XXL ON THE MOVE: RESULTS FROM DUTCH EMS TRIAL.

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ABSTRACT

In the period starting the middle of 2004 until November 2006, the Ministry of Transport, Public Works and Watermanagement has carried out an experiment with so called Longer and Heavier Vehicle Combinations (LHV's or EcoCombi's) on Dutch roads. This study offers the opportunity to experiment, under strict conditions, with combinations with a maximum gross mass of 60 ton (allowed by Dutch law: 50 ton) and a maximum length of 25,25 meters (allowed by Dutch law: 18,75 meters). Because the combinations are composed of regular components they are referred to as European Modular System (EMS).

Objectives were to gain insight in the (generalised national) effects on:
- Traffic safety (both objective and subjective),
- Modal shift,
- Use of infrastructure,
- Competitiveness of road transport sector,
- and savings on fuel, mileage, and emissions.

A dataset of 66 companies driving with 100 EMS were used to analyse these effects. Based on these results the Minister of Transport has decided in September 2006 on a more permanent allowance of EMS on Dutch roads.
With regards to effects on Road Maintenance (Pavements, Use of Infrastructure, and Bridges) as well as effects on Traffic Management, more in-depth studies are now conducted. Results will be available at the end of this year.
The results and experiences of the 2-year experiment, together with the results of the in-depth studies, are the subject of this paper.

Figure 1: Example of EMS vehicle

1. INTRODUCTION.

In the period starting the middle of 2004 until November 2006, the Ministry of Transport, Public Works and Watermanagement has carried out a follow-up experiment with so called Longer and Heavier Vehicle Combinations (LHV's or EMS) on urban and rural roads. The experiment includes EMS vehicles that are longer and heavier than presently allowed in the Netherlands (without a allowance). It was only allowed to use the EMS in The Netherlands. The follow-up study offers the opportunity to experiment, under strict conditions, with combinations with a maximum gross mass of 60 ton (allowed by Dutch law: 50 ton) and a maximum length of 25,25 meters (allowed by Dutch law: 18,75 meters). The follow-up study is a continuation of a previous experiment. The results of the first experiment were successful, but due to the small amount of participants (4) it wasn't possible to make generalisations to the national level about for example the accident risk, or the macro-economic consequences of allowing EMS in the Netherlands. This was the background for a follow-up experiment with a maximum of 100 companies or 300 EMS vehicles that were allowed to participate on the basis of an allowance. To gain insight in the (generalised national) effects before the end of the experiment, the dataset as build up in November 2005 was analysed. This dataset refers to 66 companies and 100 EMS vehicles. The pilot period expired on November 1st 2006.

2. STUDY QUESTIONS

In the EMS study the following questions were being examined:

1. Will the large scale use of EMS influence the traffic safety (both subjectively and objectively)?
2. What are the consequences for the transport market of inter-modal transport in conducting the experiment's conditions?
3. What market size and –segment can be expected by releasing the present limitations regarding the number of participants and vehicles?
4. What will be the effects of the large scale use of EMS on a macro level on environment (emission, noise), traffic (congestion, effective use of capacity, number of rides), costs (for labour, per ride and per freight unit) and competitive position?
5. What consequences does EMS have in daily life for logistic (planning) processes?

3. NUMBER OF ENTRANTS

Transport companies that wanted to participate in the trial with one or more combinations had to comply with the following conditions:

- Submit correct application;
- Allowance for driving requested routes;
- Education and certification of truck driver(s);
- Testing of vehicle(s).

A maximum of 10 routes were allowed per participant. No dangerous goods, fluids, or 45' foot containers were allowed. City Centers, urban areas and 30 km-zones were excluded in the routes.

The pilot provided a divers number of entrants with the following characteristics:

- The ratio between 'Longer/Longer-Heavier' is 1:3 (51/89), in tonnes kilometers the ratio is even greater for 'LongerHeavier', namely 77 percent;

- Routes are through the whole country with emphasis on connections with Rotterdam harbor, flower-auctions, and between distribution centers (foods and waste);
- Popularity of the D-configuration: rigid-dolly-semi-trailer (fig.1).
- Especially suited for transport packed goods and (sea)containers up to maximum of 3 TEU.

