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Effects of new vehicle concepts
on the infrastructure
of the federal trunk road network

Final report

Abstract

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1 Introduction

Based on the predictions of the traffic report [1] published by the Federal Ministry for Transport, Building and Housing (now known as BMVBS), starting from the status in 1997, passenger traffic will increase by about 20% until the year 2015 and goods traffic by about 64%. According to these statistics, goods traffic volume will increase to about 600 billion tkm within this period, which is about 33% more than in the first year. The increase mainly affects goods traffic on roads.

Some sections of the transport and forwarding business envisage the possibility of handling this increasing amount of goods traffic on federal trunk roads in Germany more efficiently in the future by introducing new and larger transport vehicles or with a changed combination of the already existing transport units. Currently there are specific demands for an increase in the length and the permissible total weights of the tractor-trailer combinations. Based on the arguments in favour of this, a considerable amount of heavy goods vehicles could be saved in this way and thus the requirement for space for carrying a certain amount of tonnage would be correspondingly reduced. Presently, there is no general demand for changing the maximum height of 4.00 m or the maximum vehicle width of 2.55 m.

The combination of a conventional tractor-trailer that is 16.50 m long or of a tractor and a 13.60 m long road semi-trailer with a 7.80 m long trailer as an articulated trailer as well as that of a 12 m long truck with a trailer consisting of a dolly (double axle with pulling device and fifth wheel coupling) and a trailer attached to this, is presently the main preference in the suggestions put forward by the associations. The total length of these combinations will be 25.25 m and the permissible total weight will be up to 60 t.

In the following pages, the effects of the tractor-trailer combinations with respect to damage of roads and bridges, obstruction of traffic and impairment of road safety will be discussed. Based on the results of the issues that are individually dealt with conclusions are finally drawn with the objective of reducing further investigations to the problems that are still open. This report cannot present any conclusive results with respect to the problems in bridge constructions in particular, since ongoing research projects by appointed institutes still have to be completed in this area.

2 Working on the subject area

The Federal Highway Research Institute was appointed by the Federal Ministry of Transport, Building and Urban Affairs to investigate technical problems of new types of vehicle concepts on the federal trunk road network. In accordance with the mainly technical issues that had to be worked on, neither the expected benefits to transportation companies, nor the predicted ecological expectations of a reduced fuel consumption and a reduction in exhaust emissions were the objectives of the investigation.

A working group with the title "Possibilities for use and effects of 60 t trucks on federal trunk roads" was established at the Federal Highway Research Institute for the investigations on the use of tractor-trailer combinations. It included representatives of the departments "Traffic Engineering", "Automotive Engineering", "Bridges and Structural Technology" and "Highway Construction Technology."

In detail the investigations of the working group focussed on the following issues influenced by an introduction of tractor-trailer combinations:

- Effects on road damage
- Effects on bridge damage
- Ability to use traffic facilities
- Influence on traffic flow
- Accident occurrence

3 Results

Initially the aspects regarding rut formation were analysed when estimating the effects on road damage of tractor-trailer combinations with increased total weights. Here, it could be concluded based on laboratory experiments that the tractor-trailer combinations with their temporally dense axle sequence do not appear to be the cause for an increase in damage of the asphalt surfaces. If we additionally take into consideration that the number of axles necessary for transporting a freight unit of one tonne increases when using tractor-trailer combinations and thus the axle loads decrease, then the problem of an increased rut formation through the high frequency of axle overruns of these vehicles does not occur. Based on the high forces of the drive axle applied to the road construction when driving uphill it will be urgently required in future to include a second drive axle in the case of total permissible weights above 46 t.

Contrary to the damage in form of rut formation which affects only the asphalt surface fatigue cracking at the bottom of the asphalt base layer is caused in the case of substantial damage, which can develop further from the bottom to the road surface in a relatively short time and thus makes the entire construction of the top layer susceptible to repairs.

On the whole, the investigations conducted for this purpose resulted in the fact that fully as well as partially loaded tractor-trailer combinations lead to a reduction in road stress and thus to less damages on the road itself as far as weight is concerned, than in the case of the vehicle types commonly used nowadays. From a purely statistical point of view, the results on road damage together with the composition of the present heavy traffic lead to the estimate that the duration of use of road structures in the case of the 40 ton vehicles being replaced by tractor-trailer combinations by 30% in the medium term, could increase by about 5.25%.

At the same time, estimates of traffic compositions as a consequence of introducing tractor-trailer combinations showed that in spite of savings on individual trailers, the total tonnage driving over the road network every day (vehicle weights + actual load) would remain unchanged. It was worked out for the number of journeys, that, assuming that in 2015 about 45% of transport performance was carried out by tractor-trailer combinations, the average daily amount of heavy traffic (veh/d) on the federal motorways could be reduced by a magnitude of about 13%.

