Ref. Ares(2022)6650436 - 27/09/2022

Support Preparation of Legislation on Trailers Certification

Procedure no: CLIMA.C.4/SER/2019/0003

Certification Methodology for Rigid Lorries Bodyworks

Task leader: **Martin Rexeis**

Date: 07/07/2022

This document contains 56 pages

Document information

Additional author(s) and contributing partners

Name	Organisation
Martin Rexeis	TUG
Martin Röck	TUG
Stefan Present	TUG

Acronyms and abbreviations

Acronym	Meaning
ACEA	European Automobile Manufacturers Association
CFD	Computational Fluid Dynamics
CLCCR	International Association of the Body and Trailer Building Industry
CLEPA	European Association of Automotive Suppliers
CLIMA	The Commission's Directorate-General for Climate Action
COM	Commission
CST	Constant Speed Test
ETRMA	European Tyre & Rubber Manufacturers Association
EU	European Union
GUI	Graphical User Interface
HDV	Heavy Duty Vehicles
OEM	Original Equipment Manufacturer
PTO	Power Take-off
SME	Small and Medium sized Enterprises
TPMLM	Technically Permissible Maximum Laden Mass
VECTO	Vehicle Energy Consumption calculation TOol
VIF	Vehicle Information File
xEV	Vehicles with electrified powertrains
XML	Extensible Markup Language (file format)

Executive Summary

This part of the final report covers the work carried out on the certification methodology for rigid lorry bodyworks. From a holistic perspective, this topic can be understood to determine the characteristics of a rigid lorry in its final state, as it is registered for road traffic. Currently, only the properties of the "base vehicle" are reflected by Regulation (EU) 2017/2400 and VECTO, whereby a so-called "standard body" is taken into account. Vehicle specifications which might be different at the final vehicle compared to the conditions as currently covered by VECTO are:

- Mass
- Air drag (CdxA)
- Power take-off (PTO)
- Auxiliaries
- Liftable and/or steered axles
- Tyres

The report analyses the relevant boundary conditions, principle options how different features of a complete(d) rigid lorry could be considered and attempts to design a tailored approach, i.e. adapted to the structure of rigid lorry manufacturing, with the current state of knowledge. The focus is on rather simple approaches that nevertheless should reflect the right trends in vehicle energy consumption. The proposed methods have been discussed with stakeholders in a dedicated workshop in February 2022. Their feedback is also summarised in this report.

The main conclusions from this work are listed below:

- First candidates for the extension of Regulation (EU) 2017/2400 to capture complete(d) rigid lorries are vehicles in group 4 and group 9 with box shaped bodywork as already defined in the trailer Regulation, i.e. bodywork codes 03, 04, 05, 06 (and possibly 32, to be discussed whether this special bodywork is of relevance for rigid lorries).
- The order of magnitude of the additional covered CO_2 reduction potential of such an extended Regulation would be less than one tenth of the amount already currently covered for groups 4 and 9.
- The rest of rigid heavy lorries would continue to follow the current „base vehicle“ (cabin + chassis + standard body) approach.
- Similar provisions should apply for the first manufacturing stage (“primary vehicle” or “base vehicle”) independent whether a specific rigid lorry falls under the “primary and complete(d)” or the “base vehicle + standard body” approach.
- Involvement of several vehicle manufacturers in the VECTO process for a single vehicle could be accomplished by the “multi-step” approach as already elaborated for heavy buses in the second amendment of Regulation (EU) 2017/2400.

- As calculation approach in VECTO, the “factor method”, which was also developed in the context of heavy buses, could be applied.
- A simple input data scheme to be provided on the complete(d) vehicle stage, which focuses only on the main CO_2 and energy consumption relevant features could cover:
    - Corrected actual mass
    - Presence of certain aero features (e.g. side covers or rear flaps)
    - Body dimensions
- Robust generic methods would have to be developed for the calculations of the effects of aero features and body dimensions on the vehicles air drag. In this context, some fundamental problems would have to be addressed, e.g. confidentiality of CdxA values of the primary vehicle manufacturer or overlapping responsibilities of different manufacturer stages for certain aero components.
- In order to make the process as simple and error-free as possible for vehicle manufacturers, it is recommended to apply the methods already developed for heavy buses i.e. tools and data flow principle via a vehicle information file.

The discussions on the topic of rigid lorry bodyworks with CLIMA and the stakeholders in this project show that there are still some fundamental decisions to be made on this topic, especially with regard to how much effort the COM and the manufacturers should put into the topic and whether this effort is in proportion to the expected benefit. This report is intended to provide the relevant information for these decisions.

Table of contents

Figures

Tables

1 Introduction

This part of the final report covers the work carried out on the certification methodology for rigid lorry bodyworks. From a holistic perspective, this topic can be understood to determine the characteristics of a rigid lorry in its final state, as it is registered for road traffic. Following the nomenclature of Regulation (EU) 2017/2400, this thus concerns “the determination of CO_2 emission and fuel consumption for complete or completed (hereinafter shortened to "complete(d)") rigid lorries”.

Currently, only the properties of the "base vehicle" are reflected in Regulation (EU) 2017/2400 and VECTO, whereby a so-called "standard body" is taken into account. Vehicle specifications which might be different at the final vehicle compared to the conditions as currently covered by VECTO are:

- Mass
- Air drag (CdxA)
- Power take-off (PTO)
- Auxiliaries
- Liftable and/or steered axles
- Tyres

The analyses carried out here are much more detailed than the work in the previous contract, also due to the additional experience gained from the work on trailers and the implementation of heavy buses in Regulation (EU) 2017/2400, which was accomplished in 2021.

The discussions on the topic of rigid lorry bodyworks with CLIMA and the stakeholders in this project show that there are still some fundamental decisions to be made on this topic, especially with regard to how much effort COM and the manufacturers should put into the topic and whether this effort is in proportion to the expected benefit. This report is intended to provide the relevant information for these decisions.

2 Analysis of boundary conditions

This chapter analyses the boundary conditions to be considered in developing the methods for capturing complete(d) rigid lorries by Regulation (EU) 2017/2400. For this purpose, the first step is to consider suitable vehicle groups and their relevance (section 2.1). This is followed by considerations on a potential legislative approach (section 2.2), the technical calculation approach in VECTO (section 2.3) and boundary conditions to be taken into account on the part of the vehicle production process (section 2.4).

2.1 Consideration on vehicle groups suitable for a complete(d) multi-step approach and the allocated relevance

For the investigations on suitable vehicle groups for covering complete(d) rigid lorries by Regulation (EU) 2017/2400 and the related benefit or steering effect, data from the currently running project [1] have been further analysed.

Table 1 shows selected data for lorries, which were determined from registration figures from the first monitoring period (2019/20) and further model calculations by TU Graz.

In the table, vehicle groups covering rigid lorries with a TPMLM > 7.5t - which are generally of interest in the context of this project - are marked in green. In terms of share on total CO_2 emissions of the HDV sector (including buses >3.5t, not shown in the table), the most relevant rigid lorry groups are group 9 (6x2, all weights) with 11.0% share and group 4 (4x2, TPMLM >16t) with 8.2% share. This is followed by group 16 (8x4, all weights) with 5.2% share and group 11 (6x4, all weights) with 3.1% share.

The latter two groups are not considered candidates for a first phase of a complete(d) rigid lorry Regulation, as these vehicles are typically construction or municipal vehicles and thus do not have a significant share of box bodies.[1] Rigid lorries in groups 1 to 3 (4x2, TPMLM > 7.5 - 16t) account for a total of 4.4% of the total CO_2 emissions of the HDV sector, and are thus significantly less relevant compared to groups 4 and 9. These vehicles are typically used in distribution transport and are therefore predominantly equipped with box bodies. However, these vehicles differ significantly from those in groups 4 and 9 in terms of aerodynamic configuration, as other types of driver's cabins and a higher variance in total vehicle heights are used (vehicles in groups 4 and 9 mostly have the maximum permissible 4 metre overall height). This means that vehicles in groups 1 to 3 would have to be treated separately in the development of methods for describing aerodynamic drag. For this reason, groups 1 to 3 appear to be only a second choice for coverage in a first phase of a complete(d) rigid lorry legislation.

[1] The basic premise from the previous project on bodies and the work on trailers is that it is not possible with a reasonable amount of effort to evaluate other body types than “boxes” in terms of their influence on CO_2 emissions and energy consumption.