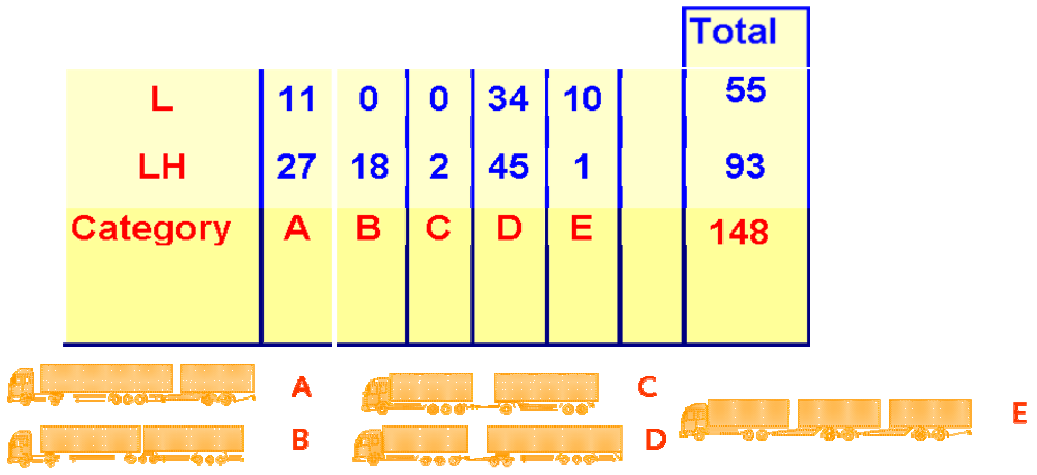


Figure 2 Distribution among configurations (76 companies)

4. PENETRATION RATES OF EMS VEHICLES

To predict the effects of general access of EMS vehicles on Dutch roads the penetration rate was calculated for four scenarios (see table 1) based on vehicle fleet statistics. For what market segments are EMS combinations interesting? On average, an EMS can transport 20 percent more weight and 52 percent more volume. This makes the concept interesting for high volume goods for example flowers.

	trial	scenario 1	scenario 2	scenario 3	scenario 4
Maximum length	25,25 m	25,25 m	25,25 m	25,25 m	25,25 m
Driving without exemption in urban areas allowed	no	no	no	no	no
International transport	no	no	no	no	no
max. GVW	60 tonne	60 tonne	50 tonne	60 tonne	70 tonne
Dangerous goods	no	no	no	yes	yes
Tank transport	no	no	no	yes	yes
Railway crossings	no	no	yes	yes	yes
Driving in bad weather	no	no	yes	yes	yes
Unrestricted use of secondary road network	no, max. 20 km	no, max. 20 km	yes	yes	yes
Unrestricted filtering in and out on highways	no, max.10	no, max.10	yes	yes	yes

Table 1: Four scenarios

Not all transport is equally suited for EMS. The assumption is that only transport from 20 tonnes and more will be replaced by EMS vehicles. Based on this assumption, dependent on the scenario, 7-31 percent of the vehicle fleet will be replaced by EMS. This is equivalent with a reduction of 2000-5000 regular vehicle combinations.

5. TRAFFIC SAFETY

Traffic Safety has always been of major concern in the admittance of EMS vehicles on Dutch roads. This already starts with the conditions on vehicles, drivers and routes. EMS combinations are not to perform worse than any regular combination. An EMS vehicle is composed of regular components: the modular concept (European Modular System). These vehicles have to comply to statutory regulations for braking, stability and swept path.
Guarantees for safety were build in through requirements on ABS, splash&spray facilities, contour marking, closed side protection and front under run protection. Every driver had to have at least 5 years of driving experience with articulated combinations and successfully completed the exam. Special attention is given to the awareness to other road users and the mentality of the driver. This from the perspective that the quality of the driver is the most determining factor for traffic safety.

5.1 Casualty calculations (objective)

Calculations have been made on casualty savings based on the four scenarios, in increasing degrees of freedom.
Scenario 1 was the base scenario with all the restrictions in the trial. The basic assumption is that the amount of casualties is calculated from the formula: number of casualties = accident risk x traffic performance. Through the use of EMS vehicles, transport kilometres will be saved. After all, if you want to deliver 6 TEU and can take 3 TEU instead of 2 per trip, you can save one trip.
As can been seen from table 2 this leads to a reduction in casualties, if you consider the vehicle safety equal to common combinations, so called “ceteris paribus” assumption.

	scenario 1	scenario 2	scenario 3	scenario 4
Fatal accidents	-4	-5	-7	-7
Casualties	-13	-17	-24	-25
Financial appreciation (mln. euro)	-9	-13	-18	-18

Table 2 casualty savings

The monitoring research supported the hypothesis that the risk characteristics for an EMS vehicle are not higher than for any other regular vehicle, provided that the right conditions are set. This despite the fact that in some cases the greater length generates extra risks, e.g. by overtaking. If accident risk is not higher, a reduction of transport kilometres leads to less people killed and hospitalized.

