%)	-1,8%	-3,4%

Table 4.5: The economic savings on micro level (million Euros and %) (Arcadis, 2006)

4.5 The fellow motorist's perceptions of LZV's

As a part of the evaluation of the trial, TNS Nipo consult carried out a report regarding motorists' perceptions on road safety. *(TNS Nipo Consult, 2005).* The report was based on a inquiry with over 500 motorists using photo material and another 500 motorists using video material.

The main objective of the report was to determine Dutch motorists' view on LZV's compared to regular Dutch combinations: road trains and tractor & semi-trailer. Further the objectives were to

- define which factors indicate danger in motorists' perception of road safety when they have to react to freight traffic.
- indicate to what extent motorists' responds differently to LZV's compared to regular freight traffic, and if so, clarify how, and why.
- determine attitudes towards, image of and support for presence of freight traffic on the road.

The report concluded that it did not appear to be any significant differences between the motorists' feeling of safety while interacting with LZV's compared to regular freight traffic. As shown in *table 4.6* below, motorists, in general, feel "safe" or "neither safe nor unsafe" when interacting with freight vehicles, although somewhat safer when interacting with regular combinations.

	Safe	Neither safe nor unsafe	Unsafe
LZV	41%	38%	16%
Regular	48%	38%	15%

Table 4.6: Motorists' feeling of safety when interacting with LZV's (25,25 m) compared to regular freight traffic (max 18,75 m).

Motorists' tend to be more careful when interacting with freight traffic than when interacting with other passenger cars. However, there are no differences in behaviour when comparing LZV's to regular freight traffic in this regard.

There is one specific manoeuvre where there is a difference in motorists' perception – when the freight vehicle is making a right-turn. Especially LZV's tend to need to occupy more than one lane for this manoeuvre. This manoeuvre is by motorists considered to be the most

dangerous when interacting with LZV's. On the other hand, when interacting with passenger cars and regular trucks, merging with traffic motorists is considered the most dangerous manoeuvre.

5 Traffic safety aspects of using EMS

In this chapter, studies and reports regarding freight traffic's effects on traffic safety, is being discussed. The chapter does not contain any new results. It does, however, indicate EMS having positive effects on traffic safety in general. The traffic safety effects of the trials in the Netherlands are discussed in *chapter 4.4.3*.

In 2004 33081 people were killed and roughly 1750000 were injured in traffic accidents in Europe (EU15), (*Eurostat*). In Sweden the numbers were 480 and 26582 respectively. Trucks with a GVW over 3,5 tonnes are involved in approximately 20% of the fatal traffic accidents in Sweden annually. During 2003, 103 people were killed in Sweden in accidents involving a truck (regardless of weight) while 457 people were severely injured, (*Swedish road administration).*

The main theory among traffic safety experts is that the number of vehicles in use is one of the most crucial parameter regarding traffic safety. More traffic leads to more accidents. Reducing the number of vehicles in use on the roads is thus of great importance to reduce the number of accidents. This is also the conclusion in the majority of reports examined.

The use of LHV combinations according to EMS is an opportunity to reduce the number of vehicles while still transporting the same amount of goods. Thus EMS leads to fewer accidents and safer traffic. One may consider that EMS vehicle combinations lead to a higher accident rate due to their larger dimensions and higher weight. It appears however, that no such statistics supporting this argument exists.

Figure 5.1 below describes the approximate distribution of accident types in severe traffic accidents involving heavy trucks (GVW>3,5 tonnes) in Europe. The figures are based on various statistics from Volvo Trucks, EU authorities, GDI, Ceesar, among others. The distribution of each accident type is approximate and varies from different countries, but the overall pattern of accident types is similar all over Europe.

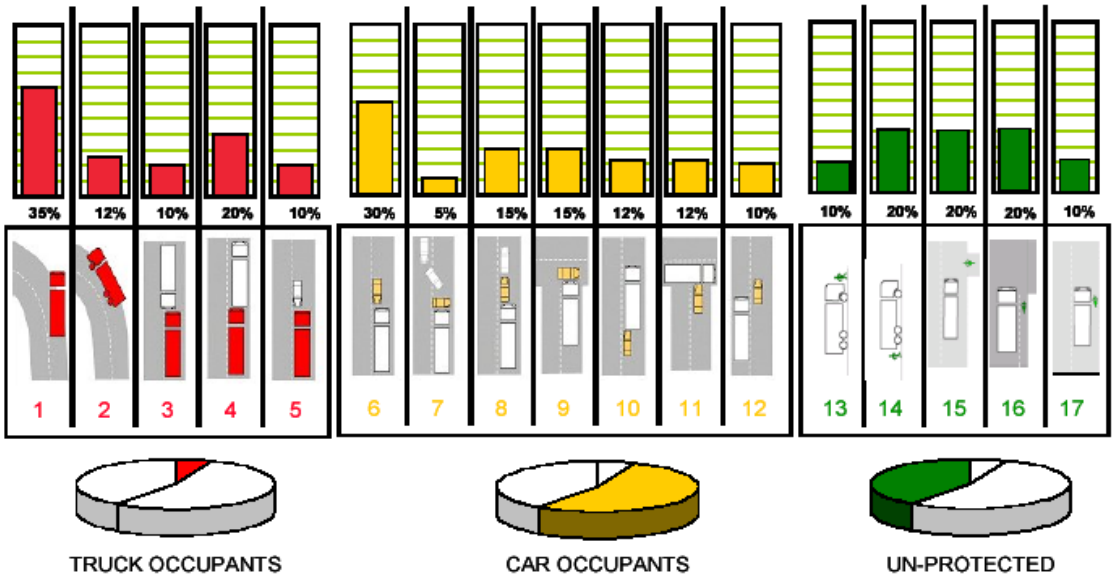


Figure 5.1: Distribution of accident types involving heavy truck (Volvo Accident Research Team)

The figure shows that head-on collision (6) being the dominant accident type (note that "car occupants" accounts for a larger accident share than "truck occupants" in the figure). This is often caused when a personal car by some "unknown reason" enters the on-coming lane, and collides with a truck.

5.1 Accident risk when overtaking long vehicle combinations

The National Road & Traffic Research Institute performed a report in 1976, (*Hammarström, 1976*) with the objective of elucidating the accident risk when overtaking long vehicle combinations. This was done in order to evaluate the continued use of 24 m vehicle combinations within Sweden. There was a debate regarding improvement in traffic safety by reducing the maximum vehicle length from 24 to 18 m, which was the standard in main Europe at the time. The study clearly indicated that the vehicle length had no significant effect on the accident risk when overtaking long vehicle combinations.

Two kinds of vehicle combinations were used during the examination: one 18 m long and one 24 m. These were driven at a constant speed along a two-lane road, 10 km apart from each other for a total of 13 640 km during 1975. Cameras were mounted on both vehicles, recording 3324 overtaking situations.

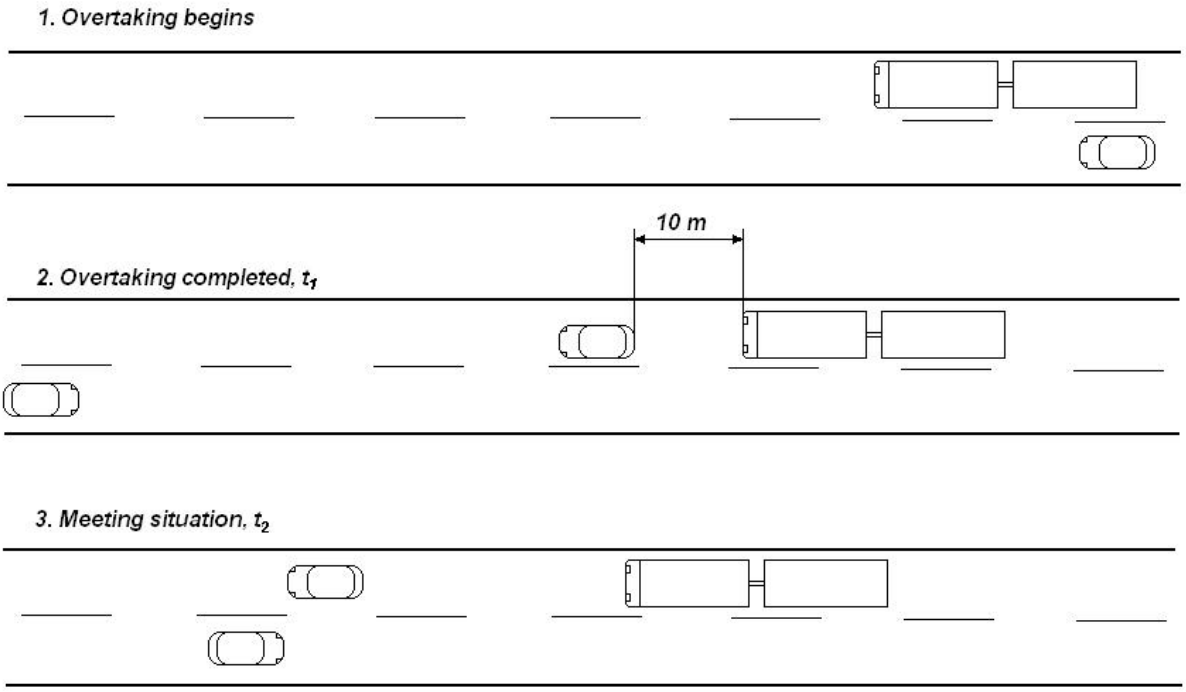


Figure 5.2: Schematic view of time recording in the report.

- t_1 was defined as the time the over-taking was finished, i.e. when the over-taking car was 10 meters in front of the truck.
- t_2 was defined as the moment of meeting on-coming vehicle or passing a "blind spot".
- The time gap was defined as t_2-t_1. Note that this could be a negative number.

The accident risk was defined as the time-gap between the moments when the over-taking was completed until meeting an oncoming vehicle. Over-taking situations were separated into two categories: with or without oncoming vehicle. In cases of over-takings without meeting, the time t_2 was defined as the moment when the over-taking car passed a "blind spot". The blind spot could be any object limiting the visibility: a hillock, a bend, etc. The reason for defining the blind spot was to include situations without visible oncoming vehicle. On these situations the driver of the over-taking vehicle had a limited sight distance, rather than an on-coming vehicle, in order to estimate if a safe over-take could be performed.

The negative time-gaps mentioned above, origin from situations when the actual meeting took place within 10 meters in front of the truck, or the over-taking was not completed before passing the blind spot. This was, above all, when travelling on wider roads, where three vehicles actually drove side by side.

The report concluded that the length of the freight vehicle had no significant effect on the time-span, hence no negative impact on the traffic safety. Further, the width of the road turned out to have a significant impact on the time-gap. Drivers are prone to perform over-takings with a shorter time-span on wider roads. This was, however, not considered to increase the accident risk since three vehicles were able to pass, side by side.

5.2 Tung-OLA

The Swedish Road Administration's study "Tung-Ola" has been examined, (*Vägverket, 2002*). Tung-OLA is a thorough investigation of all accidents during 1999 involving trucks with GVW > 3,5 tonnes. That year, heavy trucks were involved in 63 fatal accidents, causing 77 deaths. This corresponds to 20% of all fatal accidents.

- 37 of these, or 59%, were head-on collisions between a truck and another motor vehicle, mopeds excluded. In a vast majority of these accidents the other vehicle, most frequently a personal car, has crossed into the on-coming lane by some "unknown reason". The driver of the passenger car is killed while the driver of the truck usually escapes without any serious injuries but is severely chocked. The truck suffers minor damage to the lower parts while the passenger car is severely crippled.
- 13 accidents involved a truck and an unprotected road-user, such as pedestrians and cyclists.
- 6 accidents took place in an intersection. The typical accident involves a passenger car, which has stopped, and then, for some "unknown reason", drives into the intersection and is hit by a truck. The outcome is similar to that in the head-on collision, described above.
- The 7 remaining accident consisted of catch-up-, single- and turn-off-accidents. The single accidents appeared as the truck, for some "unknown reason", went off the road and overturned. The other two happened as one vehicle ran into another, either at the road or on a turn-on or turn-off.

The conclusions of the study resulted in a number of areas targeted for further work in order to achieve a higher level of traffic safety. "*The dimensions of the vehicles were not considered to affect traffic safety*" (*Lundqvist, oral reference*)

5.3 Stability test performed by Volvo

Volvo has carried out extensive testing regarding stability for a number of EMS combinations, both LHV's presently used in Sweden and Finland and regular EU vehicle combinations. Also, even larger combinations are examined. Volvo examines stability in their "Rearward amplification" test, in accordance to ISO 14791. Simply put the test simulates a lane change or a quick, sudden manoeuvre and lateral acceleration is measured. A low degree of acceleration is desirable. The RA-number is defined as the ratio of the peak lateral acceleration at the rearmost trailer's centre of gravity to that of the lead unit during a lane-change manoeuvre.

Nine different combinations were tested of which all consists of modules complying with the directive 96/53 displayed in *figure 5.3* below. Combination 2, 5 and 8 are not allowed according to current legislation in any European country. Combination 8 is allowed, and used in the Netherlands, if shorter load units are used (~6 m) and the overall combination length stays within 25,25 m. Note however that the stated stability figures are valid only for 7,82 m load units. These combinations are discussed in *chapter 10.1.3*.

The regular tractor & semi-trailer combination displays the best performance. It is however somewhat sensitive to uneven load distribution. If too much of the load is distributed at the front of the semi-trailer it increases the load on the rear axles of the tractor causing uneven axle load. This does however not affect the stability.

The third and fourth combinations are rather similar: Module A and Module C. Module A is, by far, the most dominant 25,25 m combination in use in Sweden as well as in Finland. These are also the least sensitive to uneven load distribution. Hauliers, interviewed and inquired, also praised the stability characteristics of these combinations. The general opinion among them was that these EMS combinations outperform regular Swedish 24 m combinations, consisting of truck and ordinary trailer.

Combination 6 and 9 are the longest combinations allowed within EU today. Note that combination number 6 performs decisively better than combination number 9. This is due to combination number 9 is being articulated both at the rear of the truck as well as at the front axle of the trailer. An increased number of joints lead to less stability. Combination number 6 is on the other hand more sensitive to uneven load distribution. Combination number 9 is the most common 18,75 m combination used within the EU today.

