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AUTHOR(S): **B. JACOB, F. SCHMIDT (IFSTTAR)
M. BILLIET (IRU PROJECTS)**

REVIEWED BY: **WP LEADER – B. JACOB (IFSTTAR)**
APPROVED BY: **COORDINATOR – PAUL ADAMS (VOLVO)**

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COORDINATION: **VOLVO (SE)**
PROJECT MANAGEMENT: **UNIRESEARCH (NL)**

Executive summary

This deliverable entitled "Recommendations for EC wide regulatory framework (legislation) on dimensions and loads of vehicles" is based on the work done in the WP5 which has been described in the deliverables D5.1, D5.2, D5.3 and D5.4. The impact of the TRANSFORMERS solutions on existing infrastructure has been assessed, by comparing it to reference vehicles.

This deliverable summarizes in the first chapter the results of these previous deliverables and gives some first recommendation for regulation: the TRANSFORMERS solutions are only marginally more aggressive for existing infrastructure than existing vehicles. The aerodynamic features have neither impact on pavements, bridges nor on safety barriers. However, the double floor feature and the addition of the electric drivetrain (HoD system) (and in particular the battery) below the semitrailer have an impact on the height of the centre of gravity of the truck, and thus on the impact on safety barriers in case of a crash.

The first recommendation is that the extra tonne allowed on the gross vehicle weight (GVW) of a rigid truck for alternative fuel technology, engines, batteries or any other related components, should also apply to articulated vehicles using alternative fuel technology in the tractor and/or semi-trailer unit.

Then, based on the TRANSFORMERS deliverables, it is also recommended to examine how good guidance on the load distribution and loading of trailers and semi-trailers (impact on safety barriers, dynamic behaviour of the truck) and on the longitudinal load distribution, i.e. the balance of axle loads (impact on pavements and on bridges) could be provided to road freight transport operators and shippers on a general, systematic basis and how compliance could be verified.

Additionally, the European Directive on commercial vehicle weights and dimensions¹ could be complemented in a future revision with some rules on the longitudinal and vertical distribution of loads. This could be achieved using on-board weighing sensors for self-control, as already mentioned in article 10d of the Directive.

The third chapter compares the effect of the TRANSFORMERS vehicles with the effect of an articulated vehicle with a 44 tonne maximum authorized weight. The advantages and the drawbacks of the 44 tonne-articulated vehicle combinations are highlighted. As this 44 tonne-vehicle combination is allowed in many European countries nowadays, some recommendations on use of alternative fuels technology are made.

¹ Directive 96/53/EC as modified by Directive (EU) 2015/719

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1 Introduction

This final deliverable of TRANSFORMERS WP5 “Infrastructure aspects and compliance, Regulatory framework” is the summary and the synthesis of the other deliverables of this work package:

- D5.1 presents the impact of the TRANSFORMERS solutions on pavements, with respect to various deterioration processes,
- D5.2 focuses on static and dynamic impacts of the TRANSFORMERS solutions on existing bridges,
- D5.3 analyses the impact of the TRANSFORMERS solutions on safety barriers, compared to that of existing vehicles, and
- D5.4 studies the static and dynamic behaviour of the TRANSFORMERS vehicles within the geometry of the existing infrastructure.

The TRANSFORMERS combinations presents solutions which cannot be easily implemented for cross-border intra EU road freight transport in the framework of the current EU rules on weights and dimensions EC Directive 96/53/EC as modified by Directive (EU) 2015/719 [1] without having a potentially negative impact on the load capacity of the vehicle. EU rules provide a weight exemption of up to 1 tonne for rigid vehicles using alternative fuel technology. The extra weight of the innovations on the TRANSFORMERS energy efficiency or HoD combination is distributed over the entire vehicle combination and can thus not benefit from such a weight exemption. The hybrid-on-demand (HoD) gives an additional weight of close to 1 tonne and is situated in the semi-trailer. The biggest impact of the additional weight of the HoD would be for cross-border intra-EU transports of weight sensitive goods. Also in circumstances where the allowed maximum authorized weight is higher than 40 tonnes, load capacity would be lost unless the weight exemption of 1 tonne is also applied to the full vehicle combination. So the TRANSFORMERS vehicle combination does not fully comply with the requirement allowing the extra tonne.

Section 2 of this deliverable assesses the impact of this extra tonne on the combination aggressiveness on the infrastructure and on its behaviour on the road. Then the possibility of allowing this extra ton on the articulated truck and (semi-)trailer is discussed.

Section 3 gives some recommendations about vehicle loading conditions, both vertically and longitudinally. Indeed, the work done in WP5 has shown the importance of the payload distribution in the trailer, both on the height of the centre of gravity and on the longitudinal load distribution, i.e. the axle load balance.

Section 4 discusses the advantages and the drawbacks of the articulated vehicles with a maximum authorized weight of 44 tonnes, and opens the debate to longer and heavier combinations, without discussing them in details.

Section 5 summarizes the recommendations of this deliverable.