5.2 Public Opinion (subjective)

Starting point was the development of a conceptual model of potentially risk increasing factors. These factors were obtained by literature and in-depth interviews with drivers. The figure below shows the results.

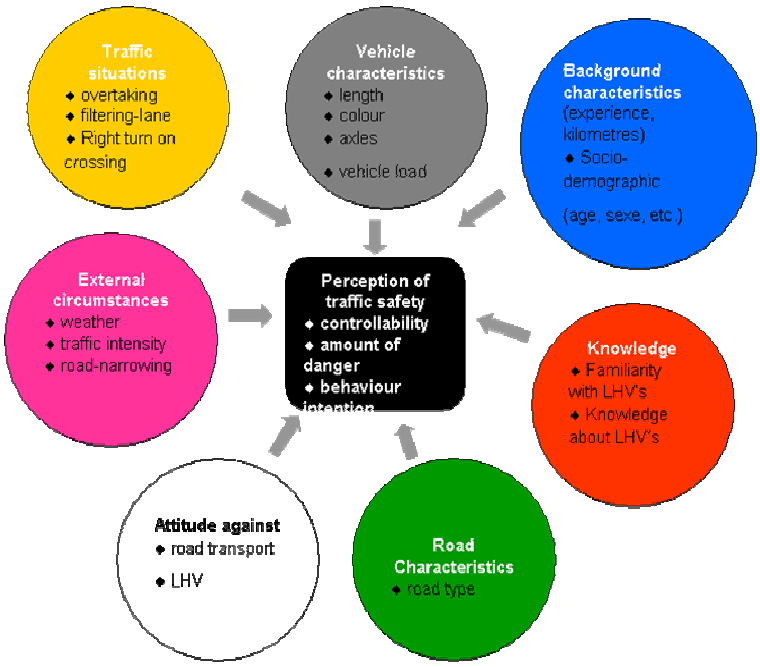


Figure 3 Conceptual model of traffic safety perception

This conceptual model was tested in two complementary sample surveys:

- *a regular quantitative survey* (n=513) where car drivers were asked about knowledge, attitude, safety perception (judgement on controllability and danger) and behaviour against road transport in general and EMS in special. This was done by specially made video material on manoeuvres like overtaking, merging, turn right and by vehicle type (private car, truck and EMS vehicle);
- *a quantitative conjunct survey* (n=534) where besides knowledge and attitude, simulations have been done to discover mutual weight of the different fear setting factors. Among those factors were: manoeuvres, weather conditions, road type, peak-off peak hours, road narrowing, type of load, axle-configuration, length and colour of vehicle/load.

The research proved that road transport in general is experienced to be unsafer than car driving, but EMS vehicles are not experienced to be more unsafe then regular transport. There is one exception: turning right. This action was experienced more unsafe then with regular combinations. Looking at all fear setting factors, “length” shows to be the most fear setting. Also colour, type of manoeuvre, road narrowing and type of load are of importance. Road type, weather, axle configuration and peak-off peak play no significant role in safety perception.

As expected we found a positive correlation between safety perception about regular road transport and EMS. Acceptance for EMS is substantial. Against all expectations, we also found that knowledge about safety supporting measures on EMS vehicles, show no influence on safety perception.

6. MODAL SHIFT

Besides traffic safety a second issue is of major (political) importance; modal shift. If the competitiveness of road transport increases by lower cost per tonnes kilometres, a shift from inland shipping and rail to road transport may be expected. From a safety perspective this is not desired.

If asked, shippers and transport companies don't see the problem; both modes are complementary and EMS vehicles transport goods not suited for rail or water (flowers, consumer goods between distribution centres).