Table 1: Lorries CO2 emissions and reduction potential (primary vehicle and standard body) [1]

Axle configuration	Vehicle group	Chassis configuration	TPMLM [tons]	Number of vehicles (EU-27) [#]	Total CO2 emissions [kt p.a.]	Share of total CO2 HDV EU 27 (all vehicles >3.5t TPMLM) [%]	Relative CO2 reduction potential (primary vehicle + standard body) %	Absolute CO2 reduction potential (primary vehicle + standard body) [kt p.a.]	Share on absolute CO2 reduction potential (all vehicles >3.5t TPMLM) %
4x2	1	Rigid (or tractor)	> 7,5 - 10	2 246	53.9	**0.3%**	29.3%	**15.8**	0.3%
	2	Rigid (or tractor)	> 10 - 12	8 782	274.2	**1.5%**	29.4%	**80.6**	1.6%
	3	Rigid (or tractor)	> 12 - 16	12 314	481.2	**2.6%**	29.4%	**141.4**	2.8%
	4	Rigid lorry	> 16	28 368	1502.9	**8.2%**	25.0%	**375.6**	7.3%
	5	Tractor	> 16	99 255	8952.5	48.9%	28.7%	2570.4	50.0%
4x4	(6)	Rigid lorry	> 7,5 - 16	1 461	19.8	0.1%	21.4%	4.3	0.1%
	(7)	Rigid lorry	> 16	2 230	41.0	0.2%	21.1%	8.6	0.2%
	(8)	Tractor	> 16	978	19.0	0.1%	20.8%	4.0	0.1%
6x2	9	Rigid lorry	all weights	27 424	2014.8	**11.0%**	25.3%	**510.7**	9.9%
	10	Tractor	all weights	12 051	1039.6	5.7%	28.7%	298.5	5.8%
6x4	11	Rigid lorry	all weights	10 981	561.9	**3.1%**	21.0%	**118.0**	2.3%
	12	Tractor	all weights	2 510	152.7	0.8%	20.7%	31.7	0.6%
6x6	(13)	Rigid lorry	all weights	2 233	43.4	0.2%	21.2%	9.2	0.2%
	(14)	Tractor	all weights	220	4.4	0.0%	21.0%	0.9	0.0%
8x2	(15)	Rigid lorry	all weights	740	19.8	0.1%	21.2%	4.2	0.1%
8x4	16	Rigid lorry	all weights	14 381	954.2	**5.2%**	21.2%	**202.7**	3.9%
8x6 / 8x8	(17)	Rigid lorry	all weights	1 213	27.6	0.2%	21.2%	5.9	0.1%
8x2 / 8x4 / 8x6 / 8x8	(18)	Tractor	all weights	n.a.					
5 axles, all configurations	(19)	Rigid (or tractor)	all weights	n.a.					
Medium lorries	51-56	Rigid lorry and van	> 5 - 7.5	25 281	334.6	1.8%	29.2%	97.7	1.9%
Light lorries	---	Rigid lorry and van	> 3.5 - 5.0	9 369	75.8	0.4%	29.2%	22.1	0.4%

Table 1 also contains figures on the CO_2 reduction potential per vehicle group. This reduction potential refers to vehicles of the year 2019/2020 as a baseline and compares this with potential 2030 vehicle technologies for non-ZEV vehicles, whereby only measures on the primary vehicle (i.e. vehicles always have a standard body in the assessment, as in the current regulation) are taken into account.[2] For the vehicle groups 4 and 9 in focus here, 886 kt CO_2 reduction potential per year is already captured with the existing method in Regulation (EU) 2017/2400. This raises the question of how much additional reduction potential could be captured if Regulation (EU) 2017/2400 is extended to complete(d) vehicles.

To answer this question, data on registrations by body type were taken from [2] and merged with data on body-specific reduction potentials from [1]. The corresponding figures are shown in Table 2. Data on annual registrations by body type were only available for EU-12 countries (survey year 2017) and were scaled to EU-27 in the analysis carried out here using the corresponding GDP shares of the countries. This results in a very good match between the number of registered bodies (138 400) and the number of rigid lorries from Table 1 (approx. 142 000, assuming medium and light lorries have a 50% van share). Unfortunately, data on the distribution of body types according to VECTO vehicle groups are not available.

If one adds all box bodies in Table 2, one obtains about 47,000 new registrations per year. If this number is compared with the number of vehicle registrations in

[2] Such measures are improvement of powertrain efficiency (including hybridisation), improvement of rolling resistance, reductions in mass and air drag of cabin and chassis and further vehicle technologies (e.g. ADAS functions, auxiliary technologies).

the main relevant vehicle groups (1, 2, 3, 4 and 9, total 79,000), the box body share in these groups is approx. 60%. This value should be treated with caution due to the different origins of the figures for vehicles and bodies, but the magnitude seems plausible.

Table 2: Shares body types on CO2 emissions and allocated reduction potential

Body type		Number of registrations EU-27[1]	Total CO2 emissions	Relative CO2 reduction potential (body)	Absolute CO2 reduction potential (body)
		[#]	[kt p.a.]	%	[kt p.a.]
Box Body	curtainsiders	9 775	405	4.0%	**16.1**
	Dry Box	23 487	973	4.5%	**44.0**
	Reefer	13 409	595	8.3%[2] / 4.3%	**49.6[2] / 25.7**
Non Box Body	Chassis	4 587	156	n.a.	n.a.
	Tanker	4 259	176	n.a.	n.a.
	Flatbed	11 282	384	n.a.	n.a.
	Tipper	18 106	469	n.a.	n.a.
	Vehicle Carrier	2 256	78	n.a.	n.a.
	Animal Transport	295	9	n.a.	n.a.
	Dropside	3 184	106	n.a.	n.a.
	Timber Carrier	42	1	n.a.	n.a.
	Other	47 750	1236	n.a.	n.a.
[1] derived from 2017 EU-12 data via scaling by GDP					
[2] including reduction potential from improved refridgeration					

In order to estimate the associated "body" reduction potential, measures in aerodynamics, mass and - in the case of reefers - improved cooling were examined in [1] and evaluated using VECTO calculations. For the sake of simplicity, the conversion to an overall CO_2 reduction potential was only carried out on the basis of the CO_2 emission level of group 4 vehicles. If one wants to estimate the additional reduction potential that can be achieved through a complete(d) vehicle regulation, one arrives at a value of approximately 110 kt/a CO_2 (including reefer measures) or 85 kt/a CO_2 (without reefer measures, which would probably still be excluded in an initial phase of the legislation). If, as proposed above, the legislation only covers groups 4 and 9, this would reduce the figure somewhat, as not all box bodies would be covered. Comparing this 85 kt/a CO_2 considered as an upper limit for benefit from an extension of the legislation to complete(d) groups 4 and 9 with the reduction potential already covered by the current legislation for these groups (886 kt/a CO_2) this gives a maximum increase of the covered reduction potential of only about one tenth.

Conclusions from this analysis:

- First candidates for the extension of Regulation (EU) 2017/2400 to capture „complete(d)“ rigid lorries are vehicles in group 4 and group 9 with „box shaped bodywork“ as already defined in the trailer Regulation, i.e.

bodywork codes 03, 04, 05, 06 (and 32, to be discussed whether this special bodywork is of relevance for rigids).

- The order of magnitude of the additional covered CO_2 reduction potential of such an extended Regulation would be less than one tenth of the amount already currently covered for groups 4 and 9.

- The rest of rigid heavy lorries would continue to follow the current „base vehicle“ (cabin + chassis + standard body) approach

2.2 Legislative approach in Regulation (EU) 2017/2400

One of the challenges in considering the properties of complete(d) vehicles in VECTO is, that in most cases several vehicle manufacturers need to be involved. This fundamental encounter has already been addressed in Regulation (EU) 2017/2400 on the occasion of heavy buses. The established method, often referred to as "multi-step" approach, provides different responsibilities in the VECTO process for the following manufacturer types:

- Primary vehicle manufacturer

- Interim manufacturer

- Complete or completed vehicle manufacturer

Furthermore, the multi-step process defines an automated data flow following the individual manufacturers based on the “vehicle information file” (VIF), which is automatically handled by the simulation tool. The multi-step approach as established for heavy buses is shown in Figure 1. A detailed description of this process can be found in point 2 of Annex I of the 2nd amendment to Regulation (EU) 2017/2400.