2 Comparison of the TRANSFORMERS solutions vs standard articulated vehicles with maximum authorised weight of 40 tonnes

The TRANSFORMERS solution is marginally more aggressive than the reference 40 tonne articulated vehicle²:

- On pavements, the fatigue and rutting phenomena are slightly increased, when comparing with the 40 tonne European articulated vehicle. For example, the rutting on the main highways is increased by approximately 5%. The numerical values for rutting on secondary roads and the reduction in fatigue life are quite similar [6].
- The lifetime of bridges in fatigue is decreased by a value between 3% and 10%. The extreme effects induced by traffic on bridges are also increased. The eigenfrequencies of the whole vehicle-bridge model are modified, see [7] for more details.
- For safety barriers, numerical simulations have shown that the TRANSFORMERS solution with a slightly lower centre of gravity (energy efficiency trailer hybrid on demand technology beneath the trailer) can have a positive impact on vehicle behaviour, while the TRANSFORMERS solution with a higher centre of gravity (load optimisation trailer with the double floor) can have a negative effect with regard to roll over in case of an accident [8].
- Static and dynamic modelling of the complete TRANSFORMERS combination have shown that, even if the behaviour of the truck is slightly different to current trucks due to the HoD driveline, it is compliant with existing European road infrastructure in terms of geometry [9].

All these assessments have been done in the TRANSFORMERS project (deliverables [6], [7], [8] and [9]) by comparing the fully loaded TRANSFORMERS vehicle to fully loaded current trucks (40 tonnes, 38 tonnes and 44 tonnes).

The Directive 96/53/EC as modified by Directive (EU) 2015/719 [1] allows up to one extra tonne for rigid vehicles using alternative fuel technology.

Indeed, Annex I, point 2.3.1 states now: "Two-axle alternatively fueled motor vehicles other than buses: the maximum authorized weight of 18 tonnes is increased by the additional weight required for the alternative fuel technology with a maximum of 1 tonne".

The TRANSFORMERS solution with the Hybrid on Demand system falls in the so called alternative fuel category. However, the weight that has been added by use of the trailer mounted electric driveline is distributed on the tractor and the semitrailer.

Therefore a first recommendation could be to extend the weight exemption of 1 tonne to articulated vehicles.

Moreover, some studies should be conducted for authorizing the same extra tonne for other road trains, where hybrid on demand could be installed on a normal trailer.

² The impact could vary according to whether weight or volume sensitive freight is being carried.

3 Longitudinal and vertical loading

As mentioned in the introduction, the deliverable D5.3 [8] investigating the impact of the TRANSFORMERS solutions on safety barriers has shown the necessity to limit the height of the centre of gravity of the payload.

Generally, in terms of road safety, high centres of gravity of payload should be avoided, also to optimize vehicle dynamics and driving stability. Up to now there is no legal requirement for the centres of gravity of payload in z-direction. In the European rules (Council Directive 96/53/EC amended by Directive (EU) 2015/719) the requirements are related only to maximum authorized vehicle weights and maximum authorised axle loads.

The pavement calculations carried out in TRANSFORMERS have also shown the importance of the longitudinal distribution of the payload, and thus of the GVW on the axles. An increase of the second (drive) axle load has a higher effect than the same increase distributed on the axles of the trailer.

Good guidance on the load distribution and loading of trailers and semi-trailers should be provided to road freight transport operators and shippers. Already today, such guidance is provided upon purchase in the vast majority of cases, however, it should be examined how the provision of such information can happen on a more general, systematic basis and how compliance could be verified by the operators. Specific diagrams, which show the permissible pay load as a function of the longitudinal position of its centre of gravity could be provided.

In addition, requirements for load positions (e.g. limits for the height of the centre of gravity of the payload) may be introduced in a further revision of Directive], as well as some requirements on the balance between axle loads for a given payload or GVW. However, a methodology for the measurement of the location of the payload centre of gravity needs to be developed beforehand.

4 Comparison of the TRANSFORMERS solutions vs articulated vehicle with maximum authorised weight of 44 tonnes

We recall here that all these assessments have been done in the TRANSFORMERS project (deliverables [6], [7], [8] and [9]) by comparing the fully loaded TRANSFORMERS vehicle to fully loaded current trucks (40 tonnes, 38 tonnes and 44 tonnes).

These assessments have shown that the TRANSFORMERS solutions are less aggressive³ than the 44 tonne articulated vehicle combination, allowed in several Member States countries for domestic transports, and for combined transport.⁴

Several countries allow a maximum authorized GVW of 44 tonnes, either on 5 or 6 axles for National transport.

An efficient solution to allow future developments of new heavy vehicle configurations, including longer and heavier combinations without affecting bridges, is to implement a bridge formula (BF). This already exists in the United States since 1975 for Interstate traffic, and in several other countries (Canada, Mexico, Australia, South Africa, etc.) [2]. Such a formula limits the total mass distributed on a series of any consecutive axles, and therefore the gross combination weight, depending on the number of axles, their spacing or the distance from the first to the last one. That automatically limits the load effects, such as the mid-span bending moment on any bridge span. There is not yet any BF in the EU, and it is a drawback.