Nevertheless this subjective opinion, a research was conducted into the consequences of EMS on modal shift. Table 3 shows the results.

	scenario 1	scenario 2	scenario 3	scenario 4
Transported tonnes (x 1000)				
inland shipping	-188	-252	-357	-360
Rail	-78	-105	-148	-149
Road	+266	+357	+505	+510
Percentage change (in tonnes)				
inland shipping	-0,2%	-0,2%	-0,3%	-0,3%
Rail	-1,4%	-1,9%	-2,7%	-2,7%
Road	+0,05%	+0,07%	+0,10%	+0,10%
Covered distance (km x 1000)				
inland shipping	-56	-75	-107	-108
Rail	-50	-66	-94	-95
Road	+1.542	+1.873	+2.391	+2.405

Table 3 Modal shift effects

Looking at table 3 we can conclude that a marginal modal shift effect occurs when EMS vehicles are allowed on Dutch roads. These calculations are based on several assumptions. Incorporated is a "generation effect" of extra transport, because of better competitiveness of road transport of 5-6%. Modal shift has been calculated on the basis of cross elasticity between modes (0,8 and 0,1 for rail and inland shipping resp.).

One thing should be mentioned. On individual transport chains, the transport volume for inland shipping might be reduced under a critical mass. This might lead to closing down of the whole transport chain.

7. OTHER SAVINGS

From the calculated "generation effect" and modal shift, national savings were calculated. These savings were capitalized. From table 4 and 5 you can see that "operational costs" (esp. fuel and personnel) give the biggest savings.

	scenario 1	scenario 2	scenario 3	scenario 4
Savings on emissions (x1000 kilogram's)				
Nox	-1.477	-1.979	-2.800	-2.825
PM10 / PM2,5	-24	-32	-46	-46
CO2	-197.052	-264.097	-373.669	-377.024
Covered distance (mln kms)				
△ Regular combination	-848	-1.137	-1.609	-1.623
△ EMS	606	813	1.150	1.160
Net total	-242	-324	-459	-463
Savings on fuel consumption (mln liters)				
△ Regular combination	-255	-342	-483	-488
△ EMS	219	294	416	419
Net total	-36	-48	-68	-68

Table 4 Savings on fuel and emissions

Although an EMS vehicle consumes more fuel per kilometre (2,77km/l. instead of 3,33km/l), a 20% higher weight (from 50 to 60 tonnes) and 52% higher volume reduces the net total fuel consumption.

	scenario 1	scenario 2	scenario 3	scenario 4
Emissions	-23	-31	-44	-44
Traffic Safety	-9	-12	-17	-17
Congestion	-9	-12	-17	-17
Operational Costs	-203	-274	-390	-393
Total	-244	-329	-467	-472

Table 5 savings capitalized in mln EUR (incl. generation effect)

8. POLICY ADVICE AND DECISION MAKING AFTER THE TRIAL

With the monitoring results of the trial, Transport Research Centre (AVV) concluded:
• The EMS is not the solution to all our (future) problems (congestion, emissions, traffic safety);
• The EMS can absorb part of the expected future growth in (road) transport;
• The EMS can help in attaining goals, lowering costs and increase transport efficiency;
• The EMS is more interesting for low weight density goods, than heavy goods;
• The EMS is especially interesting for longer distance hauls.

The pilot period ended on 1st of November 2006. After this period all exemptions were no longer valid. This would mean that all participants had to stop with their transport activities with EMS vehicles. To prevent this, and based on the good results, it was decided to extend the exemption for another one year. In this transition year preparations for a more permanent allowance for EMS vehicles are now worked out.
Part of the work are the development of new conditions and standard operating procedures under which EMS are allowed on the road.
The idea is to develop an EMS High Quality Network on which EMS vehicles are allowed without time-consuming individual authorization of different road operators.
After the market is open for every potential transport operator a new phase starts: “the experience phase”.

One thing is clear; for the coming years allowance to drive with an EMS vehicle still will be based on an exemption.

Despite this positive outcome of the trial, still some questions had to be answered. Uncertainty rose especially about the use of the infrastructure.

9. USE OF INFRASTRUCTURE

To make use of EMS trucks, transport operators had to comply to all kinds of conditions. Regarding the infrastructure these were:
• Just expressways and 10 exits each participant;
• At each of the 10 exits, a maximum of 20 kms of non-expressway or national route;
• No city-centres, 30 km-zones, pedestrian areas;
• No railway crossings if trains are allowed > 40 km/h;
• Only roads with separated pedestrian/bicycle lanes (5 km exception).