Combination number 7, Module B, is the least common LHV combination in Sweden and it is very sensitive to uneven load distribution in the centre-axle trailer. Too much cargo in front or in the rear of this trailer will cause a force on the rear of the semi-trailer.

The combination with two centre-axle trailers, number 8, must consist of rather short load carriers in order to be allowed within 25,25 m legislation, which is not the case in this test were 7,82 m load carriers were used and the combination measures roughly 27 m. Swedish hauliers are hesitating towards it, especially when driving in wet and slippery conditions. It is however used by some Dutch hauliers. As all combinations with the centre-axle trailer it is also sensitive to uneven load distribution.

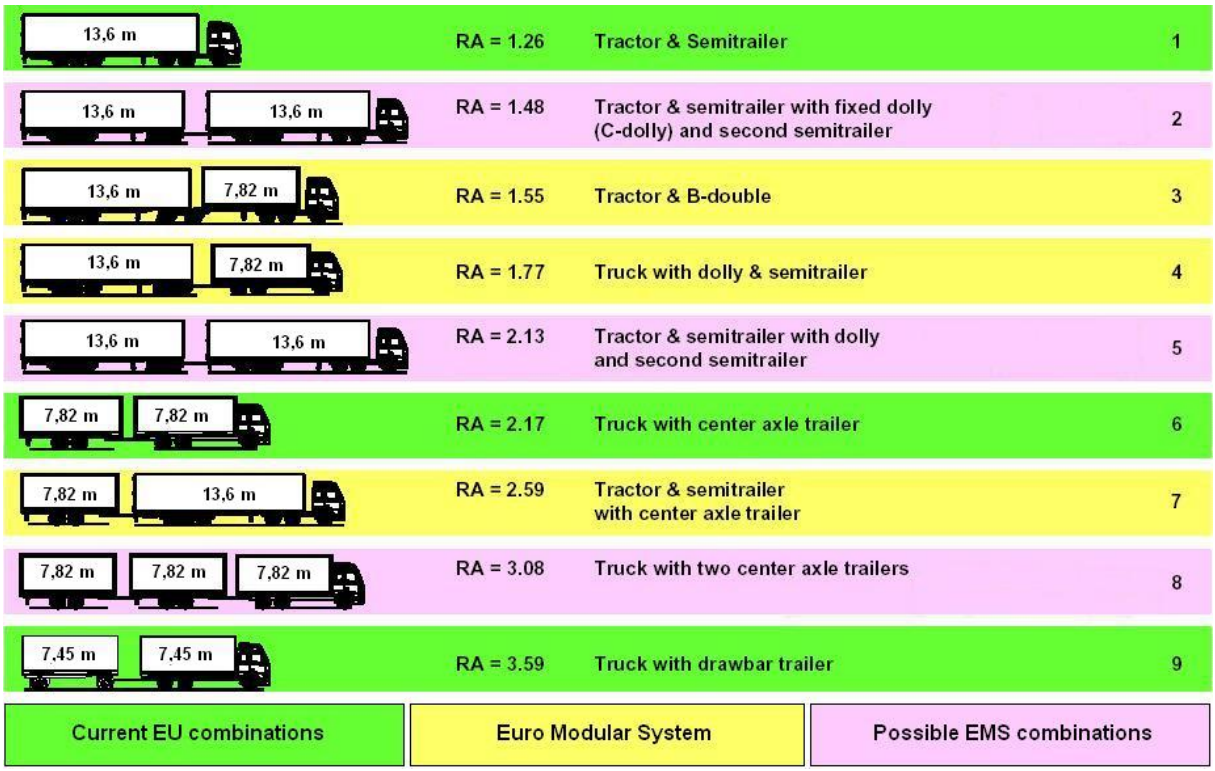


Figure 5.3: Rear-ward Amplification for some combinations (Volvo Trucks)

Note that EMS vehicle combinations do not have a worse performance than the existing regular EU combinations in these stability tests.

5.4 Effects in road safety of increasing the length of articulated lorries

At the time of Finland's entry in EU 1995, there was a similar debate regarding vehicle dimensions as in Sweden. The legislation regarding vehicle dimensions in Finland at this time set the maximum length to 22 m and maximum weight to 60 tonnes. In connection to the preparation of allowing 25,25 m vehicles according to EMS, VTT Communities & Infrastructure, Transport Research, achieved an assignment which resulted in a report called "Effects in road safety of increasing the length of articulated lorries" (*Kallberg, 1995*)

First, the report states that increased freight capacity would reduce the annual mileage of articulated freight transport by 2 to 3,5%. If the accident rate was reduced proportionally, this would mean a reduction of 4 to 7 accidents annually. Second, the EMS vehicles were assumed to have characteristics increasing their accident rate compared to regular 22 m combinations. This due to:

- Increased length adds to the risk of junction accidents.
- Overtaking manoeuvres (both passive and active) take longer time and more space.
- LHV's were assumed to be less stable in highway speeds.

These properties were considered to increase the accident rate by approximately 2 accidents per year. All together, the report states that EMS vehicles would reduce the accident rate by 2 to 5 accidents each year, due to the reduction of mileage.

6 EMS and intermodality

In order to meet the rising demands on land transports, different transport modes are now cooperating, rather than competing, with each other. The industry demands fast, reliable and cheap transports, which leads to greater productivity, higher profit and lower prices. Consumers demands cheap and, at the same time, environmental friendly transports. Railroad transports are considered to be the most environmental friendly transport mode with regard to amount of emissions per produced tonne kilometer. However, it is also a basic fact that railroads alone cannot distribute all cargo, hence needs to be complemented with use of road transports.

There are fears that increased vehicle dimensions will have negative effect on other modes of transport. The main assumption is that if road transports are becoming more efficient they will simultaneous become cheaper and thus more appealing to transport buyers.

6.1 EMS facilitates intermodal transports

Traditionally, different transport modes (rail, road etc) have been working out independent solutions for load carriers in order to optimize transport efficiency, rather than deciding on common standards. In practice, almost all transports from manufacturer to final costumer include more than one mode of transport. Thus, when looking at the entire transport chain as one, use of different load carriers lead to a kind of non-optimal sub-optimizing. Modern logistic companies struggle to work out solutions optimizing the entire transport flow, rather than each mode of transport. Effective transports are of great benefit for the entire society and different transport modes should cooperate rather than competing with each other.

As the amount of transports increases, so will intermodal transports. The EMS facilitates the use of intermodal transports thanks to the use of standardized load carriers. Standardized load carriers simplify the handling, designing of loading and unloading equipment and procedures. C-class and A-class load carriers, including containers, are already the dominant load carriers used in Europe. The wide-spread use is of great importance as it gives more companies a possibility to take part as well as contribute in the continued development.

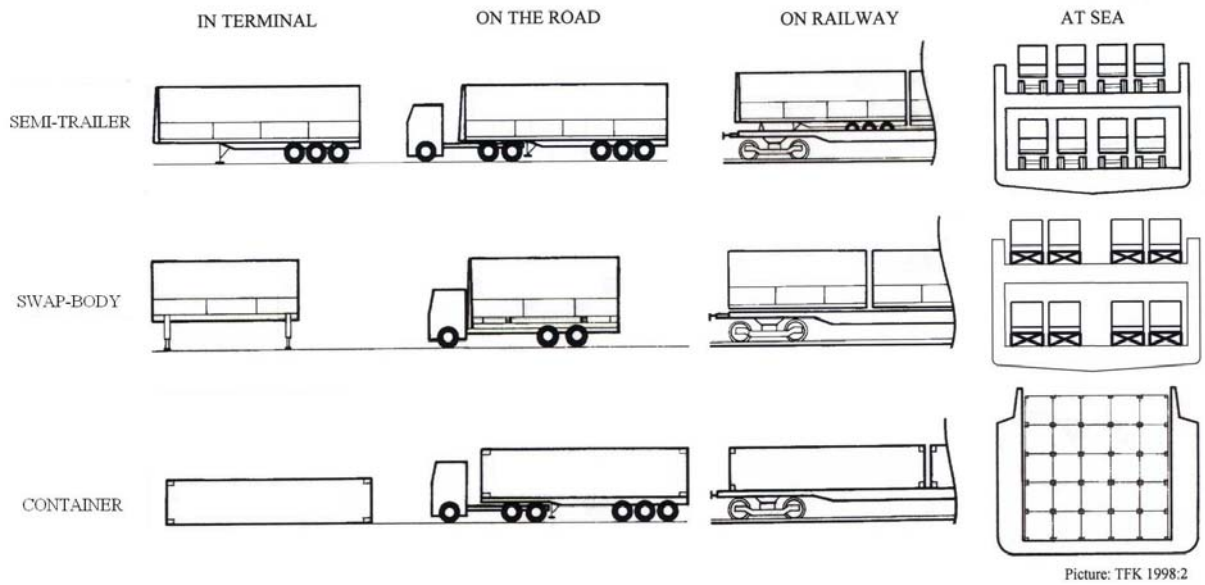


Figure 6.1: Schematic view of intermodal use of load carriers, (TFK, 1998:2)

Figure 6.1 above shows how semi-trailers, swap-bodies and containers are handled at the terminal, on road freight vehicle, on railway and at sea. The system with TEU-containers is easy to adopt into the EMS, as the 20 ft container measures roughly 6 meters and the 40 ft roughly 12 m. C-class swap-bodies and containers are loaded on train or ship without the trailer, while the semi-trailer is loaded as it is.

When using one 20 ft container and one 40 ft container there is a loss of approximately 3 meters compared to the longest C-class load carrier and semi-trailer. There are discussions of whether the 45 ft container of 13,75 m should be allowed in road traffic, which would be favorable. It does however slightly exceed the limit of 13,6 m.

6.2 Longer vehicles may cause modal shift in the short perspective

Modal shift is a term describing changes in the relation between different transport modes. There are apprehensions that increased vehicle dimensions may transfer goods from rail- and sea-transports onto the roads.

This study concludes that introduction of longer and heavier vehicles may lead to a minor modal shift towards road transport in the short term. History has however shown that these kinds of developments usually are restored with continued improvements of the other modes of transports.

As shown in *table 6.2*, different modes of transport are suited for different types of cargo and distances. However there are situations when rail and road transports do compete. It is within these segments that there will appear a modal shift. Results from Dutch trials indicated a limited modal shift with only 0,05% increased road freight on expense for other modes.

Dominating mode	Market (Billion tonneskm)	Typical weight of one shipping	Typical Value of goods (SEK/tonnes)	Typical cost (SEK/tonnes)
Sea	24	400 tonnes	200	0,1
Rail	34	40 tonnes	2000	0,2
Road	33	10 tonnes	20 000	0,6
Air	0,3	10 kg	200 000	30

Table 6.2: Characteristics for different modes of transports and cargo. (Nelldal, 2005)

6.3 A comparison regarding the share of railroad transports.

Although Sweden and Finland have had LHV's for a long time, the countries also have among the highest shares of railroad transports in Europe. *Figure 6.3* below shows the share of railroad transports in Sweden, EU (EU 15) and USA during the last decades. The figure clearly shows that railroad transports are used more extensively in USA than in Europe. It is also clear that Sweden has a larger share of railroad transport compared to the rest of EU. The share of railroad transports has been decreasing all over since 1970, but in Sweden and USA, one might observe that the slope has flattened, and the share is slightly increasing.

When examining the curve for Sweden, an interesting thing is observed. In 1974, GCW for road transports was increased from 37 to 51,4 tonnes, and the share of railroad transports decreased, as road transports became more competitive. In the early 90s, GCW was raised to 56, and a few years later, to 60 tonnes. Once again the share of railroad transports decreased. Common for both these events is that the share of railroad transport rises after a few years. This might be due to more effective rail transports as an effect of a more competitive market. Since 1997, EMS vehicle combinations of 25,25 m have been used in Sweden. At the same time, the share of railroad transports is rising. This might be due to EMS facilitates intermodal transports.

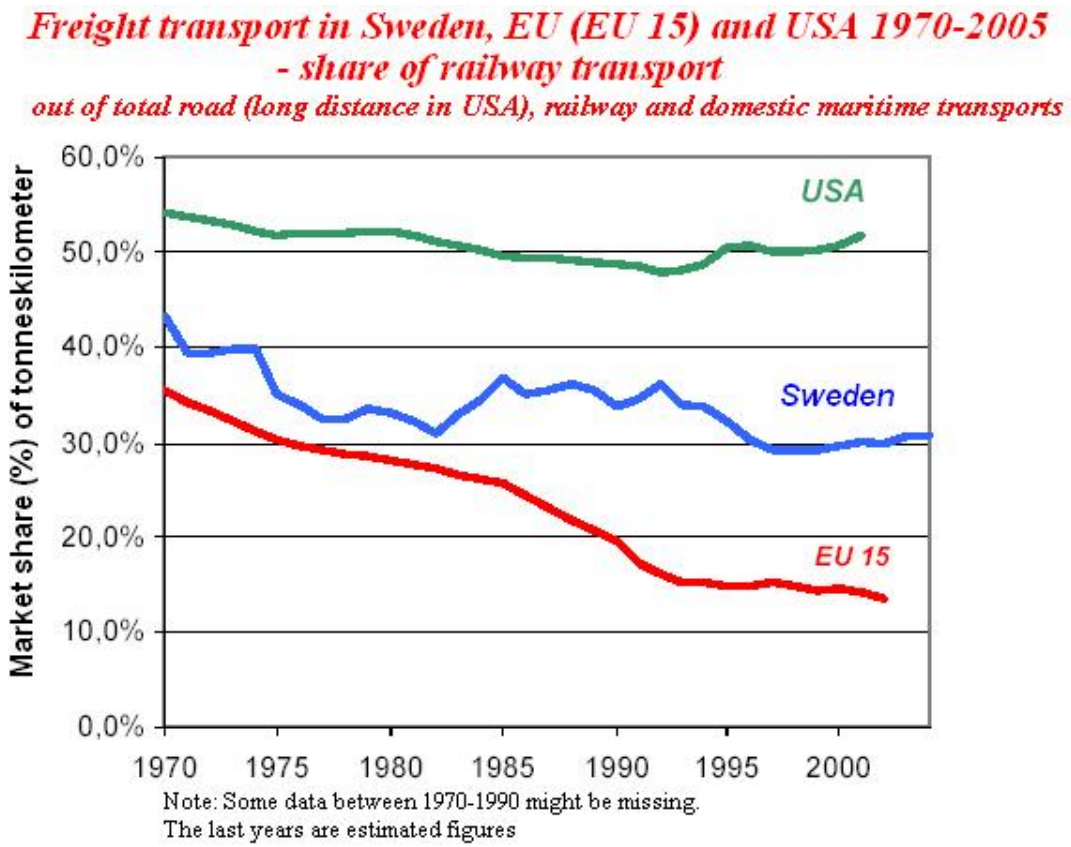


Figure 6.3 Share of railway freight transport in Sweden, EU and USA 1970-2005 (Nelldal, 2005)

The infrastructure also varies a lot between Europe and USA. In USA, the main focus for railroad transports is freight traffic, on the contrary to Europe, where focus lies on passenger traffic. Also, the US railroads benefits from large distances and a common standard all over the nation. In Europe, on the other hand, there are two different track widths and each nation has set its own standard of electricity and signal system. This is due to the dark history of warfare and nationalism. Railroads were an effective way of troop transports within the nation, but could also be used by the enemy during occupation, which was meant to be prevented. Today, there are only two border-crossings in Europe where trains can travel between nations without adjustments; Norway-Sweden and Austria-Germany.