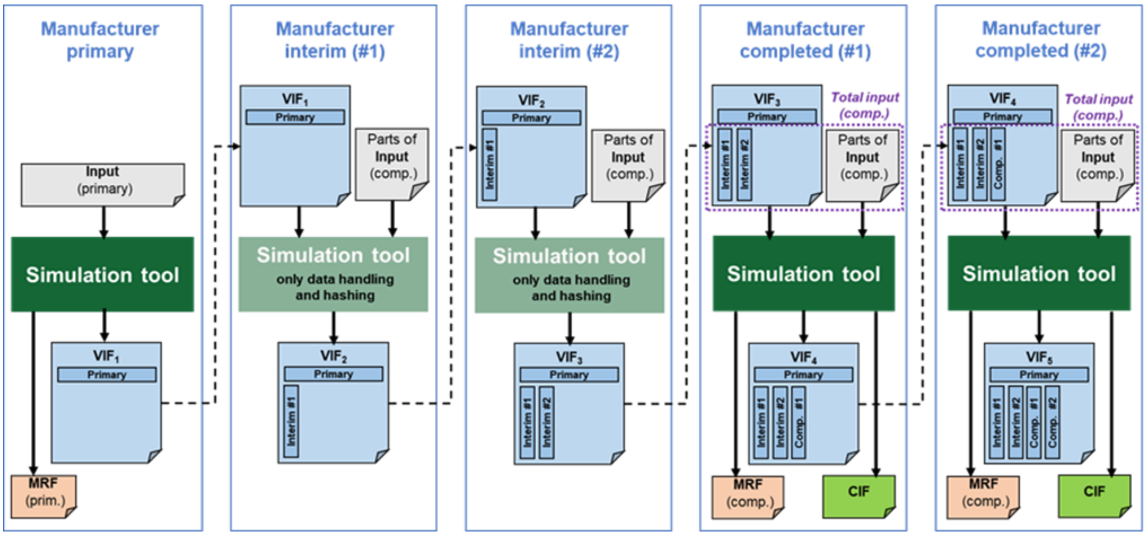


Figure 1: Multi-step process for heavy buses

This basic approach in Regulation (EU) 2017/2400 was derived from the vehicle approval Regulation (EU) 2018/858 and is generally applicable, i.e. independent of a specific vehicle category. For a concrete application in Regulation (EU) 2017/2400 for rigid lorries, however, the following elements would have to be reviewed and elaborated:

- Definitions of vehicle states and allocated manufacturers:
    - Primary vehicle (to be generalised)
    - Interim manufacturer (might not be relevant or applicable if a simpler, less sophisticated approach for complete(d) rigid lorries is chosen)
- Input data and input information to be provided per manufacturer type

  For heavy buses, about 30 inputs are required for interim and complete(d) manufacturers. These mostly concern auxiliary consumers that are not relevant for rigid lorries. Also, air drag must be treated differently from that of heavy buses; for more information, see chapter 3.2.
- Consequences for a VTP (however, this topic might not be of priority for an initial coverage by the legislation, as e.g. heavy buses added in the 2nd amendment are currently also excluded from the VTP).

2.3 *Calculation approach in VECTO*

As already suggested by the outcome of previous contract on bodies, it is recommended to apply the so-called “factor method” in order to calculate the result for CO_2 emissions and fuel consumption of the vehicle in its final conditions. The factor method can provide this, while allowing particularly sensitive component specifications (e.g. engine and drivetrain component maps) not to be exchanged between manufacturers. The factor method consists of calculations on two manufacturer levels. These are explained below, whereby a possible specific implementation for rigid lorries is already addressed:

❖ **Simulation step 1) Primary vehicle**

In the simulation part to be done at the primary vehicle all input information and input data related to the primary vehicle are available but the final bodywork and the related parts of the vehicle are not known. Thus, the simulations are performed based on generic bodywork data. For rigid lorries, it is advisable to use the standard bodies as currently defined in Regulation (EU) 2017/2400 as generic bodywork. This would be beneficial for several reasons, e.g. to be able to seamlessly continue with the existing CO_2 standards (Regulation (EU) 2019/1242) and also to avoid parallel VECTO processes depending on the body type (see section 2.4).

❖ **Simulation step 2) Complete or completed vehicle**

In the simulation part related to the complete or completed step, some of the input data from the primary stage are not available as they are considered to be confidential (engine fuel map and efficiencies of transmission etc.). Thus, this data - further referred to as “efficiency data” - is supplemented automatically by the simulation tool by generic data. Those generic data shall be chosen to be as representative as possible. The corresponding data sets would already be available from the work on heavy buses. It is assumed that these could be used for rigid lorries without major adaptations.

The simulation tool now determines a correction, how much the performance of the primary vehicle changes due to the deviation of the actual bodywork and its related other parts from the generic data used at the primary step. To determine this correction, the tool launches simulations for the vehicle with the specific bodywork and for the vehicle with the generic bodywork. It is important to understand that the estimation of the influence of the specific bodywork is relatively robust against different sets of generic efficiency data to be used as the typical shapes of engine fuel maps and losses of drivetrain components are similar to a large extend.

In the final computing operations to be done at the complete or completed step, the results from step 2 (correction for influence of specific bodywork) are combined with the results for performance of the primary vehicle (step 1). This is mathematically done using the “factor formula” as shown in Figure 2.

$$\underbrace{CO2\,[g/km]}_{\text{VECTO complete(d)}} = \underbrace{\boxed{CO2_{Spec\mathbf{PT},\,Spec\mathbf{Eff},\,Gen\mathbf{Body}}}}_{\text{VECTO primary}} \cdot \frac{CO2_{Spec\mathbf{PT},\,Gen\mathbf{Eff},\,Spec\mathbf{Body}}}{CO2_{Spec\mathbf{PT},\,Gen\mathbf{Eff},\,Gen\mathbf{Body}}}$$

Where:
PT ..... Powertrain (ICE fullload curve, transmission type and ratios ...)
Eff ..... Component efficiency data (ICE map, ICE correction factors, Drivetrain efficiencies), CONFIDENTIAL DATA
Body .. Total vehicle mass, air drag, parts of auxiliaries (HVAC, Pneumatic System, Electric System)

Figure 2: Formula Factor Method (Spec: specific data used in simulations, Gen: generic data used in simulations)

This approach is already implemented into beta versions of the VECTO tool for heavy buses with conventional powertrains (i.e. internal combustion engine, transmission and axle). These methods were tested by industry in "Pilot Phase 2" – a test phase held in the framework of the former HDV CO_2 Editing board activities. Central part of the investigation was how accurately the approach compares to a single step VECTO simulation where all vehicle data is available at once. It was concluded from this analysis, that - for conventional powertrains - the accuracy of the factor method is within +/-1% for most vehicles and within +/-2% for nearly all vehicles. Since the basic accuracy-determining mechanisms are the same for rigid lorries, it is assumed, that this approach is also very well suited for this application.

As part of the project "VECTO Extension to Cover Electric Vehicles and Additional Powertrains"[3] the factor method for heavy buses is currently being extended to xEV vehicle configurations. It is assumed also in this regard that the generic component data to be compiled for electric powertrain components can be adopted unchanged for rigid lorries.

[3] Specific contract No 090203/2021/863026/SER/CLIMA.C.4

In the development of the tool for heavy buses, it is already taken into account that the basic method could also be applied to other vehicle categories. For rigid lorries, due to the different input data structure, code or IT-related adjustments will nevertheless be necessary for:

- XML structures
- Graphical User Interface
- Hashing Tool

In addition, any rigid lorry specific calculation method as discussed in chapter 3 (e.g. generic formulas for air resistance) would need to be considered in the implementation into the tool.

2.4 *Vehicle production process*

In the production of rigid lorries, it is the case that in many occasions it is not yet clear at the primary vehicle stage which bodywork the vehicle will obtain in its final condition. Based on the approach as proposed in the conclusion part at the end of section 2.1 it however depends on the bodywork which of the VECTO methods shall be applied:

- “Cabin + chassis + standard body” or
- “Multi-step complete(d)”

If the provisions for those methods at the "base" / "primary" stage would differ (e.g. for CdxA, mass and PTO), this would mean that the manufacturer would have to carry out both processes (input data, simulations, results) in parallel. Such a scenario should be avoided for reasons of effort for the Commission (more complex Regulation and tools to be developed and maintained), vehicle manufacturers (efforts) and customers (interpretation of results).

3 Analysis of options which properties / parameters of the complete(d) vehicle should be considered and how

This chapter analyses possible approaches how different features of the complete(d) rigid lorry could be considered by Regulation (EU) 2017/2400. It proposes different options and elaborates on the associated challenges, especially in the development of the methods.

The basic hypothesis of the methods outlined in this section is that the results determined by VECTO for the complete(d) rigid lorry shall have a similarly high accuracy requirement as in the current VECTO for the base vehicle stage, i.e. resolution of the ranking in real energy consumption to a few tenths of a percent. This is an ambitious goal, as the complexity of the matter for complete(d) rigid lorries increases considerably (especially with regard to air resistance) and as measures from different manufacturers have to be evaluated and combined. However, a complex procedure appears to be in conflict with the structure of the body builder sector consisting of a large number of SMEs. Furthermore, the development of complex approaches would also require a corresponding development budget.