Before any EMS vehicle was allowed to drive on the road infrastructure all relevant road authorities had to approve the route the transport company wanted to drive. In some cases this “approval” took a long time. Usually a lack of knowledge about the phenomenon was the reason.
Different misperceptions slowed down decision-making. For instance it was believed that EMS vehicles have a longer braking distance (not), have longer swept path (not), and greater blind spot mirror (not) or too heavy for this road (usually not the case; axle weight on average less than regular vehicle).

The EMS-truck drivers are asked for their experience with obstacles in the infrastructure, like roundabouts, maneuvering, (un)loading and parking.
The following points of interest occurred:

- Space for left and right turn lanes at traffic lights is often short.
- Parking at service areas sometimes problematic (because of extra length)
- Crossing of intersections requires extra attention of truck driver.

Although the consequences for the use of infrastructure were investigated in brief, several questions remained.

- What about road wear and road pressure?
- What about bridges and other construction works?
- What about Corporate guidelines concerning Road Design and Traffic Management?
- What about secondary road network?
- What about road works, Incident Management, traffic deviations, etc?
- What about extra costs for maintenance & exploitation?

These questions induced us to do additional investigations on infrastructure implications.

9.1 EMS impact on tasks of National Road Administration (Rijkswaterstaat)

The consequences of EMS introduction on national highways and main road network are investigated. Different aspects on road maintenance were taken into account:

- Road pressure
- Bridges and Constructions
- Road design
- Road Works/working zones
- Incident management
- Traffic Monitoring/Traffic data

Regarding road pressure the conclusion was that no negative effects were to be expected. After all, the average axle load is equal or even lower in comparison to regular combinations and amount of trips decreases with constant transport volume. For bridges and constructions this is different. Research to exact effects is still in progress but preliminary calculations indicate that safety margins, especially for steel bridges, go beyond the limits.

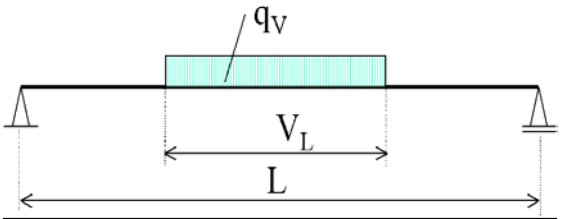


Figure 4 simplified model of bridge with EMS vehicle

q_v = equivalent vehicle load
V_L= vehicle length
L = length of the bridge
F_a= axle load

The appearance of tension in the middle of the bridge (20 m) with a vehicle of 500 kN and 19,5 m long is linear dependent from the bending moment M_z. M_z is then calculated by:

$M_z = V_B * 0{,}5 * V_L * 0{,}25 – F * 0{,}5 * L$ = 250 * 19,5 * 0,25 – 250 * 20
= 1218,75 – 5000 = 3782 kNm

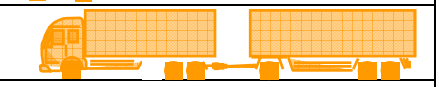
Vehicle category	Vehicle length [m]	Vehicle weight [kN]	Bending Moment M_z result from q_v [kNm]	Bending Moment M_z result from F_a [kNm]	Diagonal force Q_y Max [kN]	
Design regulation - NL	5,00	600	5625	5500	570	
EMS-A 7axle	20,50	600	4463	4130 - (1,33)	462 - (1,23)	
EMS-B 8axle	21,60	600	4380	3920 - (1,40)	457 - (1.24)	
EMS-C 6axle	21,55	600	4384	4430 - (1,24)	452 - (1.26)	
EMS-D 8axle	19,55	600	4534	4300 - (1,27)	467 - (1.22)	
EMS-E 7axle	20,25	600	4481	4320 - (1,27)	464 - (1.22)	

Table 6 calculations on EMS vehicles and loads on a 40m. bridge

Between brackets the safety margin indicator. This indicator should be equal or above 1.4. Same calculations have been performed for bridges of 6, 20, 25, 30m. Only configuration C with 6 axles gives most concern.

Assumption is that maximum GVW (Gross Vehicle Weight) will be 60 tonnes and this is fully utilized. From the trial we know this is not the case. Average payload is much less (between 16-35 tonnes).