It is not only international railroad transports having difficulties competing. Research carried out by the Technical University of Braunschweig, Germany, states that road haulage has a system speed of around 50 km/h, while rail freight transportation registers only 10 km/h. These figures are valid for national transport in Germany. This is of course one of the reason railroad transports have difficulties competing in the central parts of Europe.

7 Economic consequences of using EMS

The evaluation of the trials in the Netherlands showed that the use of LHV's had a number of positive effects, and thus positive effects on the economy. In short the findings were:

- Less fuel consumption and emissions
- Positive effects on the environment
- Increased traffic safety
- Reduced congestion
- Improved efficiency

This chapter, discussing the economic consequences of using EMS, is divided into two sections, macro level and micro level. Here macro level means consequences mainly connected with society such as costs for emissions, congestion, traffic safety and road wear. The micro level, on the other hand, is consequences connected to the hauliers.

Based on a constant amount of cargo being transported one may expect the following economic consequences, for macro and micro respectively. Note that the assumptions are supported by the findings in the evaluation of the Dutch trials.

Expected economic consequences on a macro level:

- Reduced emissions
- Improved traffic safety
- Reduced congestion
- Less road wear
- Increased transport efficiency
- Increased flexibility
- Cheaper transports
- Demands for improved infrastructure

Expected consequences on a micro level:

- Less fuel per tonne km
- Reduced number of vehicles
- Reduced number of drivers
- Increased transport efficiency
- Increased flexibility
- Higher fuel consumption per vehicle
- Higher costs for purchase per vehicle combination
- Higher costs for maintenance per vehicle combination

7.1 Economic consequences on macro level

7.1.1 LHV's will lead to cheaper transports

Introduction of LHV's according to EMS will probably lead to cheaper transport due to a number of reasons. The most important factor is the increased volume capacity meaning that a large number of EU dimensions freight vehicles could be replaced by LHV's with higher capacity. The improved volume capacity is roughly 40-60% per vehicle.

EMS vehicle combinations will give rise to a larger potential for road transports, as well as for more efficient transports over all, as standardized load carriers facilitates intermodal transports. With more available combinations to choose from, hauliers are able to optimize their operations more easily. The potential for involving intermodal transports increases, leading to more efficient, and therefore, cheaper transports. Efficient transports are desirable for the whole society since they will offer cheaper products.

7.1.2 Improved environment equals improved economy

Nowadays, emission of greenhouse gases (CO_2, CH_4) and unhealthy exhaust gases (CO, NO_x, particles) are accounted as expenses for the society. Greenhouse gases are believed to cause climate changes, which could cause tremendous effects on both the environment and society. Unhealthy exhaust gases are proved to cause diseases like asthma and lung cancer and could even lead to premature deaths and deteriorating public health in general. However, it is difficult to estimate these costs, and various methods are used.

The Danish Ministry of Transport and Energy value emission in Danish crowns per vehicle kilometre (100 DKK ~ 12,5 Euro). The Danish study Modulvogntog (*Trafikministeriet, 2004*) discussing the matter of allowing LVH's according to EMS on the Danish freeway system, concludes that 266 EMS vehicle combinations would replace nearly 400 existing regular combinations. This involves a saving of 16 million vehicle kilometres. Further, pollution is valued to 0,18 DKK per vehicle kilometre and emission of greenhouse gases is valued to 0,09 DKK per vehicle kilometre. The study concludes that the pollution savings would come to 1,1 million DKK and savings in greenhouse gases would come to 0,5 million DKK, corresponding to approximately 0,13 respectively 0,06 million Euros. Dutch studies indicated annual savings of 24-46 million Euros. Note that the Danish study comprises 266 LHV's while the Dutch study comprises 6000 LHV's.

7.1.3 Other positive effects

The increase in traffic safety will lead to economic benefits. Traffic accidents roughly costs society 2% of GNP each year (*WHO, 2004*). Results from the Dutch trials estimates that the number of killed in traffic accidents will decrease by 4 to 7, and the number of injured in traffic accidents by 13 to 25 each year (*Arcadis, 2006*). This is stated to be equivalent to 9-18 million Euros.

Congestion on the road system is another area of problem for society. Once again, it is hard to estimate the consequences of the problem in economic terms. Transport efficiency is decreased, as well as the environment is affected, due to increased exhaust gases. It is also considered congestion has a negative impact on people, affecting public health in terms of stress related complaints. Reports from the Dutch trials state that annual savings would be 10-18 million Euros.

Road wear is an inevitable effect of traffic. Large amounts have to be invested for road maintenances yearly in order to maintain acceptable road standard. Heavy freight traffic is often considered to be the largest independent factor of this issue. As discussed in *chapter 8.4*, LHV's will not necessary lead to increased axle load.

7.1.4 Demands of improved infrastructure

There may, initially, appear some infrastructural demands, which need to be accounted the society. Even if only allowing LHV's on a limited road net, such as the expressway system, small adjustments in the infrastructure may be needed. For instance: larger parking areas at pull-ups, areas for re-coupling EMS-vehicle combinations into regular combinations, some intersections adjacent to the expressway and more available space at gas stations. However, this is only a one-time investment, and not associated to any large amounts of maintenances.

In the Netherlands, hauliers were able to choose 10 routes on the ordinary road net in addition to the already permitted expressway system. There were only a very limited number of routes that had to be rejected, due to the fact that these routes were not possible to operate with LHV's. This is an indication that the size of needed investments is fairly limited. Also note that no adjustments of the infrastructure were performed prior to the trials.

In the report "Modulvogntog", the Danish Ministry of Transport and Energy states that investments of approximately 245 DKK (~30 million Euros) will be needed in order to enable EMS vehicles on the Danish expressway system. (*Trafikministeriet, 2004*)

7.2 Economic consequences on micro level

For the transporting company, as well as for hauliers and shippers, increased vehicle dimensions gives rise to positive economic effects. This chapter is based both on conclusions from earlier reports as well as experiences from interviews with hauliers operating with EMS vehicle combinations in Sweden, Finland and in the Netherlands.

7.2.1 Improved transport efficiency

The most obvious effect for the hauliers is the reduced fuel consumed per unit of cargo. Or, similarly, more cargo on the same transport unit.

A study performed by TFK, (*Backman, et al, 2002*) shows that the fuel savings reaches between 14-18%, depending on preconditions. This calculation is based on a number of recorded trips with regular EU vehicles for three different companies. A simulation is made, where the regular EU vehicles are replaced by EMS vehicle combinations, transporting the

same amount of cargo the same distance. The variation in the results has its origin in the preconditions of the performed transports, i.e. the differences in the share between the both EU combinations. The higher number, 18%, is connected to a larger share of semi-trailer combinations, and, similarly, the lower number is connected to a larger share of road-trains. The latter has a slightly higher volume capacity. At the same time, the number of trips was reduced on average by 32%, very close to the "optimal case", meaning three regular EU combinations could be replaced by two EMS combinations. However, this is only valid for one road-train and two semi-trailer combinations, thus forming one Module A and one Module B. See *figure 7.1* below.

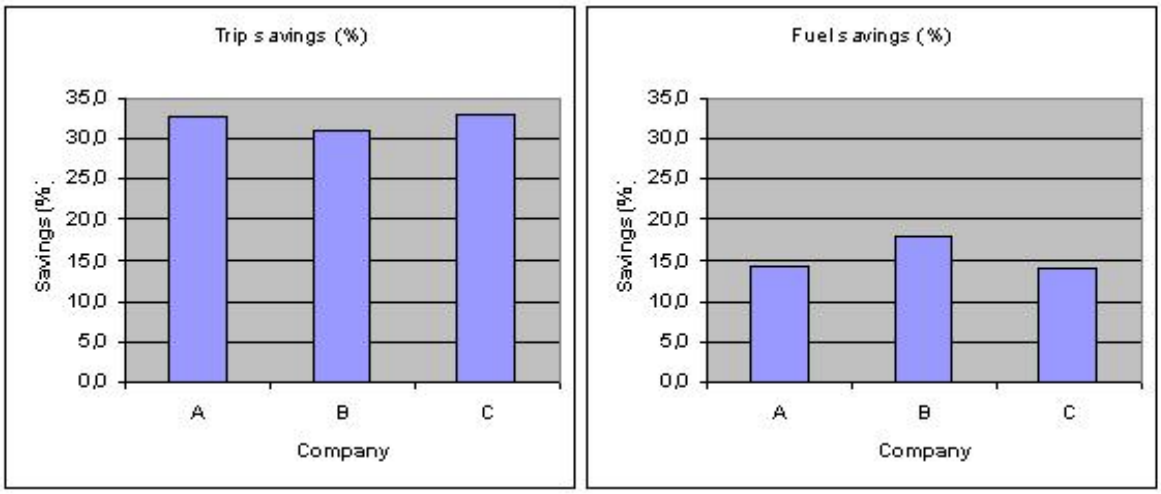


Figure 7.1: Trip and fuel savings for the companies, (Backman, et al, 2002)

In connection to the Swedish study, NEA produced a more detailed report based on the same data-set, (*NEA, 2002*). Here, a number of restrictions were introduced in five scenarios:

1. No restrictions; regular combinations replaced by EMS combinations, corresponding to the TFK report. This is however also claimed to be the realistic view.
2. Semi-trailer combinations not replaceable. Other factors than volume may have caused the choice of this combination in the first place, like easier loading or non-divisible cargo.
3. Time-window. Two trips on different days can not be replaced by one single trip.
4. Worst case. A combination of (2) and (3).
5. Worst case adapted. In (4), EMS vehicles are chosen even if the capacity of a regular combination is enough. Here, the optimal vehicle is chosen.

Also, a more detailed calculation of total transport cost is made, based on maintenances, salaries, etc.

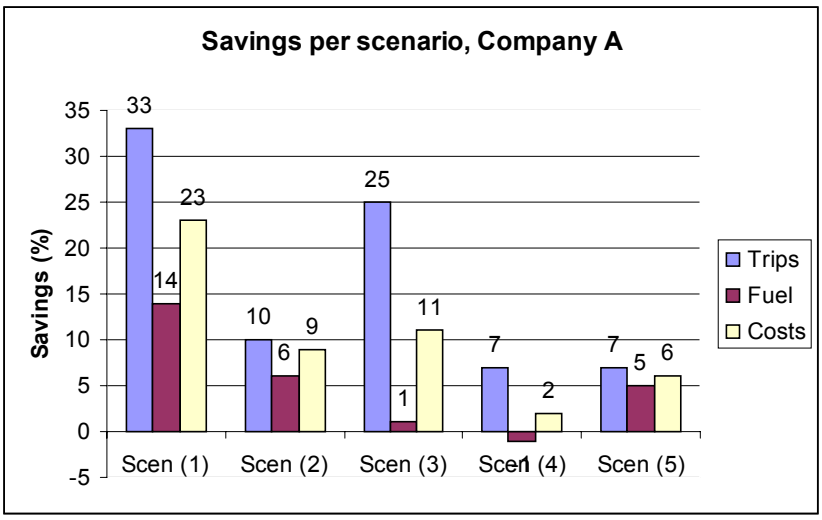


Figure 7.2: Results Company A, (NEA, 2002)

The results for Company A are presented in *figure 7.2* above. Note that the figures for trip and fuel savings in Scenario (1) correspond to the results of Company A in *figure 7.1* above. As seen, the figures are all positive, except for the increased fuel consumption in the "worst case" scenario.

Since each LHV is able to carry more cargo the total number of vehicles in use will decrease. This has a number of positive effects; less investment, cheaper maintenance, interest, insurance and repairs. Also the number of driver will decrease. Since labour cost accounts for approximately 40-50% of all expenses, this will lead to great savings for the hauliers.

7.2.2 Increased flexibility

LHV combinations according to EMS give the haulier extra flexibility in the use of the vehicles and load carriers. This leads to the possibility of the same number of vehicles for a number of different operations, resulting in a higher degree of utility. Examples of this can be found in *chapter 3.5.*

The use of EMS facilitates intermodal transports which also benefits the transporting companies.

7.2.3 Increased costs per vehicle

Naturally an LHV is more expensive to purchase and maintain than a regular EU vehicle. The increased capacity however lead to higher income and as a whole, the use of LHV will benefit the haulier, as seen in the Dutch trials.

In Sweden, an EMS vehicle combination is generally assumed to be slightly more expensive than a traditional 24 m vehicle. This is due to a higher cost of purchase and increased need of maintenance.

The main reason for higher maintenance cost is due to more advanced technical equipment in the new modern EMS-vehicles. The system causing most trouble is the EBS, Electric Brake System. The problem is that the system is designed to handle only two units, while EMS vehicle combinations consist of three. Thus adjusting the brakes are slightly more difficult.

There has however not been any traffic incident reported in connection to this. The problems will probably decrease with a larger number of EMS vehicles being sold, adding pressure on manufacturer and suppliers to introduce systems fitting the EMS vehicles. Manufacturer believes this problem will be solved within a year.