For this reason, the chapter 4 attempts to outline a procedure that is as simple as possible and still sets the right incentives in the vehicle market. The detailed discussion of the individual technical issues as presented in this chapter is nevertheless useful in order to:

- develop an understanding of the technical context
- assess the magnitude of the trade-offs between complexity and accuracy, which need to be handled in developing a simple method such as that described in chapter 4.

3.1 *Vehicle mass*

The vehicle mass - in the terminology of Regulation (EU) 2017/2400 referred to as "corrected actual mass" - of a complete(d) rigid lorry can be easily determined and directly taken into account in the simulation tool. For this purpose, a separate definition for rigid lorries that are also calculated as complete(d) vehicles would have to be prepared in Annex III, which is not considered to be problematic.

3.2 *Air drag (CdxA)*

Air drag – in VECTO represented by the input parameter CdxA - is, next to the mass, the most important influence parameter of the specific bodywork on CO_2 emissions and fuel consumption. It is also by far the most complex influence parameter to determine. In the following, the existing methods for CdxA determination for other vehicle types in VECTO are listed and then the most promising approach for complete(d) rigid lorries is described.

Table 3 lists the existing approaches for CdxA determination for VECTO.

Table 3: Existing approaches for C_dxA determination for VECTO

Vehicle category	Determination method
Medium and heavy lorries	Constant speed test (CST) in the vehicle configuration “cabin and chassis” and equipped with a standard body
Heavy buses	CST in the final body configuration
Trailers	Stepwise calculation approach consisting of: • Generic CdxA for generic towing vehicles in certain standard configurations (derived from 2019/2020 monitoring data) • Generic correction formulas for trailer and body dimensions different to the standard configurations mentioned above

Vehicle category	Determination method
	• Application of additional reduction rates for certain aerodynamic devices (either certified via CFD or using “standard values” for reduction rates as implemented in the tool)

3.2.1 Proposed approach

For rigid lorries in a multi-step approach, the most promising method appears to combine existing elements from the above approaches. Specifically:

- **Primary lorry:**
  - CST with cabin, chassis and standard body (exactly following the current provisions)
  - Possibly adding an option to further differentiate configurations using CFD (as proposed by ACEA in their proposal for Appendix 10 to Annex VIII)
- **Complete(d) lorry:**
  - Take over CdxA from primary lorry as a starting point
  - Apply generic corrections for the influence of specific box body dimensions vs. standard body dimensions
  - Apply CFD or “standard values” reduction rates for aerodynamic devices

Topics which need to be clarified or elaborated in connection with this approach are described below.

3.2.2 Passing on the CdxA value from the primary manufacturer to subsequent manufacturers

CdxA values were previously classified as confidential information by ACEA. Therefore, in the data published from monitoring and reporting (Regulation (EU) 2018/956), the CdxA values are divided into bins. If the CdxA values of the primary vehicle in the approach for complete(d) rigid lorries are decided not to be passed on via the VIF[4], VECTO could alternatively write the worst value of the corresponding bin into the VIF. Since the CdxA bins in monitoring and reporting are chosen relatively narrowly anyway, this approach is also considered a viable path.

3.2.3 Vehicle heights other than those covered by standard bodies

The standard body concept according to the current Annex VIII specifies that certified CdxA values only have to be determined for the standard body defined

[4] If the CdxA value is part of the VIF, it can be considered publicly available information

by an overall vehicle height (Appendix 3 to Annex VIII). This concept was chosen because otherwise the variety of aerodynamic configurations requiring CST certification would be even greater. The prescribed overall vehicle heights are defined separately for the different vehicle groups and specified in such a way that they depict the most relevant configuration on the market. E.g. for rigid lorries in groups 4 and 9, the overall vehicle is defined with 4 meters (maximum permissible vehicle height on the road). For groups 1 to 3 different and lower heights, more typical for delivery applications, are specified.

In the market a range of vehicle heights occurs even within a vehicle group. The problem that arises from the approach described above is that the CdxA value determined for the primary lorry for vehicle heights that do not correspond to the standard body might be of little significance for the complete(d) lorry. In such cases the aerodynamic configuration might be significantly changed by the body builder by modifying or adding components (usually available as accessories from the OEM, i.e. new or different spoilers or gap fillers). These modifications also affect the aerodynamic configuration of the cabin and chassis element and thus exceed the influence of the body size only.[5]

A solution for this problem, i.e. determining CdxA with reasonable effort and with good accuracy also for other vehicle heights deviating from the standard body, has not yet been identified.[6] A non-quantitative measure in the context of an extended regulation could be that for typical aerodynamic adjustments carried out by the body builder, a kind of legal requirement list is drafted (e.g. with provisions on the position of the upper edge of the spoiler in relation to the upper edge of the front body) which has to be confirmed in the VECTO input file. In case of non-confirmation, VECTO could apply a generic increase to the CdxA value.

For the vehicle groups identified in section 2.1 with the highest share of CO_2 in rigid lorries, 4 and 9, this subject is of minor importance, as the majority of vehicles (>99% according to the feedback as provided by CLCCR) has an overall height of 4 metres. For the few vehicles in these groups with other heights, one could accept a reduced accuracy resulting from the procedure described above. For other rigid lorries groups (1, 2, and 3) it is estimated that the situation is not so uniform, and the variance of the aerodynamic configurations would have to be analysed more closely and more complicated approaches for targeted incentives would have to be designed. It is therefore recommended to exclude these vehicle groups at least in a first phase of a multi-step legislation for rigid lorries.

3.2.4 Consideration of aerodynamic devices (AD)

In accordance with the approach described above, typical aerodynamic configurations would have to be defined for rigid lorries - analogous to the method in the trailer Regulation - for which standard values would then also need to be developed. Examples are rear flaps and side covers possibly each in different

---

[5] How the actual procedures look like in practice would be worth investigating, possibly also apart from the development for complete(d) rigid lorries but with regard to the meaningfulness or the effectiveness of the existing provisions in Regulation (EU) 2017/2400.

[6] A high accuracy solution but with extremely high effort for the primary vehicle manufacturers would require to determine CdxA for a vehicle and different vehicle heights. However, this approach is considered disproportionate.

variants. If a "simple" approach (e.g. without CFD option) is chosen, the methods to be developed in this aspect are of even greater importance for the functioning of the legislation. Another point to note when considering ADs for rigid lorries is that - in contrast to trailers - these are to be analysed in two vehicle configurations, namely as "rigid plus standard trailer" (R+T), relevant for the long haul cycle and as "rigid only" (R) relevant for the delivery mission profiles.[7]

3.2.5 Overlapping responsibilities regarding certain aero parts of primary vehicle manufacturer and body builder

Certain aerodynamic equipment could be mounted either by the primary vehicle manufacturer and body builder (e.g. spoilers, gap fillers). Therefore, in the approach outlined above, it must be prevented that certain equipment is considered twice in the CdxA value. For this purpose, a classification of aero components could be created, whose presence in the CdxA value of the primary vehicle is also noted in the certified XML for primary vehicle air drag. No CdxA bonus can then be awarded for such equipment at the complete(d) level. Solutions furthermore need to be elaborated to deal with cases in which the body builder makes changes to the existing aerodynamic configuration because, for example, the existing gap filler does not fit the actual box body. This could be the "requirement list" already mentioned in the previous section.

3.2.6 Mounting of other equipment which is of aerodynamic relevance

In the provisions for CST in the current regulation it is stated that "*all different removable add on parts like sun visors, horns, additional head lights, signal lights or bull bars are not considered in the air drag for the CO2 regulation. Any such removable add on parts shall be removed from the vehicle before the air drag measurement*". This provision certainly makes sense at the base vehicle/primary vehicle level, because firstly, such add-on parts are often added in later manufacturing stages or in the aftermarket (and thus the comparability of the vehicles would not be given at the primary level) and secondly, the number of variants would explode for CST testing.

The strategy how to handle such parts when assembled at the body builder needs to be defined separately. The following options have been identified:

- Neglect as for the primary vehicle (but not fully elegant if only aerodynamic features with positive properties are taken into account in the VECTO results and not others).
- Restrictions on the assembly of such components (would be a market intervention, i.e. triggering a shift to the aftermarket, and could also be problematic for the customer).
- Generic corrections (probably very complicated to elaborate)

[7] Remark: Results for long haul always should be simulated as "R+T" (i.e. also for vehicles with rear flaps) as: Firstly, otherwise the comparability of results with other vehicles would be lost and secondly the overall transport efficiency in long haul missions in the R+T configuration will always be higher compared to R only.