Please bare in mind the Dutch National Road Administration (Rijkswaterstaat) has more then 1000 bridges and constructions from before 1963 (!) which fall under their jurisdiction! Based these preliminary findings and concerns, the National Road Administration is now looking into this subject on a more thorough basis. This might lead to the conclusion that allowed GVW will be less then 60 tonnes.

Looking at road design a whole spectrum of design principles have been looked into. From merging traffic, ramps to service areas and crash barriers.
In general, only small potential problems occur on roads of the Rijkswaterstaat Administration, because basic assumption is EMS follows infrastructure. Still some points of particular interest are indicated on behalf of traffic safety, i.e. tunnel safety, traffic lights and length of lanes for right turns.
Exception to this rule is adjustment of service areas. Transport Research Centre is now listing the problem and it's costs.

At working zones in the Netherlands sometimes only one lane is available (4-0 system). The maximum width of the right lane is 2.85m. If the amount of EMS vehicles grows this type of design at working zones might be discouraged because of the swing of the EMS vehicle.

Regarding Incident Management the existing regulations are sufficient. For example, when an articulated vehicle is involved in a crash, two salvage vehicles are already needed. No problems are expected.

The last subject concerns collection of traffic data. These data are used for modeling and simulations. For some models, like count and Weigh in Motion systems new vehicle categories had to be added.

To summarize, the impact of EMS introduction for main roads and high ways is quite clear. Nevertheless, little is known of the implications for the secondary road network. For this reason end 2006 a Quick Scan was conducted on effects of existing design principles and regulations.

9.2 Quick Scan on publications, directives, manuals and regulations

The national information and technology platform for infrastructure, traffic, transport and public space CROW, is a not-for-profit organization. It develops, disseminates and manages practically applicable knowledge for policy preparation, planning, design, construction, management and maintenance. The knowledge, which usually consists of guidelines, recommendations and sets of systems, is transferred to the target groups via websites, publications, training courses and conferences.

CROW has performed a quick scan on the impact of EMS vehicles on current publications. The work was divided into two groups: one on traffic management and transport of goods (105 publications), the other on engineering and construction (58 publications). Every potential bottle-neck was scored on "critical", "severity" and "investment" for adapting the publication.

Allowance of EMS vehicles has a structural impact on in total 47 publications: 21 on traffic management and 26 on construction.
Most important points of interest:

- Traffic signs;
- Minimal length of safe havens,
- Safety margins for railway crossings;
- Clearance at traffic lights;
- Design Guidelines Motorways (ROA) and construction sites (WIU)

And,

- Road rutting/healing
- Sound emissions when using wide tires
- Widening of roundabouts

9.3 Follow-up research

As a follow-up on the Quick Scan a new publication fully dedicated to EMS vehicles will be developed in close co-operation with road authorities and pressure groups. In this process the remaining questions regarding the secondary road network will be answered. Alternative measures will be taken into account with respect for traffic safety and traffic management. The EMS vehicle follows infrastructure not vice versa. So only small measures are at stake. If large countermeasures are necessary the road is in fact not suitable for EMS vehicles. The new publication is planned to be ready by November 2007.

When on November 1st 2007 transport companies are free to apply for an exemption, this is not the end of all research. Now of all times it is extremely important to monitor the developments in the area of traffic safety and modal shift.

10. SUMMARY AND FUTURE OF EMS IN THE NETHERLANDS AND EUROPE

• Current situation frozen (1 year), after that we go into the “experience phase”
• Additional research on infrastructure (traffic management, traffic safety, road design)
• Definition of new conditions (vehicle, road)
• Developing standard operating procedures
• Developing “high quality EMS network”
• Emphasis on enforcement, technical conditions, shift of responsibility to haulier
• International co-ordination on research & implementation, harmonization

At this moment (spring 2007) the Ministry is working on new conditions for transport companies to obtain their exemption to drive with EMS vehicles.
Part of these conditions will be extra requirements on the vehicles, like stability systems (ESP). Furthermore training and examination of drivers must be formalized by law. Finally, the process of getting an exemption to drive on the EMS quality network is complex and means involvement of many parties and road authorities. A lot of work has to be done to start the “experience phase” by 1st of November 2007.

The Dutch Ministry has experienced great interest from neighbour countries (Belgium, Germany, UK) and the European Commission. For the future “XXL vehicles” will continue to be on the move, in the Netherlands anyway.