It appears that the supposedly increased costs of using EMS in Sweden however are debatable. When studying the calculations provided by some hauliers willing to share their economic analysis of EMS the differences in costs are insignificant. The investment costs of EMS are higher than that of 24 m combination. But when evaluating the costs per km the EMS is actually cheaper to operate. These calculations are however based on a low number of hauliers willing to share their calculations.

This may depend on a couple of different reasons. The actual demand of maintenance could be underestimated for EMS. The hauliers providing calculations may have favourable agreements when purchasing EMS vehicle. Also, the hauliers stating that EMS is more expensive may have performed an insufficient analysis of the costs.

For certain cargo characteristics, the increased volume will lead to a positive overall economic effect, thus the increased income exceeds the increased costs.

8 Consequences on infrastructure from increased vehicle dimensions

The infrastructure varies between nations as well as in nations. Sweden and Finland have a tradition of long and heavy vehicles, and the road net has been built to satisfy those demands. This is not the present situation in the far more dense populated parts of Central Europe.

Although increased vehicle dimension may be considered a way to increase transport efficiency, it might not be possible to operate on all roads with longer and heavier vehicles due to infrastructure. Therefore, a road-class system, where LHV's are allowed on a limited road net, might be necessary.

Denmark is considering a trial period in this matter. A report has been produced where needed investments are presented. This report is discussed in *chapter 8.2*. The trials in the Netherlands were performed on a limited road net.

Further, road wear is an issue for road keepers. Road users are considered to cause road wear, proportional to the fourth power of the axle load of the vehicle. The use of LHV's according to EMS however entails a lowered axle load per tonne on average, thus reducing road wear.

Finally, the capacity of road transports is limited by the number of available roads. Congestion is becoming an even greater issue in all of Europe. Introducing LHV's is one way to improve the situation, i.e. increase transport efficiency.

8.1 Road class system

LHV's are most efficient in long distance transport. In Sweden this means that most of the roads travelled are motorways and on main roads. Towns and city centres are avoided unless that is not possible. This is due to long vehicles are quite difficult to manoeuvre in narrow crossings, bends and turnabouts, etc. In Sweden and Finland, LHV's are allowed almost on the entire road net. Some exceptions are made, but they are often connected to a general ban of freight traffic.

However, infrastructure varies among nations. Further, LHV's are most likely able to operate on all freeway-standard roads in Europe. One solution is the one used in the Netherlands, a limited road net, according to a road class system, as described below.

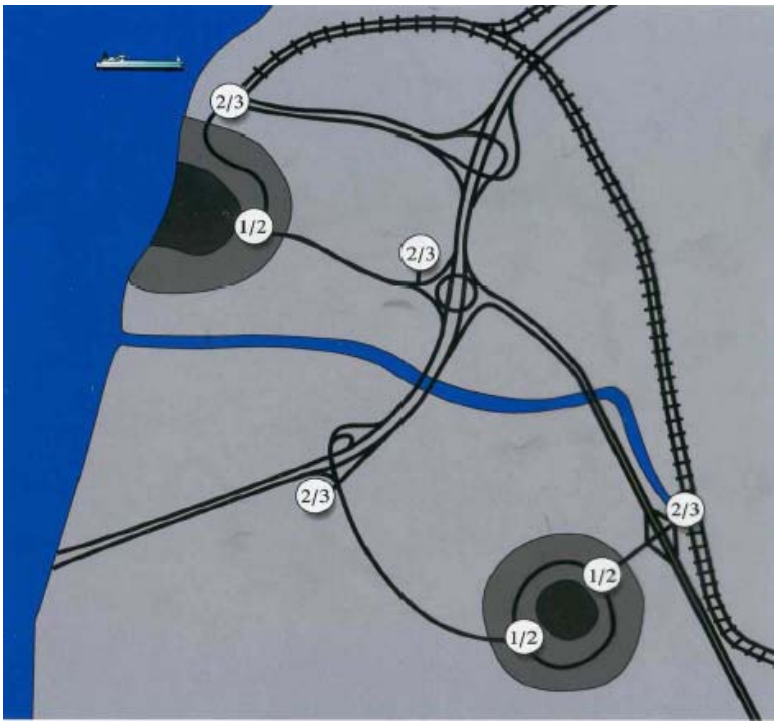


Figure 8.1: Road class system, (Volvo Trucks)

Figure 8.1 above suggests a road classing system into (3) primary roads such as motorways, (2) normal roads and (1) city streets. LHV's are intended to be used on primary roads and when possible on normal roads. This is however something that has to be decided by each nation. In the Netherlands normal roads are allowed up to 20 km from the primary roads. EMS offers the possibility of coupling and decoupling in order to fit each of the classes above, ranging from 1 to 3:

- Class 3 roads allow LHV's.
- Class 2 roads might need further studies regarding which lengths should be allowed, depending on the preconditions of each road. If possible, LHV's. If not, for instance a tractor with semi-trailer or a truck.
- Class 1 roads allow short distribution trucks. A common limit is 12 m, thus a truck.

However, this method requires an investigation of the main roads associated with some kind of administration.

8.2 Danish study of the infrastructural needs

Two Danish studies, (*Trafikministeriet, 2004 and DTL; 2005*) investigated the possible need for improved infrastructure upon allowing LHV's on a limited road net; the Danish freeway-system. The basic idea is to proceed in four steps, each related to certain investment costs. Already in the second step, almost the entire freeway-system is included. The third step involves roads through the city centres of Helsinore and Aarhus. The fourth step includes upgrading regular roads to freeway standard to two different locations. See *figure 8.2*

Figure 8.2: Danish roads included in each package, (DTL, 2005)

	Investment cost (DKK)
Package 1 (green)	2 375 000
Package 2 (yellow)	7 925 000
Package 3 (light blue)	4 025 000
Package 4 (dark blue)	1 750 000
In total	16 075 000

Table 8.3: Investments costs for each package, (DTL, 2005)

8.3 Reduced congestion

Congestion on the road system is another area of problem for society. Transport efficiency is decreased, as well as the environment is affected, due to increased exhaust gases. It is also considered congestion has a negative impact on public health in terms of stress related complaints.

The Dutch trials stated that an introduction of LZV's would reduce congestion by 0,7-1,4%, depending on preconditions. Congestion will decrease if fewer vehicle combinations will transport the same amount of cargo. Thus fewer trucks will occupy less space on the roads. A calculation by Swedish truck manufacturer Volvo shows that LHV's will occupy 27% less space than vehicles of the current EU legislation while transporting the same amount of cargo. See *figure 8.4* below.

The calculation was performed with a 55% transport increase, as stated in EU White Paper. In order to transport 5115 pallets, 99 LHV's are required while 155 trucks of EU dimensions are required. The safety distance between the vehicles is set to 50 m. EU vehicles occupies a total of 10300 m while LHV's only need 7400 m, corresponding to 28%. The difference will increase with increased amount of goods.

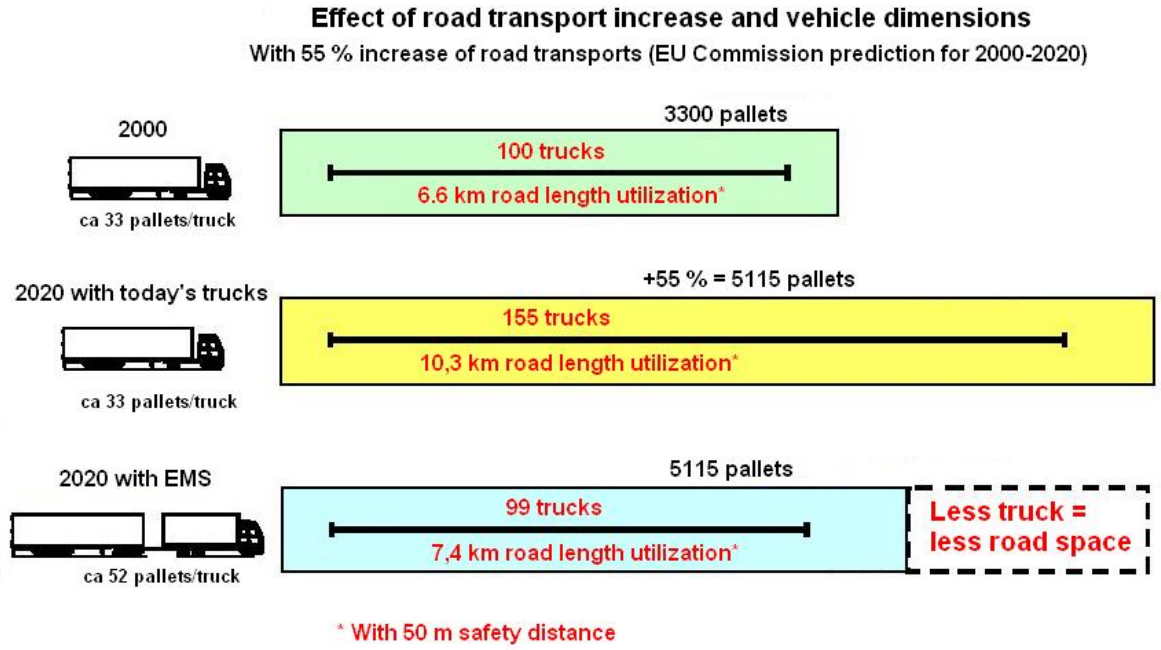


Figure 8.4: Road utilization of different combinations, (Volvo Trucks)

8.4 Less road wear

Road wear is an inevitable effect of traffic. Large amounts have to be invested for road maintenances yearly in order to maintain acceptable road standard. Heavy freight traffic is often considered to be the largest independent factor of this issue. The *American Association of State Highway and Transportation Officials, AASHTO*, has produced a formula, describing the road wear, *N*, as dependant of the number of equivalent 10 ton axles.

$$N_{10} = \sum (A/10)^{\alpha}, \qquad [Formula\ 1]$$

where α is a constant, between 3-5. Most common, α is estimated as 4, meaning road wear is dependant on the 4th power of the axle load. The exponent is dependent on the individual road standard and a high standard road corresponds to a lower factor.

There are several configurations of as well tractors, trucks and trailers regarding the number of axles used. As shown in *figure 8.5* and *table 8.6* below, LHV's do not necessarily result in higher axle load. The figure shows that, according to *formula 1*, the LHV in the example has a higher N_{10} per vehicle. However, the N_{10} per tonnes is actually lower meaning that for the same amount of transported goods the road wear is thus less stressing. In the most favourable situation, where EU combinations with two-axle tractors are replaced by LHV's the result is 22% lower N_{10} per tonnes. Note that the EU dimensions vehicle combination with a three axle tractor, as listed in the table, has a significant lower N_{10} than the combination with a two-axle tractor. Also note that 60 tonnes is the legislated GCW in Sweden, Finland and the Dutch trials. As discussed in *chapter 3.4.1,* there is a greater demand for extra volume than for extra weight.

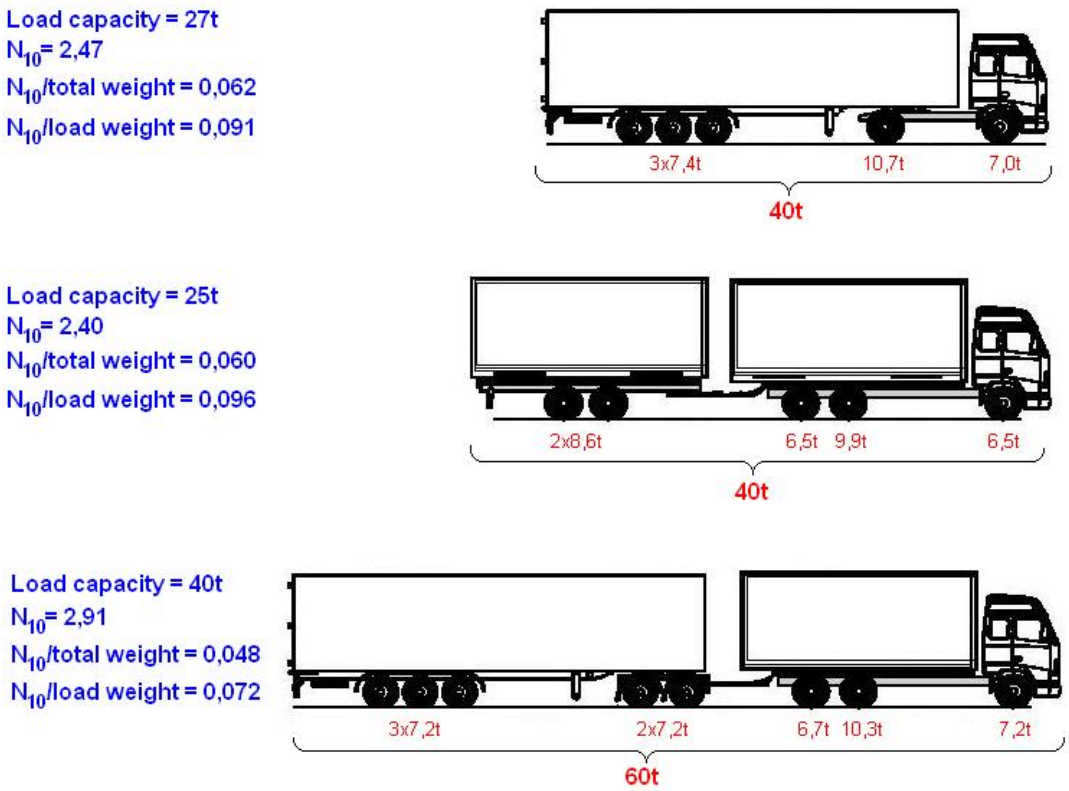


Figure 8.5: N_{10} per vehicle and per tonnes for some combinations.

	Total Weight (t)	Load capacity (t)	N10	N10/total weight	Index
2-axle tractor with 3-axle semi-trailer	40	27	2,467	0,062	**1,00**
Road-train; 3-axle truck with 2-axle trailer	40	25	2,399	0,060	**0,97**
3-axle tractor with 3-axle semi-trailer	40	26	1,421	0,036	**0,58**
3-axle tractor with 3-axle semi-trailer and 40"-container	44	30	2,081	0,047	**0,77**
LHV Module A; 3-axle truck with 2-axle dolly and 3-axle semi-trailer	60	40	2,909	0,048	**0,79**
LHV Module B; 3-axle tractor with 3-axle semi-trailer and 2-axle trailer	60	40	2,943	0,049	**0,80**
LHV Module C; 3-axle tractor with 2-axle link and 3-axle semi-trailer	60	40	2,943	0,049	**0,80**

Table 8.6: N_{10} and N_{10} /total weight for some combinations.