3.2.7 More detailed issues if a sophisticated concept (set of provisions, rules and calculation methods) is chosen

In case a more sophisticated concept for air drag determination is chosen (e.g. similar to trailers with calculation formulas for the influence of the basic configuration and additionally the possibility of CFD certification of aerodynamic features), further methodologically sensitive issues have to be considered:

- Interaction of family concepts at the primary level (air drag family for CST) and the complete(d) level (e.g. in the case of CFD for aerodynamic components). It would have to be ensured that the areas of validity for the two elements do overlap.
- Consideration of the yaw-angle. When evaluating aero features, especially side covers, cross wind effects, i.e. yaw-angle dependency of CdxA play an important role. For this, a coherent approach would need to be found in the combination of methods for the primary vehicle and complete(d) vehicle described above. The problem here is that yaw angle influence cannot be determined or verified via CST at the primary level. Following the approach of trailers for the complete(d) level, the yaw angle influence of ADs should however be taken into account. It must therefore be ensured that the combination of methods still represents the correct tendencies for the aerodynamic configuration of the final vehicle.

In a "simple approach", these detailed questions can probably be given less importance in the development. However, a certain amount of attention must also be paid in a later application to whether the right incentives of the approaches predominate and artefacts are rather the exception.

3.2.8 Verification requirements

Finally, when developing methods for determining the air drag of complete(d) lorries, the question arises as to whether verification requirements should also be drafted in this context. Relevant elements would be conformity of production and in service verification.

If a simple approach is chosen for the complete(d) level (i.e. only generic formulas), such measures would not make sense. Similarly, none of these elements are foreseen in the trailer legislation.

3.3 *Power take-off (PTO)*

The handling of drag losses of PTOs was intensively discussed in the context of the work on the second amendment of Regulation (EU) 2017/2400. The approach as currently implemented only reflects an incomplete and slightly distorted state as:

- PTOs mounted after the "base vehicle" stage are not considered
- Only “transmission PTOs” are covered (the other main relevant mounting position is at the engine, which accounts for some 50% of the cases)

- There is currently only a single PTO to be declared, whereas there might be more than one on-board

An extension of Regulation (EU) 2017/2400 to a complete(d) vehicle approach thus in principle offers the possibility to correct those deficiencies. However, in the elaboration of extended provisions, the following boundary conditions need to be taken into account:

- Relevance of PTOs for the vehicle groups under consideration for multi-step complete(d), i.e. 4 and 9 with box shaped body work. A rather low significance is assumed here as PTOs are typically used for construction and municipal vehicles. This assumption was compared by the feedback as received by stakeholders. [8]

- Should there be any change to the current methods for vehicles that are still treated according to the "base vehicle" approach (i.e. rigids with non-box bodies and groups not allocated to multi-step complete(d))? As the current approach has already been a difficult compromise between the positions of the Commission, ACEA and CLEPA, it is recommended that no changes should be made.

- Consequences for the CO_2 standards if the approach is changed. Presumably, the changes would be below the limit that would make an “adjustment” necessary.

Based on an analysis of the situation, two possible options were identified for dealing with the PTO issue in the context of complete(d) rigid lorries:

❖ **Option 1**

Due to the low relevance of PTOs for the rigid lorry groups in focus, the current provisions could be continued unchanged. In concrete terms, this would mean:

- Base/primary vehicle declares a PTO as specified by the 2nd amendment

- No further input on PTO at the complete(d) vehicle level

❖ **Option 2**

This option aims to fully capture the drag losses of all PTOs on the complete(d) vehicle and would thus address all deficiencies as described in the introduction to this section. This includes the following elements for the complete(d) vehicle stage:

---

[8] At the stakeholder meeting on 18 February 2022 and in the feedback by CLCCR as received at the end of the project it was mentioned that "PTOs" in rigid lorries are sometimes also used to drive the refrigeration unit in the case of refrigerated bodies. A closer analysis shows that, technologically, these are not the "classic mechanical" PTOs discussed here, but additionally mounted belt driven alternators that cover the electrical power demand of the electrical refrigeration machines. This power demand could be treated in VECTO in the same way as the electrical system (and without requiring additional inputs to "PTO").

If the energy consumption of the refrigeration unit, as with the first trailer regulation, is not part of the procedure, this topic would also not (yet) be relevant.

- All PTO mounting positions to be considered: engine, transmission, others of relevance (e.g. sandwich?[9])
- Multiple PTOs at certain positions to be declared
- For any PTO technology which does not have a shifting or clutch element: generic drag of a coupled hydraulic pump to be added, otherwise the customer would be misinformed by the impact predicted by VECTO. This approach was already partly introduced with the second amendment.

For the primary vehicle or base vehicle stage, in option 2 no change to 2nd amendment provisions is recommended.

An implementation of option 2 would require considerable method development and a large amount of coordination between ACEA and CLEPA. Thus this option is only recommended if the PTO topics gets a high priority by stakeholders and by the Commission.

3.4 *Auxiliaries*

An analysis regarding the auxiliary configurations has shown that in the case of rigid lorries no further input information is required after the primary stage. The only exception would be if steered axles are added to the vehicle configuration at the complete(d) stage. For such cases, anyhow, rules need to be provided at a higher level, because such would also entail a change of the vehicle group. Analogous to heavy buses, it is recommended for such changes corresponding to the primary vehicle configuration, the VECTO process must be started again at the primary vehicle.[10]

3.5 *Liftable and steered axles*

Impacts of liftable and steered axles are considered in the methods elaborated for trailers and have been claimed by ACEA also for consideration at motor vehicles (however only for driven tandem axles which are not present in group 4 and 9, see presentation at the April 2021 VECTO board). This naturally raises the question of whether those technologies, which are currently not included in the official VECTO values for motor vehicles, should also be taken into account for complete(d) rigid lorries.

In the VECTO Trailer Tool, a very simple approach is used with regard to the influence of liftable and steered axles, namely the application of fixed bonus factors, which are applied on fuel consumption and CO_2 emissions as a final step in the calculation. This approach works out well for the official calculations for

[9] A sandwich PTO is applied in cases where an engine PTO option is not available and a transmission PTO is not capable of providing the necessary amount of mechanical power. For this purpose a dedicated split shaft unit is mounted between engine and transmission ("sandwich") requiring a separate setup of the powertrain system.

[10] For these special cases, a special solution must also be found in Regulation (EU) 2019/1242, as two results are then available at the primary level for a single physical vehicle (but for two different manufacturers).

trailers, as the same generic towing vehicles - with a conventional ICE powertrain - are always used. Such a simple method would not be reasonable in the VECTO application for motor vehicles, because a wide variety of powertrain configurations would have to be taken into account. In addition, the matrix of possible technologies with regard to liftable and steered axles has the additional dimension "driven" and "non-driven" axle. A clean approach to motor vehicles would require e.g. the use of semi-physical models, which describe the reduction of rolling resistance and axle losses “in-side” the corresponding VECTO component models but not as a bonus factors applied to the final results for fuel consumptions and CO_2 emissions in a post-processing step.[11]

With regard to future method development for rigid lorries, three options were identified:

- **Option 1:**

No consideration of liftable and steered axles

- **Option 2:**

Simple consideration of liftable and steered axles, e.g. only for driven tandem axles as proposed by ACEA, which would however affect other vehicle groups than “4” and “9”. Thus this subject would be part of a further development outside the proposed “rigid lorry multi-step” as discussed here.

- **Option 3:**

Comprehensive solution to depict the influence of liftable and steered axles as described in the section 3.5 above. The responsible manufacturer for these technologies would be the primary manufacturer. This raises the question of how to deal with the implementation in the existing CO_2 standards for these vehicles, as the VECTO methods would change compared to the 2019/2020 baseline. Furthermore, the development effort is estimated to be relatively extensive. For these reasons, option 3 is not recommended here.

3.6 Tyres

The vehicle's equipment in terms of tyres may change in the course of the production process. This circumstance must also be taken into account in the provisions on the multi-step process. In this regard it is recommended for rigid lorries to adopt the provisions laid down in the second amendment for heavy buses:

“ *... as long as the tyres used in the primary vehicle simulation are with the vehicle when it is registered, sold or put into service additional tyre sets added to the vehicle do not require a new primary vehicle simulation*”.

---

[11] In this context it is noted that VECTO is a pure longitudinal dynamics model that does not include modelling of cornering resistance. As a result, the basic energy consumption, compared to which liftable and steered axles bring savings, is not included in the model at all. However, the effect could still be included, as the potential savings in total energy consumption of these technologies are within the range of VECTO's systematic uncertainties in terms of rolling and aerodynamic drag.