However, these theoretical observations on stress and damage in road constructions as a consequence of an introduction of tractor-trailer combinations become relative in view of the continuously increasing number of heavy goods vehicles on federal trunk roads:

By using tractor-trailer combinations, the stress on roads when transporting the same capacity would drop, and at the same time more space and capacity would become free on the roads as a result of the lower numbers of vehicles required for processing. But, this space, which can be viewed as a potential transport capacity, would disappear sooner or later due to the general increase in transportation performance, whereby the main lane on federal motorways would not only be exposed to more vehicles every day, but also by a larger tonnage than before. This effect will finally lead to the damage of road fixtures in future - that is calculated in numbers of years and relatively speaking much earlier - i.e. after the transport performance has been completed.

A general check for the total number of bridge constructions on federal trunk roads with respect to the load bearing capacity for increased total vehicle weights must be conducted to investigate the effects of a possible approval of tractor-trailer combinations of a total weight up to 60 t on bridge constructions.

Based on the results of already conducted simulation calculations available at present it was found that in case of a possible approval of the 60 t tractor-trailer combination, the load carrying reserves of bridge stock are reduced. Moreover, we must assume that in all structures of the bridge classes 30, 30/30 and 45 as well as in double- and multi-span bridges of the bridge classes 60 and 60/30 exceeding a span width of 30 and 40 m stresses for 60 t tractor-trailer combinations exceeding the design values could occur. In these cases the condition of the structure must additionally be observed.

Older, multi-span post-tensioned concrete bridges built before 1980 show larger deficits due to the lack of consideration for forced stresses resulting from differences in temperature, than comparable recently designed systems.

Apart from bridges, there is also requirement for further investigations on tunnels of federal trunk roads. Due to the considerably higher load volume compared to the presently permitted vehicles, it is assumed that there will be higher demands on the safety equipment within tunnels (e.g. due to a higher fire load).

As far as the usability of road traffic facilities is concerned, it can be generally determined, that due to the longer vehicle lengths and additional inflexion points, the here regarded new tractor-trailer combinations display more unfavourable curve running properties.

In case of intersections and roundabouts, it has to be considered that even small deviations from the optimised driving lines lead to using correspondingly more additional room of the neighbouring lane or the roadside. Crossing or sweeping over areas at the side can put other road users (especially pedestrians and cyclists) at risk, and can also lead to damage of road equipment as well as the edge of the carriageway.

The investigations show that the road facilities can only be used with tractor-trailer combinations with a steering axle. Whereas turning right off a major road at a T-junction does not create any problems, there is no more room for movement when turning right onto a major road. The free room must be used to the full extent.

The situation is similar when driving in small roundabouts. Turning left and right is possible with new tractor-trailer combinations with a steerable trailing axle, however, the room for movement must be fully used. Using areas on the sides of roads, if only to a lesser degree, must be taken into consideration.

Intersections within built-up areas cannot be driven through, even when using all available room for movement and safety.

The new tractor-trailer combinations also present problems when it comes to parking the vehicles. Since truck parking spaces nowadays are usually too short for such long vehicles, the drivers have to park longer vehicles in parking spaces in longitudinal direction in parallel with the driving lanes which are not available everywhere or in case of parking lots that have not been restructured, in the entrance or exit roads. The latter must be avoided for reasons of road safety.

As far as traffic flow and traffic safety are concerned, no serious problems should be expected by using new and longer tractor-trailer combinations on motorways. With reference to the higher vehicle weights, new tractor-trailer combinations would have to be accordingly motorised and equipped with reliable brake systems, so the traffic flow on inclines and gradients will not be disturbed.

On the lower ranked road network negative effects of the use of new, longer tractor-trailer combinations would be expected particularly at unsignalised at grade intersections as well as on single carriageway, two lane rural roads. Due to the longer clearance times required by tractor-trailer combinations for turning off, turning in and crossing at intersections and for passing railway crossings, negative effects would be expected especially on road safety but also on traffic flow.

When overtaking long tractor-trailer combinations, an additional 50 m overtaking sight distance must be considered compared to the overtaking process of a conventional semi-trailer due to an additional time requirement of about 0.8 s.

A further problem is that the existing safety rails or barriers on roads would not withstand a collision with longer and/or heavier vehicles. Restraint systems for 60 t tractor-trailer combinations are not available at present. A countrywide equipping of the network is not economically feasible. Modern driver assistance systems (brake assistant with Active Cruise Control, lane keeping assistant) could contribute to minimising the risk and severity of accidents.

Assuming that the accident risk of tractor-trailer combinations corresponds to that of today's heavy goods vehicles with a total max. weight of over 12 t, it has to be further assumed that tractor-trailer combinations would be involved in 1.2% of all personal injury accidents (corresponds to 255 fatalities) on federal motorways. Compulsory use of driver assistance systems would reduce both, the risk and severity of accidents.