8.5 Swept path and turning radius

The swept path is space required for performing a turn with a vehicle or vehicle combination as sees in *figure 8.7*. The swept path is depending on the design of the vehicle, especially distance between axles and number of hinge points and curve-radius. In Europe, swept path is legislated in terms of turning radius.

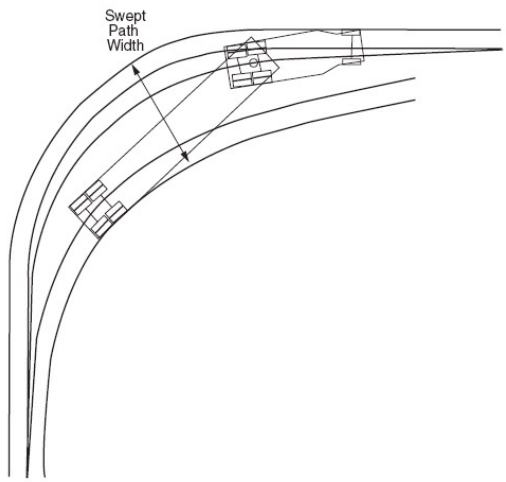


Figure 8.7 Swept path width

According to directive 96/53, any motor vehicle or vehicle combination must be able to turn within a swept circle having outer radius of 12,50 , and an inner radius of 5,3 m, corresponding to a swept path of 7,2 m. This implies that all single vehicles involved in EMS vehicle combination must fulfil this criterion. However, an LHV according to EMS is unable to fulfil this, due to its larger dimensions. Therefore, Swedish authorities have set their own national legislation: The EMS vehicle combination must be able to turn within a swept circle having outer radius of 12,50 m, and an inner radius of 2,0 m. I.e. the same outer radius, but as the LHV's are considered to require a larger swept path, the inner radius is smaller.

During the Dutch trials authorities chose another strategy. Both the outer and inner radius was expanded for LHV's. The outer radius to 14,5 m, thus making turning easier. The inner radius was expanded to 6,5 m, decreasing swept path. These are the same figures as used for "exceptional transports" already and is found to suit the Dutch infrastructure, especially roundabouts.

LHV's do result in increased swept path. Module A performs similarly to a regular tractor-semi-trailer combination. It is also considered to perform better than a comparable Swedish 24-m vehicle, due to shorter wheelbase. Both Module B and C show worse performance than Module A. This study has not been able to carry out extensive tests of swept paths for LHV's.

9 Environmental consequences of increased vehicle dimensions

Pollution is closely linked to exhaust gases from engines. Lowering the total amount of fuel used is thus of great interest. The use of increased vehicle dimensions has positive effects on the environment, mainly due to one reason: For a given amount of cargo the use of LHV's will lead to a reduced number of trucks, thus a reducing the use of fuel.

There are several different types of emissions in exhaust gases. This report will discuss three types:

- CO_2, which is a greenhouse gas, considered to cause global warming.
- NO_x, which is considered to cause acid rain.
- PM_{10} and $PM_{2,5}$, which are small particles in exhaust gases.

The TFK-report states that the fuel savings when replacing EU dimensions vehicles with LHV's are approximately 15%, (*Backman, et al, 2002*) discussed in *chapter 7.2.1*.

The trial in the Netherlands resulted in an annual fuel saving by 14%. This would lead to a total reduction of fuel consumption by 36 million litres. The slightly higher fuel consumption per vehicle for LHV's is taken into account. The numbers are very close, indicating that this is a reasonable number.

When powering a heavy vehicle over 20 tonnes, a Euro 3 diesel engine, is producing 814 g/km of CO_2, 6,1 g/km of NO_x, and 0,1 g/km of PM_{10} and $PM_{2,5}$. When applied to the estimated reduction of trucks made in the evaluation of the Dutch trials, this would lead to a total reduction as shown in *table 9.1*.

	Reduction in tonnes:	Reduction in %
CO_2	197 052	3,0
NO_x	1477	1,9
PM_{10} and $PM_{2,5}$	24	1,2

Table 9.1: Reduction of emissions in the Dutch trials.

Please note that the reduction in percent is valid for road freight in general in the Netherlands, thus spanning all freight vehicles in the nation. The fuel savings by using LHV's, of 14 %, thus lead to a total saving of CO_2 by 3 % for the entire Netherlands.

10 Discussion

This chapter is discussing the analysis of the report. The outline of this chapter is similar to the previously read report.

10.1 Discussion regarding EMS in general

The use of EMS is of great value primarily for Sweden and Finland since the system enabled these nations to maintain their present vehicle dimensions upon entering the European Union. Although it will never be known for sure how the nations would fare if forced to use the shorter EU vehicles, the reports carried out before the entry indicated that the nations would suffer great losses.

Of greatest need is an international harmonization of legislation regarding road transports. EMS of today does not interfere with directive 96/53, rather it has its roots in the directive as the same vehicles are used. A harmonization of the legislation facilitates international transports. If every nation within EU has the exact same legislation, hauliers do not have to concern whether their vehicles are allowed in other countries. Deviation from the directive should only be allowed in nations due to extreme conditions. If this is necessary it should only be done in such a fashion that it does not cause unjust competition between nations.

10.1.1 Modular systems have many benefits

The concept of using modules of load carriers already frequently used has many advantages:

- A large number of units already in use equal less investment.
- Standardized load carriers facilitate handling.
- Large scale use leads to benefits such as economics of scale for users and manufacturers.
- The same engine can be used in a wide variety of operations using different load carriers.

One may consider that there is a weakness in using two units where the length of two short units does not correspond to the length of one long unit. However, by using modules based on one single module, the possible combinations are more limited compared to using two different lengths of modules. As seen in *figure 10.1* below, the use of two different modules give a larger number of possible combinations, enabling companies to find their most optimal combination. It should however be stated that systems involving a single module further facilitates handling and is cheaper.

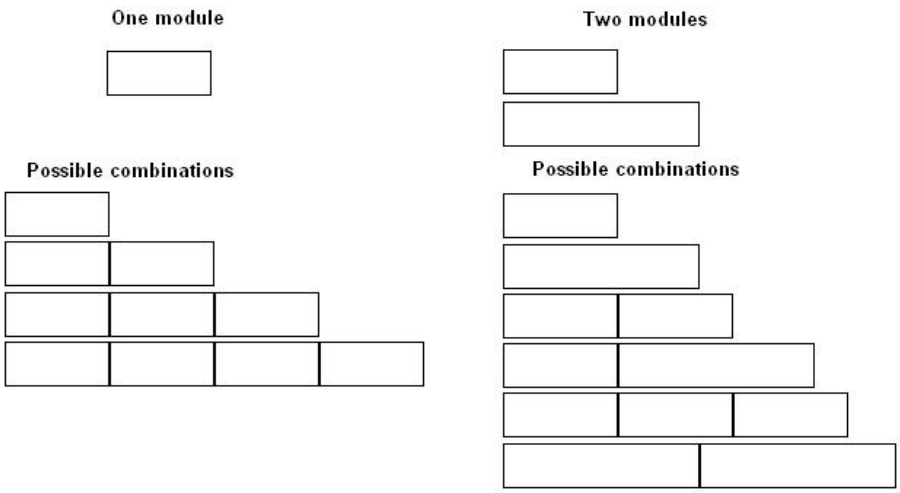


Figure 10.1: Two modular concepts, to the left is a concept where the lengths are multiples of each others. To the right is a concept with two different modules, just like EMS.

10.1.2 How many vehicles can be replaced?

"There are approximately 2 million trucks with a GVW over 16 tonnes in use in Europe at the moment. According to the statistics, roughly 42-45% of these are used for longer distance transport of palletised goods. This indicates that approximately 700 000 – 900 000 trucks could be replaced by LHV's. In the optimal case, where 3 EU vehicles are replaced with 2 EMS vehicle combinations, this means ~230 000-300 000 less vehicles on the European roads. Although the actual number of possible replaceable trucks might be a bit lower than every third, it still means a considerable number." (*Lumsden*)

The effects on infrastructure, traffic safety and the environment are closely related to the number of vehicles in use. In the sections discussing those subjects it is often stated that positive effects will arise due to a reduced number of vehicles. Here, the authors of this report have tried to predict a possible development of the number of freight vehicles in use. The development is depending on two factors:

1. the share of regular EU dimension vehicle being replaced by LHV's
2. the increase in transported volume.

Note that the model's increase in transported volume both simulate a transfer of cargo between modes of transports as well as an increased future demand of transport capacity. The simulation has been done by studying a fixed amount of cargo, 1000 pallets were chosen. The type of cargo is actually irrelevant since the relation between the different types of freight vehicles is studied. Note that this model only discusses one-time fully loaded units. There is thus no time involved, however this approximation is affecting both vehicles identically. A regular EU dimension vehicle is able to carry 33-38 number of pallets depending on which combination is used. For this study 35 pallets were chosen. The LHV is able to carry 52 pallets. A calculation is made of how many EU vehicles and LHV's are needed to perform the desired transport respectively. It was found that roughly 29 EU dimension vehicle and 19 LHV's were required. The effect of the increased share of LHV's was studied, replacing a number of the EU-vehicles, thus lowering the total number of vehicles in use. Then,

simulations of the increased demand of transported pallets were performed, from 0,5% to 40%The results are displayed in *figure 10.2*.

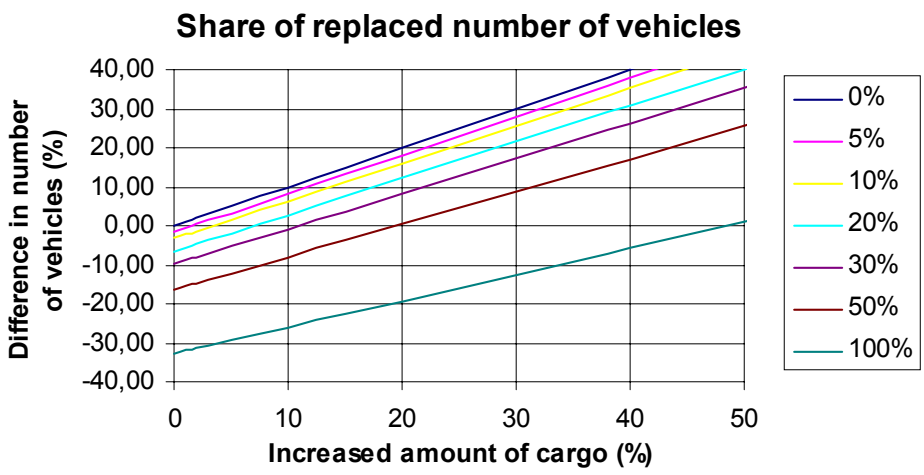


Figure 10.2: Simulation of increased cargo and share of replaced number of EU dimension vehicles.

The different curves in the plot are displaying different scenarios of the share of the replaced number of EU dimension vehicles. If no vehicles are replaced the total amount of vehicles will increase proportionally to the increased amount of cargo. If every vehicle is replaced the total number of vehicles will increase when the demanded amount of cargo is increased by roughly 48%, corresponding to the increased load capacity of the LHV's.

Even if the model is quite simple, it is representative for all types of road transports and cargo. Instead of pallets, similar calculations can be made for volume or weight units.

For example, when examining an entire nation, the share of replaceable vehicles is probably quite low, for instance 5%. This due to a large number of vehicles only performing short distance distribution is included. Thus the total number of vehicles will increase for an increased transport demand of approximately 2%. However keep in mind that the total number of vehicles will decrease if there is no increase in demanded transports. On the other hand, if only examining long distance transports of pallet goods, the share of replaceable vehicles is much higher, for instance 50%. Then, the total number of vehicles within this type of transport will decrease until the total amount of cargo is increased by 20%.

If we for a moment return to Lumsden's estimation in the quote above of roughly 40% replaceable vehicles, the result is a 13% decrease in number of total vehicles. Also, a 20% increase in demanded transport is attained before the total number of vehicles is increased.

In the EU White paper a 38% increased demand of transport is predicted by 2010, in this example thus corresponding to 1380 pallets. Using this method, the authors found that if 85% of all EU dimension vehicles were to be replaced by LHV's the total number of vehicles in use year 2010 would be the same as today. The figure of a 38% increase has later been revised to a 55% expected increase until 2020. It is easily seen that if all vehicles are replaced by LHV's, the total number of vehicles will increase compared to the number in use today.

10.1.3 EMS in the future

Characteristics of LHV's is not yet legislated by directive 96/53. If LHV's according to EMS should be allowed in EU, if only on a limited road net, the directive has to be updated. While height and width already are legislated, legislation for manoeuvrability, GCW, maximum length and total load length needs to be set for LHV combinations.

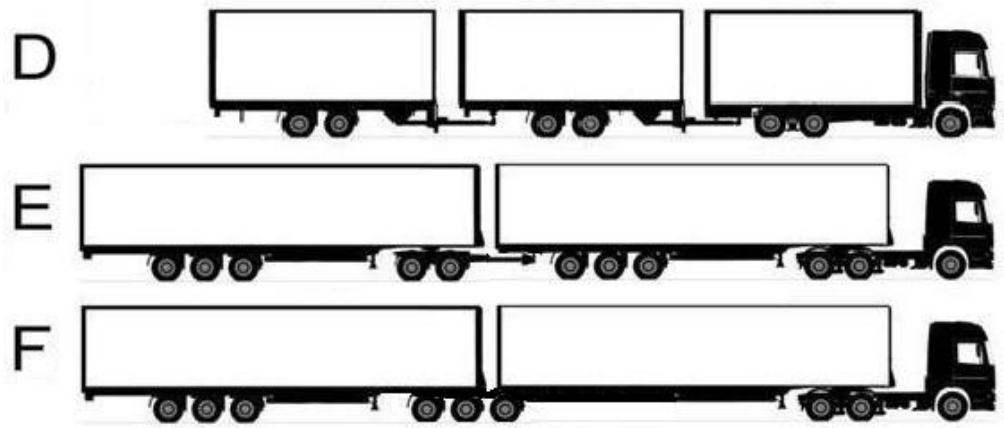


Figure 10.3 Possible EMS vehicle combinations.