In the event that the tyres are replaced, the VECTO process must be restarted at the primary vehicle level.

4 How an approach tailored to the structure of rigid lorry manufacturing could look like

In the following, an attempt is made to design a tailored approach, i.e. adapted to the structure of rigid lorry manufacturing, with the current state of knowledge. The focus is on rather simple approaches that nevertheless should reflect the right trends in vehicle energy consumption. As mentioned above, simple yet well-functioning approaches are not necessarily much less elaborate in development. This point is particularly relevant for the topic of method development air drag and should be taken into account in the design of the project work.

Which properties of the complete(d) vehicle should be covered and how?

Table 4 outlines a specific proposal for a simple input data scheme to cover complete(d) rigid lorries by Regulation (EU) 2017/2400.

Table 4: Simple input data scheme to cover complete(d) rigid lorries

Vehicle property	Simple way how to cover	Related challenges in method development
Mass	"Corrected actual mass" to be defined for Annex III and to be determined for each complete(d) vehicle	No substantial challenges expected
Air drag / Influence of aero features	Generic ΔCdxA scheme to be defined and applied in case of: • roof spoiler present which was not on primary vehicle • gap filler present which was not on primary vehicle • side covers • rear flaps (in case of relevance for rigids) Furthermore, it could be analysed whether certain guidelines for bodybuilders make sense that have to be followed with regard to aerodynamics (e.g. handling of spoilers that were already part of the equipment of the primary vehicle). In case of non-compliance, VECTO could apply a generic CdxA increase.	Elaboration of: • Proper definition for each of the devices • generic values • judgement that the approach works properly for not less than some 80% of the cases • discussions with stakeholders on the limitations of the approach i.e. that not all systems on the market will be covered properly
Air drag / Influence of body dimensions	Generic formulas to consider body dimensions different to standard body: • Total vehicle height	Elaboration of: • generic functions • an analysis of whether the influence of the body dimensions on

Vehicle property	Simple way how to cover	Related challenges in method development
	• Body width (if considered necessary) • Body length (if considered necessary)	air drag is significant enough to be considered separately in the Regulation. If, as described above, only group 4 and 9 vehicles are covered, this effect could possibly be neglected. • In case body dimension influence shall be considered: judgement that formulas work properly for not less than 80% of the cases
PTOs	No further provisions compared to 2nd amendment of Regulation (EU) 2017/2400 and no input on PTO on the complete(d) stage	None
Liftable and steered axles	No consideration	None
Tyres	Apply similar principle as for heavy buses: “ ... as long as the tyres used in the primary vehicle simulation are with the vehicle when it is registered, sold or put into service additional tyre sets added to the vehicle do not require a new primary vehicle simulation”	None

Minimising the effort in the official application – for primary vehicle manufacturers

The key points identified for a lean VECTO process for primary vehicle manufacturers are as follows:

- No major changes to the currently applicable VECTO process. Similar provisions should apply independently whether a specific rigid lorry falls under “multi-step complete(d)” or “base vehicle + standard body”.

- Only minor changes to the current provisions regarding air drag certification, i.e. the information needs to be included in the air drag XML which of the defined "aero devices" is already included in the primary vehicle CdxA and which not

- The CdxA value of the primary vehicle shall be written to the VIF (or the highest value in the CdxA bin used for monitoring, if the former is not preferred by the manufacturers in general of the specific OEM in particular).

- All necessary steps in VIF file handling can be automated, analogous to the existing system at heavy buses. The VIF shall be provided to subsequent vehicle manufacturers.

Minimising the effort in the official application – for body builders:

For body builders, the complete(d) vehicle approach in Regulation (EU) 2017/2400 means a considerable additional effort in any scenario. Studying the legal provisions, setting up the official processes with the approval authority and a minimum of effort in the actual determination of the official results for the final vehicle cannot be avoided. The operational framework for such a "minimum" effort could be as follows:

- Availability of a standardised tool with a simple graphical user interface (as the “multi-step tool” for heavy buses, but with much less input parameters to be provided)

- Limitation of the obligations in the process to manufacturers of the complete(d) vehicle (so-called "interim manufacturers", as they are also relevant for heavy buses, would thus not be involved in the VECTO process).

- Limitation of the work steps in the tool for body builders to a few steps:

    - Import of VIF from primary manufacturer (or previous manufacturer of the complete(d) vehicle)

    - Specification of mass, aero features (yes/no) and relevant overall vehicle dimensions

    - Based on this information the tool calculates the set of official CO2 figures (using the factor method in the background) and writes the hashed output files

- Process license provisions: In case of SMEs the tool may be operated by a technical service

- Verification provisions for CdxA or any other vehicle specification which is input to VECTO : No additional measures to existing type approval regulation (as for trailers)

In addition, CLCCR suggests in its feedback that the CO_2 value of the primary vehicle could be directly adopted for the complete(d) vehicle if the actual body remains within certain tolerances (dimensions, mass?) compared to the standard body. How this approach could be implemented in concrete terms would first have to be analysed (e.g. since the elimination of obligations in relation to Regulation (EU) 2017/2400 is the objective: can this be fully achieved?).

5 Summary of stakeholders feedback

The content described in chapters 2 to 4 were officially presented and discussed in a meeting on 18 February 2022 with stakeholder representatives from the various associations. The slides shown there are included in Annex A of this report.[12] At this meeting, specific questions were distributed to the organisations, for which written feedback was requested by 25 March.

In total, two questionnaires were received as responses from CLCCR and ACEA. Below is a summary of the main key points of the feedback as concluded by the author of this report. The resulting additional information and ideas have been incorporated into the previous chapters. The complete questionnaires are given in Annex B (CLCCR) and Annex C (ACEA).

- **Summary feedback by CLCCR**:
  - The overall relevance of the topic (share of box bodies and associated reduction potential) should be further investigated in order to avoid disproportionate effort.
  - Manufacturers of truck bodies are not comparable with manufacturers of heavy bus bodies (much smaller share of value added, higher number of very small companies).
  - Share of vehicles < 3.9 meters total height in groups 4 and 5 is less than 1%.
  - Proposal that the CO_2 value of the primary vehicle also applies for the complete(d) vehicle if the actual body is within certain tolerances.
- **Summary feedback by ACEA**:
  - Confirmation of the basic analyses and proposals as discussed by TUG at the stakeholder meeting.
  - Restricting additional provisions for rigid lorries to certain sub-sectors (groups, bodywork types) could cause disruption in the market.
  - CdxA values for primary vehicles and CAD data for the vehicles are considered confidential information.
  - ACEA sees issues with addressing the only vehicles that actually are well represented by the todays VECTO scheme. The shown increased complexity, work load and most likely increased inaccuracy (e.g. using aero bins) will, in their view, not add value to the current procedure.

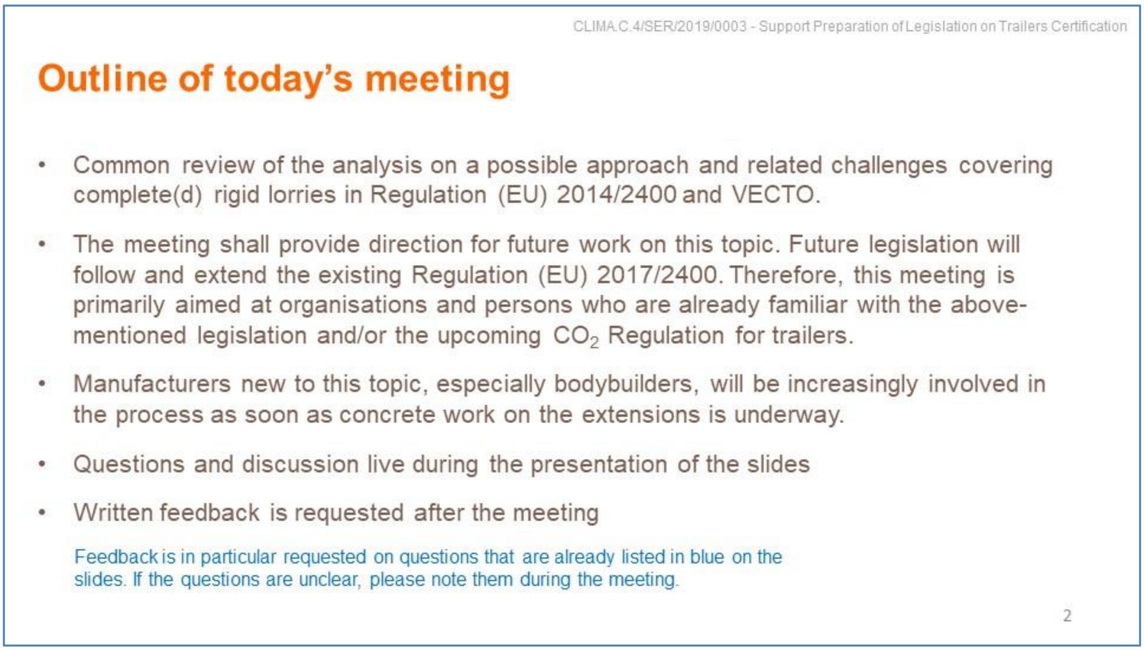
[12] The analyses shown in this report on the relevance of the vehicle groups and the associated reduction potential were developed in this form (using the data from [1]) after the stakeholder meeting.