Nevertheless, 44 tonne articulated vehicle combinations have a significantly higher impact on bridges, above all for fatigue and crashes on bridge piers. Therefore, in case of any further increase of the maximum combination GVW for international transport above 40 tonnes and up to 44 tonnes in the European Directive, a good compromise could be:

- (i) using a bridge formula to guarantee that the aggressiveness (structural effect) remains acceptable on the existing stock of bridges, and above all that the axle loads are NOT increased,
- (ii) keeping a provision of 1 tonne for electric devices or alternative fueled engines, and to only increase the payload by 3 tonnes.

This proposal, which remains to be proposed to and discussed by the stakeholders and the EU Member States, would introduce an incentive to green the articulated commercial vehicles with a fair share of the extra load. However, it is noted that some Member States are not in favour of any increase of the GVW above 40 t.

There are also some demands and proposals to generalize the EMS (European Modular System) for international transport in the EU. However, there is no consensus about the conditions of that [3, 4]. Some Member States are reluctant to allow longer and/or heavier combinations above 40 tonnes and 16.5 m or 18.75 m. Germany authorized vehicle combinations up to 25.25 m with a GVW limited to 40 tonnes [5]. Some Scandinavian countries have for a long time allowed the 25.25 m combinations up to 60 tonnes and are now increasing this limit. Other Members States (e.g. The Netherlands, Denmark) are going in the same direction. Investigations carried out in France showed that the effects of EMS on bridges are limited for a GVW up to 52 to 55 tonnes, but become quite significant above that.

In any cases, if the Directive 96/53/EC is revised in the future and allows vehicles or combinations above 40 tonnes, it is recommended to allocate at least 1 t to alternative fueled engines or electric devices, and the remaining added load to the payload.

³ The impact could vary according to whether weight or volume sensitive freight is being carried.

⁴ Currently, Directive 96/53/EC stipulates that a 44 tonne maximum authorised weight in combined transport is only allowed for the carriage of 40 foot containers. Directive (EU) 2015/719 extends this to the carriage of 45 foot containers in intermodal transport. It should however be noted that several EU Member States have extended the scope of the 44 tonne maximum authorised weight to all types of combined transport operations.

5 Recommendations

Three recommendations are made in this deliverable for amending the Directive 96/53/EC on weight and dimensions as amended by Directive (EU) 2015/719 [1] :

The extra tonne allowance for alternative fueled engine, battery or any other electric or energy saving device should also be allowed for articulated vehicle combinations, in order to balance this additional tonne between the tractor and the (semi-)trailer.

It should be examined how good guidance could be provided on the loading and related load distribution of trailers and semi-trailers (impact on safety barriers, driving stability of the truck), and on the longitudinal load distribution, i.e. the balance of axle loads (impact on pavements and on bridges). In this case, the guidance should be targeted at road freight transport operators and shippers on a general, systematic basis, and how compliance could be verified.

The a future version of Directive (EU) 2015/719 could provide some provisions on the height of the centre of gravity of the payload (impact on safety barriers, dynamic behaviour of the truck) and on the longitudinal load distribution, i.e. the balance of axle loads (impact on pavements and on bridges). This may be discussed with the relevant parties and DG MOVE.

The Directive should include a bridge formula, adapted to the European stock of bridges and allowing the current combinations complying with the Directive 96/53/EC revised in 2015. However, such a bridge formula should last for many years and prevent future heavier or longer combination to induce increased load effects in the existing bridges, which are mainly designed for a life of several decades.

If the European Directive is again revised introducing a maximum GVW for 5 or 6 axle combinations above 40 tonnes, e.g. up to 44 tonnes, 1 tonne should be allocated to electric devices or alternative fueled engine, and only 3 tonnes given for extra payload. If longer combinations such as the EMS are allowed for international transport, the same provision (1 tonne) should be made. Moreover, these combinations should comply with a bridge formula which guarantees that the aggressiveness remain acceptable for the existing bridge stock.

6 References

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- [7] Effects on bridges of the various vehicle configurations, deliverable D5.2, project FP7 TRANSFORMERS, May 2017.
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List of Abbreviations

BF = Bridge Formula
CoG = Center of Gravity
GVW = Gross Vehicle Weight
HCV = High Capacity Vehicle

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PROJECT PARTICIPANTS:

VOLVO	VOLVO TECHNOLOGY AB(SE)
BOSCH	ROBERT BOSCH GMBH
DAF	DAF TRUCKS NV
FEHRL	FORUM DES LABORATOIRES NATIONAUX EUROPEENS DE RECHERCHE ROUTIERE
FHG	FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V
IFSTTAR	INSTITUT FRANCAIS DES SCIENCES ET TECHNOLOGIES DES TRANSPORTS, DE L'AMENAGEMENT ET DES RESEAUX
IRU	IRU PROJECTS ASBL
P&G	PROCTER & GAMBLE SERVICES COMPANY NV
SCB	SCHMITZ CARGOBULL AG
TNO	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK (NL)
UNR	UNIRESEARCH BV (NL)
VEG	VAN ECK BEESD BV
VIF	KOMPETENZENTRUM - DAS VIRTUELLE FAHRZEUG, FORSCHUNGSGESELLSCHAFT MBH

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