The combinations in *figure 10.3* above would produce new possibilities for hauliers to further develop their operations. Hauliers interviewed appreciated combination E while feeling combination D would be instable, especially in slippery conditions. The stability test performed by Volvo presented in *chapter 5.1.4* shows that the combination actually performs quite well, better than the commonly used European road train consisting of a truck and a full trailer.

The combinations seen in figure 10.3 above are disallowed in the nations using LHV's due to length restrictions while satisfying the "modular concept" stated in the directive. Combination D is allowed and included in the Dutch tests with shorter loading units keeping the combination overall length within 25,25 m. Similar to the idea of allowing LHV's on a limited road net in the rest of Europe, Sweden and Finland could possibly allow these combinations on a very limited road net. There are on-going trials in the port of Gothenburg with B-train combinations for 2 x 45 foot containers, similar to combination F above.

10.2 Discussion regarding experiences of using EMS

There have been some issues when comparing EMS-vehicle combinations to the "alternative" in this study. It is difficult for a Swedish haulier to have a valid opinion of the difference between regular EU vehicle combinations of maximum 18,75 m and EMS vehicle combinations of 25,25 m. Likewise, it is also sometimes difficult to compare EMS with regular 24-m vehicle combination, due to the tiny differences.

One thing that is striking is the ability of participating hauliers to select and use combinations to their fullest potential, fitting the company's operations. Swedish hauliers also seem to be working efficiently. This point is supported by the fact that the numbers of vehicles in use remain fairly constant while the amount of transported cargo is steadily increasing. Another thing the authors find striking is the consensus found in the answers.

Statistics in this study indicates that general cargo is volume sensitive. Therefore hauliers transporting general cargo prefer EMS vehicles. This is true to some extent, while there are exceptions. Some of hauliers interviewed in this study state that the characteristics of the cargo vary over time. Most Swedish hauliers have solved this by using both EMS vehicles and a regular 24 m road train.

One area this study has not been able to cover is to what extent foreign hauliers are using the possibility of running LHV's in Sweden. One of the main conditions in directive 96/53 was to ensure foreign hauliers competition on similar conditions when operating in Sweden and Finland. There are some foreign hauliers using this possibility at the moment. As far as the authors of this report are concerned this is most common for hauliers with some kind of facility in Sweden. The occurrences when hauliers re-arrange vehicles at the Swedish border to form LHV's seem to be very unusual.

Swedish hauliers performing international transports in comparison, often use the possibility of running LHV's in Sweden and re-arrange the vehicles at a facility in the south of Sweden before continuing to Europe.

10.3 Discussion regarding the Dutch trials – LZV-proef

The trials carried out in the Netherlands indicate that it is possible to launch a large-scale trial with LHV's without any adjustments to the infrastructure. The trial also resulted in a number of positive effects listed earlier.

10.3.1 Discussion regarding preparations and preconditions:

Rigid restrictions are necessary in order to maintain traffic safety and to avoid accidents during the trial. If a serious accident, involving a LZV, would occur, the possibility of a permanent allowance of these vehicles would suffer greatly.

The idea of operating with LZV's only on a limited road-net is not as restrictive as it sounds. Since LZV's may use the entire freeway system and regular roads up to 20 km in the vicinity, in theory, nearly the entire Netherlands is covered. See *figure 4.1* where the freeway system is marked red and the selected routes of one haulier is marked green. Also, LZV's are most effective for longer distance transports, from and to terminals and hubs. These logistic centres are often already located nearby freeways. Distribution within city centres is preferably performed by smaller vehicles. One of the benefits using EMS is the possibility to use the independent units separately for this purpose, using the same truck as a distribution vehicle. The same can be said of the tractor and semi-trailer. With its' centre-axle trailer decoupled, it can be used as a distribution vehicle as well.

It is also wise limiting the number of regular routes for each company, even though 10 may be considered a bit meagre. If LZV's were to be allowed in a 20 km vicinity from freeways without fixed routes, it could have led to a number of smaller incidents; like vehicles blocking roads, as the roads were too narrow. The restriction regarding roads had to have separated bicycle-lanes is only for public relations. Already, these roads are operated by regular freight vehicles, and drivers claim there are unnoticeable differences between these regular

combinations and LZV's. Once again, IF an accident would occur where the LZV driver failed to observe the blind spot, massive opinion could have rose towards LZV's.

The restriction regarding railroad crossings is the one that hauliers have least understanding for. Already, "exceptional transports" may use these crossings. Instead, participating hauliers had to drive detours, avoiding railroad crossings, and also, occasionally, it became impossible reaching some destinations due to this restriction.

As stated, a maximum of 100 participants and 300 vehicles could take part in the trials. According to *Eurostat*, there were approximately 13 000 trucks with weight capacity exceeding 15 tonnes in traffic in the Netherlands during 2004. Further, there were roughly 64 000 tractors in traffic the same year. One might consider 300 LZV's not forming a significant share of the total amount of road freight vehicles; only ~0,5%. However, the trial spanned for more than two years, hence giving a massive amount of statistic material. At the same time, it was of great interest being able to monitor all the vehicles.

The driver is the most important factor affecting traffic safety. It is a common opinion that more experienced drivers tends to commit fewer mistakes in the traffic than less experienced. Education for drivers is always positive, and it would probably be wise to demand a certain certificate for drivers driving LZV's if, and when, they are allowed permanently. This action would ensure a high standard among drivers in general. Companies involved in the trial would also probably choose their best drivers for driving LZV's.

The outer turning radius of the swept path legislation is more generous than in Sweden, while the inner radius is stricter. One might notice that these restrictions deviates from those laid in the EU directive 96/53; outer radius 12,5 m, inner radius 5,3 m. Each member nation is however eligible to set their own, less strict, legislation, as long as vehicles according to the directive are allowed. Dutch authorities used the same legislation for LZV's as already used for "exceptional transports" instead of looking at Swedish or Finnish legislation. As mentioned earlier, the authors of this report insist that the legislation should be kept intact as far as possible.

Demands for ABS and stability tests should not even be considered a restriction, rather to be mandatory for all freight vehicles. The same could be said for the rest of listed devices, which also should be mandatory for all vehicles, not only LZV's.

In general, the authors consider the trials being well prepared and performed. They could definitely serve as examples for other nations wishing to conduct similar trials. The results also indicate that the use of LHV's on a limited road net has a number of positive effects.

10.3.2 Discussion regarding the outcome of the trial

There occurred only one accident during the Dutch trial. Compared to the total amount of accidents in the Netherlands, of roughly 33 000 annually, this is a considerable low figure. The authors of believe this a result of the well-designed preconditions. The dedication of the hauliers is a key contribution and the extra training of the drivers probably had its share as well. The positive outcome of the second phase of the trials and the additional year of testing is a testimony of the Dutch authorities' confidence in the use of EMS.

Two other things in the results of the trials are worth a special mentioning:

1. Since the trials were time-limited, hauliers were hesitating to adjust their operations. Rather, they used their LZV's in the daily operations, thus limiting the combinations efficiency. It is not out of place to believe that if LZV's are allowed permanently, hauliers will alter their operations in order to make greater use of the LHV's added capacity. The positive effects may thus be even greater than the results indicated.
2. The trials were carried out without adjustments in the infrastructure, furthering supporting the view that LHV's can be allowed on an existing, limited road net.

10.4 Discussion and conclusions regarding LHV's effects on traffic safety

Although EMS vehicle combinations of 25,25 m and 60 tonnes have been in use on Swedish roads for nearly a decade, there are no statistics available regarding traffic safety for these vehicles. One reason is that the Swedish Road Administration, Vägverket, is using a rather coarse categorization, where it is not possible to separate 25,25 m vehicles from regular trucks. Sometimes, the terms "heavy truck" and "heavy truck with trailer" are used. "Heavy" indicates that the truck weighs over 3,5 tonnes, thus excluding small distribution trucks. EMS vehicle combinations belong to the latter category, but still cannot be separated from regular heavy trucks with trailer, which, in Sweden, may be up to 24 m long with a total weight of 60 tonnes.

The majority of the traffic safety experts consulted during this study claims that a reduced number of vehicles reduce the number of accidents. Kallberg is connecting an "accident rate" to the annual mileage (*Kallberg, 1995*). As the annual mileage is reduced (by 2-3,5%), so is the accident rate proportionally. Likewise, the findings from the Dutch trials are drawn from an estimated number of accidents per vehicle-km (*Arcadis, 2006*). Comparing the actual numbers is difficult and rather pointless since the conditions differ in the Netherlands and Finland. Both reports however state that the use of LHV's will probably led to a higher level of traffic safety.

However, a reduced number of freight vehicles may have other consequences among fellow motorists, e.g. fewer vehicles resulting in less aware drivers, higher average-speed, etc which may result in an increased number of accidents. This is, however, an area way too complex and difficult to deliver a satisfying answer within this study.

LHV's are claimed to be one way to reduce the number of vehicles, thus reducing the number of accidents. This is true for a constant amount of cargo. Further, LHV's have characteristics that may increase the accident rate for the individual vehicle. The authors reckon that the reduced number of vehicles will probably not lead to a noticeable difference in the number of accidents. The trial in the Netherlands indicated that a reduction of 2000 vehicle would lead to a reduction of 4 casualties, the Finnish report discussed in *chapter 5.4, (Kallberg, 1995)* included similar results. Based on the results in the Dutch study, a reduction of 500 vehicles is corresponding to one less casualty. In comparison, each year roughly 33000 people are killed in traffic accidents in EU15.

It is also very hard to properly estimate the effects of vehicle dimensions. Statistics covering situations where a freight vehicle may have an affect on the cause of an accident without

actually being actively involved in the accident are missing. There might be accidents where a car is colliding or running of the road trying to avoid a freight vehicle.

There are a number of more important areas requiring work in reducing the number of accidents, such as separated lanes, decreased number of drunk drivers, lowering speeds etc. This is, however a discussion outside the scope of this study.

Sweden and Finland, the only nations in Europe allowing LHV's at the moment, are constantly ranked among the nations with the highest level of traffic safety in the world. This cannot, of course, be entirely attributed to the use of LHV's, but nonetheless proves that LHV's can be used while still maintaining a high level of traffic safety.

10.4.1 Stability

Stability is important for traffic safety for multiple reasons. Rapid manoeuvres, lane-changes and driving on icy and slippery roads are examples of situations where a high level of stability is crucial. There are a number of factors affecting a vehicles' stability: e.g. vehicle dimensions and design, distance between axles, load distribution and distance between king-pin and the last axle. A vehicle with higher value of driving stability increases the driver's comfort in terms of safety.

For articulated vehicles, stability is of even greater importance, as the effects of low stability sooner becomes dramatically. "Jackknifing" is a common term, describing the occurrence of the trailer and towing vehicle folding like a pocket knife, often with serious injuries as result. As Volvo's tests shows, LHV's according to EMS, are comparable to regular EU vehicle combinations.

While a high level of stability is crucial for safety reason it is also generally affecting the vehicle's manoeuvrability characteristics. In order to design a vehicle with high stability, the manufacturers tend to spread the axles over a longer distance, thus making the manoeuvrability worse, and vice versa. Stability must however be seen as more important since the outcome of stability-related accidents are worse.

10.4.2 Collision

As presented earlier, the majority of fatal accidents involving trucks are head-on collisions. According to *figure 5.1*, these situations correspond to approximately 30% of all fatal accidents involving a truck in Europe. The investigation made in Tung-OLA shows that the cause of the accident often is a car that for some "unknown reason" enters the on-coming lane, resulting in a head-on collision.

Statistics satisfyingly describing what effect the dimensions and weight has on the outcome of the collision are presently not available. However, one might assume that in the most cases, it is unessential whether the personal car collides with a truck of 40 or 60 tonnes. As described in *chapter 3.4.1*, cargo in LHV's is usually volume sensitive resulting in LHV's weighing less than the maximum legislated 60 tonnes. The greater demand for increased volume rather than increased GCW mean that weight restriction for LHV's in Europe not necessarily has to be 60 tonnes.

New technologies, like FUPD (front underrun protective devices), improved crumple zones, etc. is a way to improve traffic safety. However, one negative aspect of the current legislation used in Sweden and Finland is the limit of the total length. A focus on maximum vehicle length leaves less space for development of frontal crumple zones and other safety devices. With current legislation either the load length or the cabin space has to be decreased in order to create space for FUPD or crumple zones. History has however shown that hauliers and manufacturers are reluctant to cut back on load length.

10.4.3 Overtaking

One of the first things that come to people's mind when discussing longer vehicles is overtaking situations. Motorists are claimed to feel unsafe and exposed when overtaking long vehicle combinations. However, the VTI-study, (*Hammarström, 1976)* indicates that there are no significant differences in accident risk between overtaking 18 and 24 m long vehicle combination. This shows that drivers actually have a rather good understanding of the distance required in order to perform a safe overtaking. The difference between 24 m and 25,25 m is negligible in this matter.

Also, as LHV's preferably operates on at larger roads, complicated overtaking situations are rather unusual. If LHV's are allowed only on a limited road net, mostly consisting of multi-lane roads, the number of overtaking situations will be considerable low.

One issue mainly regarding Sweden is the different speed limits for personal cars and freight traffic. There are a number of two-lane roads where cars are allowed to drive 90 km/h while LHV's are allowed to drive only 80 km/h. This implies a number of overtaking situations and the effects might be object for further studies.

10.4.4 Braking

Heavier vehicles need longer braking distance. However, if the number of braking axles is increased, the braking distance is reduced due to less weight on each axle. As stated in *chapter 8.4*, LHV's according to EMS will in most cases lead to a lower axle load. And once again, there is a greater need for increased volume rather than increased GCW.

The experiences from Swedish hauliers stating problems with the maintenance of the braking systems must be taken seriously. The EBS is designed for two vehicles while EMS combinations consist of three vehicles needing brakes. Today this is solved by using pneumatic brakes on one vehicle. Of course this is an area that needs to be handled properly. Manufacturers claim that the problems will be solved within a year. If the Netherlands decides to allow LHV's the market and number of costumers will increase, thus probably speeding up the process.