6 Bibliography

[1] Nik Hill et al, Technical support for analysis of some elements of the CO2 emission standards for heavy duty vehicles (HDV) Service Request N'2020/19 (SR19): Under Framework contract CLIMA.A4/FRA/2019/0011.

[2] DG CLIMA, Bodies and trailers – development of CO2 emissions determination procedure. Procedure Number CLIMA/C.4/SER/OC/2018/0005, 2019.

Annex A – Slides as shown at the stakeholder meeting on the 18th of February



Content

- Objective
- Analysis of boundary conditions
  - Relevance of rigid lorries vehicle groups
  - Legislative approach in Regulation (EU) 2017/2400
  - Technical approach in VECTO
  - Vehicle production process
- Analysis of options which properties / parameters of the complete(d) vehicle should be considered and how
  - Attempt 1: Following the level of sophistication as applied for heavy buses and trailers
  - Attempt 2: Simplified process adapted to the situation of the sector
- If necessary, discussion of relevant topics which were not covered
- Organisation of written feedback

3

OBJECTIVE

4

Objective

Extension of Regulation (EU) 2017/2400 so that properties of the „complete(d) vehicle" as to be registered on the road are covered.

Vehicle specifications which might be different at the final vehicle compared to the conditions as currently covered by VECTO for lorries (i.e. „base vehicle" + standard body) are:

a) Mass
b) C_dxA
c) PTO
d) Auxiliaries
e) Liftable / steered axles
f) Tyres

ANALYSIS OF BOUNDARY CONDITIONS

Analysis of boundary conditions

- Which vehicle groups are most relevant for a „complete(d)“ approach?

Vehicle group		Cumulated CO_2 2020-2035 [Mt CO_2]		Mission profile weights: Long haul	Regional delivery	Urban delivery	Municipal delivery	Con-struction	Generic CAD models already available	Proposal for a first implement-ation	Explanations
9	RD	104.1	350.5	10%	90%	0%	0%	0%	yes (day cab?)	INCLUDE	
	LH	246.4		90%	10%	0%	0%	0%	yes (sleeper cab)	INCLUDE	
4	UD	4.8	134.4	0%	0%	100%	0%	0%	yes (day cab?)	INCLUDE	
	RD	94.0		10%	90%	0%	0%	0%	yes (day cab?)	INCLUDE	
	LH	35.6		90%	10%	0%	0%	0%	yes (sleeper cab)	INCLUDE	
2		89.6		0%	50%	50%	0%	0%	no	exclude	Significantly different aerodynamics than group 4 and 9 (other cab heights, more variance in body heights and spoilers) → air drag more complex to cover
16		88.0		0%	0%	0%	0%	100%	no	exclude	8x4, boxed shaped bodies of no relevance → even more difficult to regulate than group 2
3		71.4		0%	50%	50%	0%	0%	no	exclude	as for group 2
11		46.7		0%	50%	0%	0%	50%	no	exclude	6x4, as for group 16
1		37.2		0%	40%	60%	0%	0%	no	exclude	as for group 2

Source ICCT, 2021: Ragon P. et al.: Benefits of extending the EU´heavy-duty CO2 emissions standards to other truck segments

7

Analysis of boundary conditions

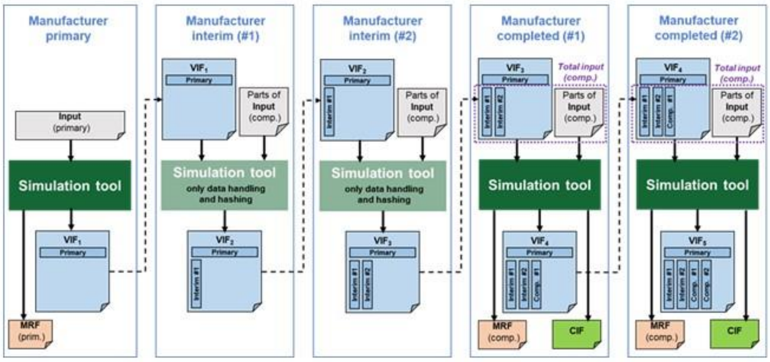
- Which vehicle groups are most relevant for a „complete(d)“ approach?
- → Recommendation:
  - Go for „complete(d)“ vehicle approach in **group 4** and **group 9** for vehicles with „box shaped bodywork“ as in the trailer Regulation, i.e. **bodywork codes 03, 04, 05, 06 and (32, tbd)**
  - Rest of heavy lorries to continue with „base vehicle“ (cab + chassis + standard body) approach only

8

Analysis of boundary conditions

Legislative approach:

Wrap up of "multi-step process" to involve several manufacturers as applied for heavy buses



See detailed explanation in point 2. of Annex I of 2nd amendment to Regulation (EU) 2017/2400
"Primary vehicle" stage corresponds to the base vehicle stage except that primary vehicle stage also applies in the case of complete vehicles.

9

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

Analysis of boundary conditions

Legislative approach:

For the involvement of several vehicle manufacturers it seems to be obvious to **adopt the "multi-step" process** as developed for the 2nd amendment for heavy buses. The following principles can be adopted with possibly only minor adaptations:

- Definitions for the different types of manufacturers (primary, interim, complete, completed)
- Data flow principles from primary to complete(d) vehicle (VIF, hashing etc.)

New provisions will be necessary:

- Input data and input information to be provided per manufacturer type
- VTP (item for the further future, i.e. the x+1st/2nd amendment)

10

Analysis of boundary conditions

Technical approach:

Adopt the „factor method“ as explicitely implemented for heavy buses and implicitely applied for trailers.

In doing so main simulation tool structures as already developed for heavy buses can be maintained, adaptions will be necessary due to differences in input parameters and „typical vehicles“ for

- Generic data used at the complete(d) steps
- For aerodynamic drag a large set of generic formulas needs to be developed (as for trailers)
- XML structures
- Graphical User Interface
- Hashing Tool

11

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

Analysis of boundary conditions

Vehicle manufacturing process

- It can be assumed that in many cases it is not clear at the "base" / "primary" vehicle stage which bodywork the vehicle will end up with. Based on the proposed approach it however depends on the bodywork which of the VECTO methods shall be applied:
  - “cab + chassis + standard body” or
  - “multi-step complete(d)”
- If the provisions for those methods at the "base" / "primary" stage differ (e.g. for CdxA, mass and PTO), this would mean that the manufacturer would have to carry out both processes (input data, simulations, results) in parallel.
- If this assumption is confirmed, it would be a reason to avoid such a differentiation unless absolutely necessary.
- Or in other words: Target of the development should be that there is the same hash in the CoC in case of “cab + chassis + standard body” and in “multi-step complete(d)”

12

Feedback on analysis of boundary conditions

- Slides 7 and 8: Do you agree with the analyses on the relevance of individual vehicle groups for inclusion in a first phase for complete(d) lorries? Do you have other suggestions?
- Slide 10: Do you agree that the multi-step approach as developed for heavy buses can be applied to rigid lorries with the above mentioned adaptions? If you see specific difficulties please specify.
  The question only relates to the general approach (e.g. manufacturer definitions). Determination of specific parameters describing the vehicle is addressed later.
- Slide 12: Do you agree to the outlined boundary conditions from the vehicle manufacturing process?
- Have you identified relevant points which have not been addressed?

13

ANALYSIS OF OPTIONS WHICH PROPERTIES / PARAMETERS OF THE COMPLETE(D) VEHICLE SHOULD BE CONSIDERED AND HOW

Attempt 1: Following the level of sophistication as applied for heavy buses and trailers

14

Vehicle parameters of the final vehicle - Mass

Approach:

"Corrected actual mass" to be defined separately for lorries undergoing "final vehicle" approach

To do's:

Draft for Annex III to be elaborated and discussed with stakeholders

- Slide 15: Do you expect any difficulties with definition of corrected "actual mass" for a complete(d) lorry?