10.5 Discussion regarding EMS and intermodality

The opinion about intermodal transports is quite negative among the Swedish hauliers. Remarkably though, is that the hauliers actually performing intermodal transport are quite pleased with the results. In Sweden, studies performed by the Royal Institute of Technology, states that rail freight are competitive only in distances over 550 km (*Nelldahl, 2001*). Collected experiences from interviews with Swedish hauliers indicate that road transports are dominant on distances up to 300 km. All together, one might consider these figures as indications of road transports being dominant towards rail freight. The authors, on the other hand, wishes to illustrate a great potential for intermodal transports.

With the EU White Paper "European transport policy for 2010: Time to decide" taken into account, one understand that there is need for improved, more efficient transport solution in order to meet the increasing demands. Each mode of transport is better suited for different cargo and distances. In order to meet the increasing demand of transport the key is to let each mode improve, while at the same time develop solutions facilitating intermodal transports.

The authors of this report wish to stress the need of co-operation rather than competition. All modes are needed and the increase in demand will result in enough cargo for all modes.

One solution that may be used if wanting to prevent cargo being transferred from rail to road when allowing LHV's is to maintain the spirit of today's legislation where the maximum allowed weight is 40 tonnes and 44 tonnes for intermodal transport. Railroad transport is better suited for heavy cargo and longer distances. History in Sweden has shown that increasing the GCW has lead to a cargo being transferred from railroad to road.

One way to approach this delicate issue could be by allowing 50 tonnes for LHV's and 60 tonnes GCW for LHV's performing intermodal transport. This way the volume capacity is increased by roughly 50% compared to a regular EU dimension vehicles. The weight capacity on the other hand is increased by roughly 25%. Since most hauliers state that they primarily transport volume sensitive cargo this could perhaps be a reasonable solution. On the other hand, if the GCW is set too low, the number of replaced vehicles might be too low. This is obviously a subject that requires further studies in order to optimize the efficiency of LHV's.

	EU dimension	LHV's	Result:
Pallets	35	52	+48%
GCW	40	50	+25%
Weight capacity	22	28	+27%

Table 10.4: A possible legislation of the GCW.

Negative impact on other modes of transport is one of the main arguments against increased vehicle dimensions in Europe. Some sources mentions modal shifts in size of 30% cargo transferred from rail to road. Sweden and Finland are currently the only nations within EU to allow LHV's while both nations also have a large, and increasing, share of railroad. Also the results from the Dutch trials indicate only a limited modal shift.

10.6 Discussion regarding economic consequences

In the Dutch trial the total sum of all transport costs were estimated to decrease by 1,8-3,4% annually, depending on the preconditions. Due to the trial being time limited few participants has implemented drastic changes to their operations. The total economic transport cost would presumably decrease further if LHV's were allowed all together.

One might assume that if the price of the product is reduced, the demand of the same product will increase. With this in mind, is it likely that the total amount of transports will increase due to the price of the transports being reduced? The answer is probably no, since there is already a shortage of transport capacity.

One might advocate that the costs associated with an introduction of LHV's are accounted the society while the benefits mostly are connected to the hauliers. Lowered transport costs however benefit the entire society since it will lead to reduced prices for the end-costumers.

The Dutch and Danish figures regarding economic savings associated with the improved environmental effects differs greatly. This is mainly due to two different reasons: The numbers of vehicles and valuation of the cost of emissions. The estimation for the Netherlands span roughly 6000 LHV's while the Danish study only comprises 266 LHV's. Further, the Netherlands associate the environmental effect from road traffic to a higher cost then Denmark does. The figures thus differ greatly. However, what is important is that both nations estimate that using LHV's has a positive effect on the environment leading to positive economic effects.

10.7 Discussions regarding effects on the infrastructure

There are two types of infrastructural consequences. First, there are limitations set by current infrastructure, i.e. it might not always be possible to operate with LHV's. Then, there are the effects of using LHV's, i.e. reduced congestion, less road wear etc.

Based on experiences from the Dutch trials, the authors of this reports believes it is possible to allow LHV's on a limited road net and still achieve numerous positive effects. Also, the fact that no infrastructural adjustments were made during the trials is another indicator that it is possible. Swedish hauliers performing international transports participating in this study further supported this view. These hauliers are already performing a large amount of international transports and thus have a good understanding of the infrastructure in Europe.

Deciding what routes that should be allowed do not have to be a major issue. Most nations within EU already allow "exceptional transports", combinations longer and heavier than normally used. There is thus already a good knowledge of the infrastructural standard. The same authorities allowing the "exceptional transports" will probably deal with the issue of allowing routes for LHV's. One possible way of doing this is to, in the beginning, allow LHV's on the same routes as the "exceptional transports".

Based on the assumption that the number of vehicles will be reduced, it is obvious that congestion will be reduced as well.

Road wear is primarily dependant on load per axle, not load per vehicle. Depending on which GCW is set for LHV's, the axle load may decrease. However, hauliers strive to keep maintenances costs as low as possible. In this case, meaning using minimum number of axles, while not exceeding current legislation regarding axle load. Hence the issue of reducing road wear is preferably solved by limiting axle load, rather than limiting GCW. The axle load is however quite difficult for hauliers and authorities to control, hence the legislation focuses on the total GCW. The legislated sum of the axle loads shall exceed the legislated total GCW.

There is also an ongoing debate regarding the AASHTO-formula (*formula 1*), which is derived from test carried out some 50 years ago with then current road standard.

Swept path is another area of debate, mostly regarding which factor (swept path, outer turning radius or inner turning radius) is the most important. There are available technologies to make sure the EU legislation is fulfilled for LHV's. This will however affect the standardization of EMS, since special vehicles has to be used. Also, a high degree of manoeuvrability worsens the vehicle's stability characteristics.

10.8 Discussions regarding effects on the environment

The environmental effects of increased vehicle dimension are closely connected to the reduced total fuel consumption. Above all, the assumption is based on fewer vehicles producing the same transport work. The numbers in the TFK-report (*Backman, 2002*) and the Arcadis-report (*Arcadis, 2006*), both stating a fuel saving of 15% indicating that this may be a reasonable number.

Reduced fuel consumption is one of the most obvious effects of increased vehicle dimensions for a certain volume of cargo, due to reduced number of trips. There are, however, other ways to achieve lower fuel consumption per cargo-unit, e.g. lower speeds, use of new and environmental friendlier engines and higher utilisation level.

10.9 Conclusions

Based on the finding in this study, the following generalized effects of using LHV's according to EMS, as shown in *table 10.5*, can be assumed:

Area	Most positive	Most negative	Result
Environment	Less fuel consumption per transported cargo unit.	May increase the market share of road transports	+
Economy, micro level	Reduced transports costs	Increased fuel consumption and maintenance per vehicle	+
Economy, macro level	More efficient transports, lower total costs	May need infrastructural adjustment	+
Congestion	Fewer vehicles transporting the same amount of goods	May increase the market share of road transports	+/-
Traffic safety	Fewer vehicles transporting the same amount of goods	Characteristics of the vehicles may increase the accident rate	+/-
Consequences on other transport modes	Facilitates intermodal transports	May increase the market share of road transports	+/-

Table 10.5: Generalized effects of LHV's according to EMS

Positive effects regarding economy and environment are easily understood and origin from reduced fuel consumption and more efficient transports.

Positive effects can also be achieved regarding congestion, due to fewer vehicles on the road, although the difference will probably not be significant.

Further, "fewer vehicles on the roads" are assumed to reduce the number of accidents, due to less travelled vehicle km. However, LHV's have some characteristics that may increase their accident rate compared to shorter combinations. Some of these negative characteristics are reduced by allowing LHV's only on a limited road net consisting of multi-lane roads. In total, the authors believe that traffic safety will not be affected greatly in any direction.

Finally, in the short perspective, more efficient road transports may lead to a slightly increased share of road freight. However, in a longer perspective, other modes of transport will also be more efficient, thus levelling situation.

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APPENDIX I

Description of the European Modular System

The EU Council directive 96/53 (1996) regulates the dimensions of vehicles used within the European Union. The directive states that all member states within EU are forced to allow the vehicles listed in the directive. The member states may however dictate their own maximum dimension and weight allowed, i.e. set a less strict legislation for transports within the nation, as long as a fair level of competition between nations are maintained. The aim of the directive is to facilitate international transports, i.e. a common legislation regarding vehicle dimensions for all European countries.

At the time of Sweden's and Finland's entry in EU, an interpretation of the directive led to the both nations could maintain the use of longer vehicle combinations. This according to a "modular concept", which is mentioned in the directive and also according to member states authorization to apply different values regarding dimension in national traffic. The result was larger vehicle combinations, consisting of load carriers according to directive 96/53. These combinations measured 25,25 m with a total weight of 60 tonnes, compared the legislated maximum length 18,75 m and maximum weight 40 tonnes in EU. The concept of standardized load carriers was to be called European Modular System, EMS.

Presently, only Sweden and Finland allow the longer combinations, and also, to some extent, vehicles that are slightly wider than laid out in the directive. A number of nations allow higher total weight than 40 tonnes and some nations allow vehicles having higher maximum height. The Netherlands have been active testing longer vehicle combinations, and there is also interest in Norway, Denmark and Great Britain to carry out similar trials.

Generally, there is a continuous growing demand for increased transport capacity in Europe. Roads transports are forecasted to increase with 38% from 1998 to 2006 (*EU White Paper, 2001*). A major use of EMS, i.e. increased vehicle dimensions, is said to be one, of many, actions to deal with this increase.

Origin of the EMS

The idea with a modular concept, similar to the EMS of today, within the road transport business aroused in the 1980s.

Due to differences in infrastructure; road net, bridges etc, there were very different points of views of vehicle dimension between the Scandinavian countries and Central European countries such as Germany and France. The "bridge formulas" in Scandinavia required a longer distance between the first and last axle, whereas bridges in other parts of Europe were constructed to handle shorter vehicles with mass concentrated over a shorter axle distance. Because of this, legislation differed greatly between European countries thus resulting in complications for international traffic. When performing international transport the vehicles met different requirements, regarding dimensions and weight, in different countries thus leading to inefficient transports.

In 1985, the first directive legislating vehicle dimensions for international transports within EU, was set. The EU Council directive 85/3 (1985), legislated a total length of 15,5 m for semi-trailer combinations and 18,0 m road-trains. These figures were similar to current legislation in most of the member states. Total weight was set to 38 tonnes for both combinations. As intended, this led to less complicated and more efficient international transports. Further, as the directive only regulated vehicle length, it also had an impact on the driver's comfort. Hauliers shortened the cabin space to a minimum, in order to extend the load capacity of the vehicle. The trucks were equipped with "top-sleepers", i.e. the sleeping cabin was moved from behind the driver's seat to the top of the cabin. This showed to be hazardous in case the truck would be set on fire and the sleeping driver had nowhere to escape.

Next step was an update of 85/3, namely directive 96/53 (1996). Here, more focus was placed on legislations of maximum load space. 13,6 m was set for semi-trailer units, and 15,65 m for road-trains (see *chapter 3.2*). From then on, the drivers' space was no longer a target for competitions between the truck manufacturers. The results of this legislation led to 13,6 m semi-trailers and load-spaces similar to C782 (2x7,82m=15,64m) swap-bodies being among the most frequent used load carriers within EU. Although different dimensions of swap-bodies, e.g. C715, C745, were still preferred by many hauliers.

At the time of Sweden's and Finland's entrance into EU, the discussion regarding vehicle dimensions once again arouse, as these both nations had a long history of using longer vehicle combinations. A report from TFK; (*Nordström, et al, 1994*), showed that Sweden would lose as much as 6,5 thousand millions SEK if being forced to adopt vehicle dimensions of EU standard. Also negative impacts on industry and society, especially in the sparsely populated areas in northern Sweden were feared. Another factor was that a higher number of heavy vehicles on the roads would lead to more emission, congestion and more traffic accidents.

The main idea of the EMS was to develop a system enabling Sweden and Finland the continued use of their longer vehicles while at the same time giving hauliers in the rest of Europe a chance to compete on similar conditions. This was achieved by allowing the use of the long and short load-carrier in the EU-directive 96/53 together, producing a vehicle combination, according to a modular concept. These became Module A and Module B. The difference compared to the rest of EU, where one long or two short load-carriers were used, was the combination of one long and one short load-carrier.

Hauliers from other countries were now given the possibility, when entering Sweden and Finland, to attach another load carrier to their unit, thus resulting in an EMS vehicle combination.

APPENDIX II

Technical description

The EU directive 96/53 contains the following regulation regarding vehicle weight and dimensions for freight traffic:

Length:	Motor vehicle	12,00 m
	Trailer	12,00 m
	Articulated vehicle	16,50 m
	Road train	18,75 m
Width	All vehicles (except conditioned vehicles)	2,55 m
	Superstructures of conditioned vehicles	2,60 m
Height	All vehicles	4,00 m
Weight	Two-axle motor vehicle	18 tonnes
	Three-axle motor vehicle	25/26 tonnes
	Four-axle motor vehicle	32 tonnes
	Two-axle trailer	18 tonnes
	Three-axle trailer	24 tonnes
	Road trains with 5 or 6 axles	40 tonnes
	Articulated vehicle with 5 or 6 axles	40 tonnes
	40” container in intermodal transports	44 tonnes

Table 1: Vehicle dimension listed in EU directive 96/53

Further, the following is written regarding load length:

- Maximum load length for road train: 15,65 m.
- Maximum distance between king pin and rear of semi-trailer: 12,00 m.
- Distance between king pin and any point at the front of the semi-trailer must not exceed 2,04 m.

Figure 2 below shows a schematic view of the restrictions. Basic geometry results in maximum load length for a semi-trailer according to the directive is ~13,6 m.

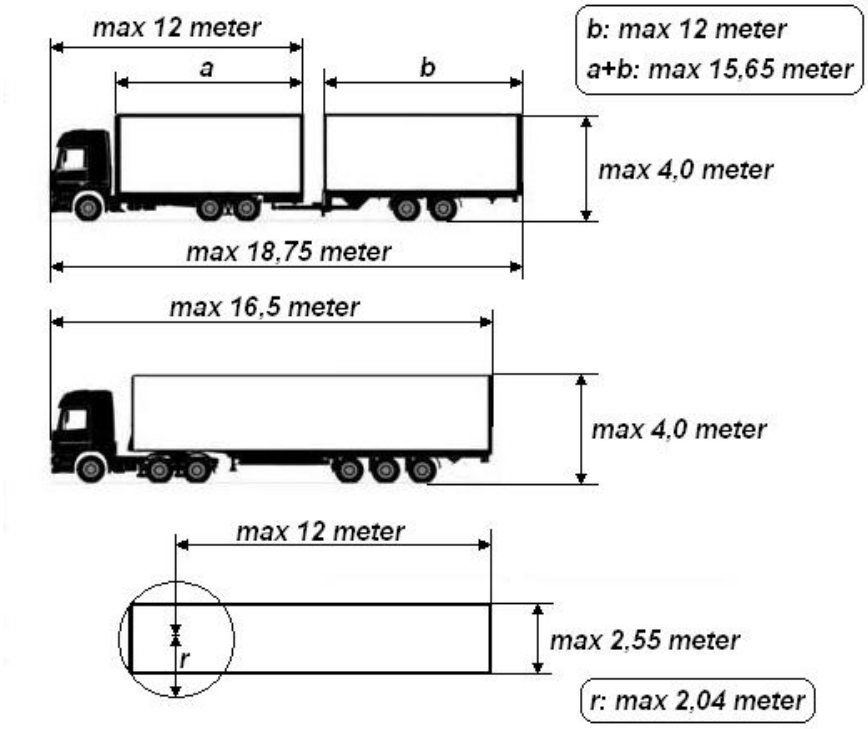

Figure 2: Schematic view of the restrictions in directive 96/53.

The basic idea of EMS is to combine load carriers according to a modular concept. The most common LHV's in Sweden and Finland are Module A and Module B, shown in *figure 3* below.

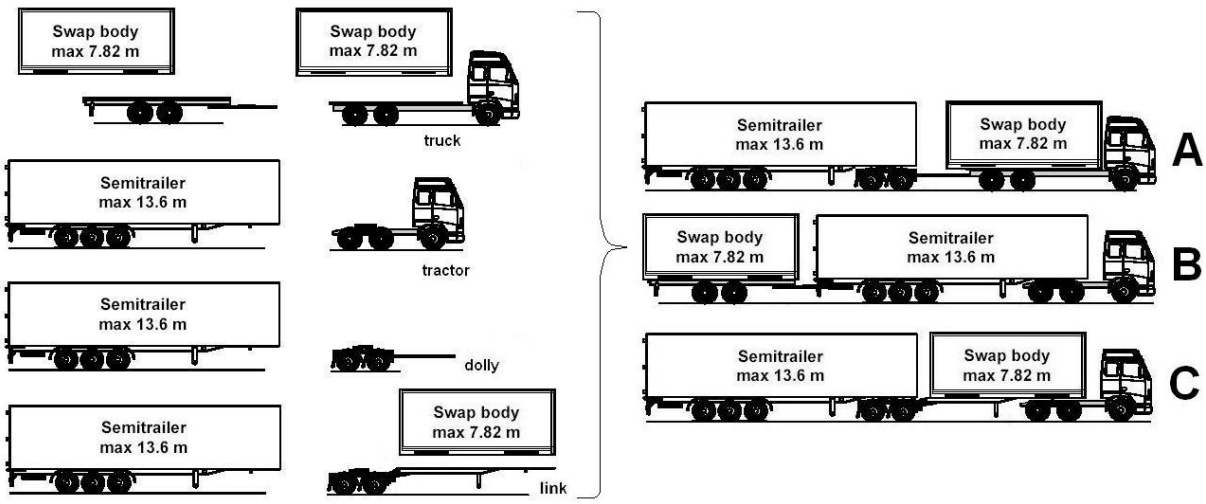

Figure 3: All vehicles and module A, B and C.

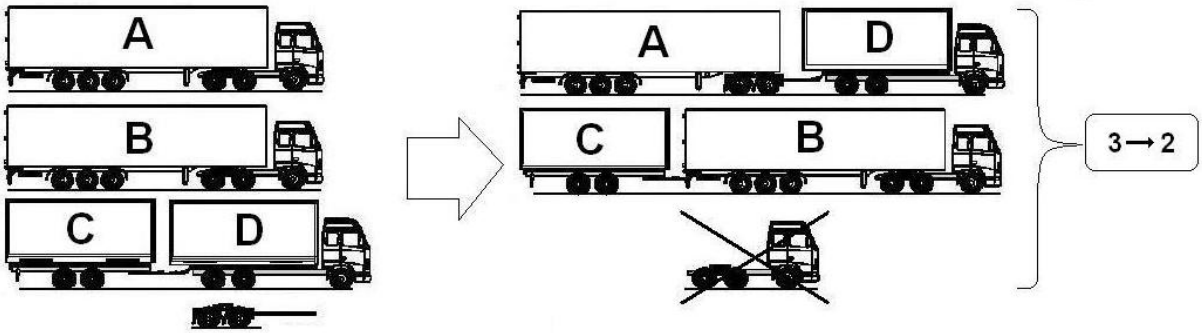

Figure 4: Three combinations become two.

By using LHV's, three regular EU-combinations can be replaced by two LHV's while still transporting the same amount of cargo, as shown in *figure 4* above.

Due to the need of clear legislations, parameters regarding maximum length and weight had to be set. 25,25 m was the smallest possible limit when combining the modules, due to cabin space, distance between units and the need for manoeuvrability. Hence 25,25 m became the length limit. GCW was set to 60 tonnes in Sweden and Finland. Also, as in the directive, a maximum load length was set to 21,86 m for LHV's.

APPENDIX III

Current situation in some European nations.

The legislation for long and heavy vehicles varies between the European nations. This is the result of different geographical and infrastructural conditions and some historical reasons. In *table 4* below, the EU standard legislation is showed, as well as national differences in bold.

Country	Length (m) [1]	Width (m)[2]	Height (m)	Weight (tonnes)
EU standard	16,5/18,75	2,55 (2,60)	4,00	40 / 44[3]
Sweden	**24 / 25,25[4]**	**2,60 / 2,55 (2,60)[4]**	**4,50[5]**	**60**
Finland	**22 / 25,25[4]**	**2,60 / 2,55 (2,60)[4]**	**4,20**	**60**
Denmark	16,5/18,75	2,55 (2,60)	4,00	**48**
The Netherlands	16,5/18,75	2,55 (2,60)	4,00	**50**
Italy	16,5/18,75	2,55 (2,60)	4,00	**44**
Luxembourg	16,5/18,75	2,55 (2,60)	4,00	**44**
Belgium	16,5/18,75	2,55 (2,60)	4,00	**44**
Czech Republic	16,5/18,75	2,55 (2,60)	4,00	**48**
France	16,5/18,75	2,55 (2,60)	**No limit**	40 / 44[3]
Ireland	**16,5/18,35**	2,55 (2,60)	**4,25**	40 / 44[3]
Great Britain	16,5/18,75	2,55 (2,60)	**No limit**	**44**
Norway[6]	**17/18,50**	2,55 (2,60)	**No limit**	**50**

Table 4: Legislation in some nations as of January 1, 2006.(Sveriges Åkeriföretag, 2006)

[1] Length of semi-trailer combination / Length of road-train.

[2] Numbers inside parentheses represents superstructures of conditioned vehicles

[3] ISO containers 44 tonnes

[4] EMS vehicle combinations

[5] No legislated height limit in Sweden, but obstacles less than 4,5 m high have to be marked with signs by the road "keepers"

[6] Legislation recently changed, se "*Norway*" below

Sweden

Sweden has a long history of long vehicle combinations, much due to the country's forests industry which heavily depends on the use of long vehicles in order to be successful. Since 1968, the maximum vehicle combination length has been limited to 24 m, prior to that there was no maximum length restriction, and some vehicle combinations measured over 30 m. One of the reasons why 24 m became the limit was a foreseeing of demand of efficient transports. Within 24 m it was possible to carry three TEU containers, either one long and on short module or three short modules.

Around 1973, discussions were held regarding limiting vehicle dimension even further, towards 18 m, which was the maximum vehicle length in most of Europe at the time. Investigations, mainly regarding traffic safety, however showed that longer vehicles, like those used in Sweden, did not have negative impacts on traffic safety. Hence 24 meter remained as maximum vehicle length.

The forest industry did not only need long vehicle, but also rather high GCW. Thanks to long vehicles were allowed, GCW was raised from 37 to 51,4 tonnes in 1974. The construction of old bridges demanded the mass of the vehicle to be spread over a longer distance. In the beginning of the 1990s, most of the pre-war bridges had been reinforced or rebuilt. GCW was raised to 56 tonnes in 1990 and three years later, in 1993, it was set to 60 tonnes.

In the 1990s, negotiations were held between Sweden and EU due to Sweden's entry in the union. In the negotiations, EU insisted that Sweden should adopt the same rules as the rest of the union. Sweden however claimed that the nation would lose as much as up to 6,5 billion SEK (*Nordström, et al, 1994*) due to the reductions in vehicle dimensions. Therefore Sweden was allowed to continue its use of longer vehicles as long as foreign hauliers were given the possibility to compete on similar conditions. This was basically the birth of the EMS.

"The EC only permits trucks a net weight of 40 tons and 18.35 meters length, while Sweden allows a net weight of 60 tons and 24 meters in length. Today the annual felling of timber (70 million cubic meters forest) requires 1,888 trucks. EC regulations would require an additional 1,112 tractors for the same volume. A favorable situation for the trucking industry perhaps. But more expensive for the forest industry. And the environment. The emissions of carbon dioxide would increase by 50 percent."
(*Gahrton, 1994*)

Since 1997, 25,25 m long and 60 tonnes heavy vehicle combinations are allowed in Sweden according to EMS. For national transports, Swedish hauliers are still able to operate with "regular" vehicle combinations, of same dimensions as before entering EU; maximum length 24 m for articulated vehicles. These combinations still forms the larger share of the produced transport work over longer distances within Sweden.

Finland

Since 1997, 25,25 m vehicle combinations of 60 tonnes are allowed in Finland Like Sweden, Finland has a major forest industry, and similarly a long history of allowing long road trains. Before entering EU, maximum allowed length was 22 m for articulated vehicles, and the maximum total weight was 60 tonnes. This combination is still used in national traffic.

One difference from Swedish legislation is that Finnish hauliers may use 13,6 m long full trailers for this purpose. These trailers are not allowed for international traffic as they exceed the dimensions in directive 96/53.

The Netherlands

The Netherlands has a long history of trade and transports. One of the world's largest ports, Rotterdam, is located in the country and distributes a large share of all cargo destined from and to Europe. For several years, Dutch authorities have allowed vehicle combinations with a total weight of 50 tonnes, less restrictive than EU in general. This is due to a large share of container traffic, which sometimes demands higher GCW. There has also been an on-going debate regarding adopting rules similar to the ones used in Sweden and Finland; 25,25 m and 60 tonnes.

The Netherlands have carried out extensive trials regarding the use of LHV's. The trials began in January 2000 and were rather limited. Four hauliers took part and the trial took place within the Rotterdam Port area. Since the trials proved to be successful the Dutch parliament agreed to expand the trial to a maximum of 300 LHV's with a maximum GCW of 60 tonnes in December of 2003. 77 hauliers took part in the trial and they were given access to the entire Dutch expressway system of 2250 km. Additionally these vehicles were permitted to drive on roads that are within 20 km from the expressways except for small towns and city centres. This trial ran from February 1, 2004 until November 1, 2006. In November of 2006 the trial was prolonged for an extra year, thus continuing to November of 2007. This extended period of the trial is intended to fine-tune the final legislation if allowing increased vehicle dimension. The trial in the Netherlands is discussed further in *chapter 4*.

Denmark

Due to Denmark's geographic position between Sweden and the mainland Europe the country is of great interest to Swedish hauliers. Since July 1, 2006, EMS vehicle combinations are allowed on the entire Øresund bridge. Denmark is interested in allowing EMS vehicle combinations and the country will carry out trials with LHV's, beginning in 2008. The exact details were not available at the time of the completion of this study, but LHV's will primarily have access to the free-way system as well as roads to some major harbours.

Germany

Germany applies vehicle dimensions according to directive 96/53; 18,75 m and 40 tonnes. However, one exception is made at the corridor between Hamburg and Lübeck, where local authorities allow limited use of longer vehicles for container transports. Freight vehicles are allowed to carry 3 TEU, compared to regular EU vehicles, which only may carry 2 TEU. Companies in the transport sector are struggling to extend the corridor to Bremerhaven. Germany's location in the heart of Europe makes it an important market for all transporting companies. In Germany the term Euro-Combi is often used when discussing LHV's

There is a growing demand for increased transport capacity in Germany and the subject of introducing LHV's is frequently discussed. Three federal states; Nordrhein-Westfalen, Thüringen and Niedersachsen, are already conducting similar trials as the Dutch ones. The German Association of the Automotive Industry (VDA), the Federation of German Wholesale and Foreign Trade (BGA), the Federation of German Industries (BDI) are all positive towards increased vehicle dimensions according to EMS.

Other federal states, have tried to carry out trials with EMS-vehicles, but so far the federal government has rejected the idea of large-scale trials similar to the ones in the Netherlands. Also, the German federal association for logistics and the transport of merchandise by road (BGL), are negative.

Norway

Norway is not member of the European Union, but for practical reasons, they follow EU standards according to directive 96/53. This, since almost all international road transports are destined to EU. The maximum length is 18,50 m and maximum weight is 50 tonnes in Norway. Due to insufficient road standard, Norway is increasing the overall vehicle length during a transition period. On hilly and curvy roads, and also when boarding road ferries, there is a need for wider space between the motor vehicle and the load carrier in order to avoid damage. Therefore, 19,5 m is to be the new restriction for road trains, and 17,15 m for semi-trailer combinations. However, the actual load length remains, as according to the directive.

Norway has so far taken a hesitating stance towards vehicles according to Swedish legislation due to the nation's insufficient road standard. However, there are plans for a trial with EMS vehicle combinations on some larger roads.