15

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

Vehicle parameters of the final vehicle – C_dxA (1/5)

Boundary conditions:

Existing approaches for C_dxA determination for VECTO:

- **Lorries:** CST cabin + chassis + standard body
- **Heavy buses:** CST with final vehicle body
- **Trailers:** Generic CdxA for standard vehicle configuration + generic formulas for different dimensions + CFD or "standard values" reduction rates for aerodynamic devices

Most obvious approach for complete(d) lorries:

Solution could be to combine existing elements, i.e. CST, generic formulas and CFD

- Primary lorry:
  - CST with cab + chassis + standard bodies
  - CST extended by CFD to cover a wider range of "cab + chassis + standard body" configurations
- Complete(d) lorry:
  - Take over C_dxA from primary lorry as a starting point (issues with confidentially?, use just bins?)
  - Apply generic corrections for real box body dimensions vs. standard body
  - Apply CFD or "standard values" reduction rates for aerodynamic devices

16

CST .... Constant Speed Test

Vehicle parameters of the final vehicle – C_dxA (2/5)

To be addressed in method development for CdxA

- **Vehicle / body height**
  The standard body concept according to Annex VIII specifies that certified CdxA values only have to be determined for a single body height, i.e. 4 meters total height for groups 4 and 9.
- How to handle other body heights?
  It is assumed that for such cases also accessories for roof spoilers and side flaps are used, but no information is currently available in Reg. 2017/2400 / VECTO.
- What is the relevance?
  It is assumed that for vehicle groups 4 and 9 most of the vehicles do have 4 meters height, so simple (and less accurate) approaches for others could be accepted
- Options how to handle other total vehicle heights than 4 meters:
  - Generic corrections + supplementing inputs (like roof spoiler mounted or not at final vehicle)
  - Extension of the standard body concept (e.g. multiple standard body heights, would be extremely elaborate and costly and violate the "same hash" target as formulated on slide 12)
  - Others?

17

Vehicle parameters of the final vehicle – C_dxA (3/5)

To be addressed in method development for CdxA

- **Overlapping responsibilities of primary vehicle OEM and body builder**
  E.g. side flaps / gap fillers could be either mounted by the primary OEM or by a body builder. A method needs to be elaborated which is able to handle both cases and prevents double counting.
- **Modifications to cabin and chassis after the primary stage**
  According to Annex VIII "all different removable add on parts like sun visors, horns, additional head lights, signal lights or bull bars are not considered in the air drag for the CO_2 regulation. Any such removable add on parts shall be removed from the vehicle before the air drag measurement"
  → It must be borne in mind that what is in the end calculated for the the complete(d) vehicle is still meaningful. It would be not elegant if all "positives" (e.g. side covers) were taken into account and all "negatives" (e.g. roof signal lights) were not. Of course "negatives" could always be mounted in the aftermarket ....
- **Any other issues with the existing family concept according to Annex VIII?**
  Interaction between freedoms in the family concept according to Annex VIII and generic formulas for body dimensions and aerodynamic devices (certified or standard values) need to be analysed.

18

Vehicle parameters of the final vehicle – C_dxA (4/5)

To be addressed in method development for CdxA

- **Interaction ACEA CFD proposal with methods for bodies (generic formulas + aero devices)** to be analysed
- **How to handle yaw angle influence**
  This influence cannot be determined or verified by CST.
  The generic corrections as applied for tailer box dimensions however cover this influence.
  How to deal with this in the proposed combined approach for rigids?
- **Consideration of aerodynamic devices (AD)**
  - Are there definitions needed which ADs belong to the "cabin" (and thus to the CdxA allocated to the primary OEM) and which to the "body"?
  - Is the use of generic CAD models sufficiently accurate to determine the effect of body related ADs?
  - Which body related ADs shall be available as standard values?
    e.g. side covers in 1 to 2 versions, rear flaps in 1 to 2 versions, combination of both, others?

19

Vehicle parameters of the final vehicle – C_dxA (5/5)

To be addressed in method development for CdxA

- **Consideration of aerodynamic devices (AD) continued**
  - Rigid trucks are simulated in VECTO in two vehicle configurations:
    - as truck and standard trailer ("R+T") combination in long haul
    - as solo rigid ("R") in other cycles
    This means that the impact of ADs needs to be evaluated separately for those two cases.

    Remark: Results for long haul always should be simulated as "R+T" (i.e. also for vehicles with rear flaps as):
    - Otherwise the comparability of results with other vehicles would be lost
    - The overall transport efficiency in LH in R+T configuration will always be higher as R only. So no result should be provided for R in LH.
- **Verification requirements**
  - Any changes in CoP for "primary vehicle manufacturer" (due to CFD option and/or possible additional provisions for standard bodies, add ons etc?)
  - Any CoP for the complete(d) vehicle manufacturer? There isn't any CoP for trailers ....
  - In Service Verification to be discussed at later stage

20

Feedback on vehicle parameters of the final vehicle – C_dxA

- Slide 16: Do you have any basic other ideas as the outlined method to determined CdxA for complete(d) lorries?
- Slide 17: What is the approx. share of vehicles < 3.9 meters total height on group 4 and 9 box body (curtain, drybox, conditioned, refrigerated) vehicles?
- Slide 18: Any ideas how to treat aero influence of removable add on parts like sun visors, horns, additional head lights, signal lights or bull bars on the complete(d) vehicles' air drag?
- Slides 16 to 20: Other questions as listed related to air drag are assumed to be subject to deeper analysis in a dedicated task force. If you already have specific comments or ideas please specify ...

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

Vehicle parameters of the final vehicle – PTO (1/3)

Boundary conditions:

- Dealing with PTOs was intensively discussed for the second amendment, as the current approach only reflects an incomplete and slightly distorted state regarding drag losses from PTOs
  - PTOs mounted after the "base vehicle" stage are not considered
  - Only "transmission PTOs" to be declared
  - Only a single PTO to be declared etc.
- The extension to the complete(d) vehicle approach thus offers the possibility to correct this deficiency. However, some boundary conditions must be taken into account:
  - How relevant are PTOs for the vehicle groups under consideration (i.e. 4 and 9 with box shaped body work)? Assumption: low importance for those
  - Should something be changed in the approach for vehicles that are still treated according to the "base vehicle" procedure? → default = no
  - Consequences for the CO2 standards

Vehicle parameters of the final vehicle – PTO (2/3)

Approach - Option 1

- Due to the assumed low importance of PTOs for the vehicles under consideration no change compared to the current provisions, i.e.;
  - Base/primary vehicle declares PTO as specified by the 2nd amendment
  - No further input on PTO at the complete(d) vehicle

23

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

Vehicle parameters of the final vehicle – PTO (3/3)

Approach - Option 2

- For the complete(d) lorry all PTOs should be considered
  - All mounting positions: engine, transmission, others of relevance (e.g. sandwich)?
  - Multiple PTOs at certain positions to be considered
- For any PTO technology which does not have a shifting or clutch element: generic drag of a coupled hydraulic pump to be added, otherwise consumer is desinformed by the impact predicted by VECTO. This approach was already partly introduced with the second amendment.
- For the primary / base lorry: no change to 2nd amendment (would violate postulation from slide 7 and slightly mix up CO_2 standards)

→ *Option 2 would require considerable method development and a large amount of coordination between ACEA and CLEPA --> only possible if desired by stakeholders and/or highly preferred by COM*

24

Feedback on vehicle parameters of the final vehicle – PTO

- Slide 22: What is the relevance of different PTOs for the targeted vehicle group (groups 4 and 9 with curtainsider, drybox, conditioned and refridgerated bodies)?
- Slides 23 and 24: Please specify your favourite option if possible with an argumentation.

25

Vehicle parameters of the final vehicle – Auxiliaries

Boundary conditions

- Analysis given below, whether a change in auxiliary parameters from primary to completed lorry needs to be considered.
- Conclusion that **no inputs on auxiliaries might be required after the primary lorry stage**.

Auxiliary type	Relevant change from primary to completed lorry?
Engine cooling fan	**No**
Steering system	**No**, under the boundary condition that changing the axle configuration requires a new "primary vehicle step"
Electric system	**No**
Pneumatic system	**No**
Heating, ventilation and air conditioning (HVAC) system	**No**

As for trailers it is assumed that power/energy demand for refridgerated vehicles (insulation, A/C units) are to be added in later amendments ....

- Slide 26: Any comments on the analysis regarding auxiliaries?

26

Vehicle parameters of final vehicle – Liftable + steered axles (1/2)

Boundary conditions

- Impacts of liftable and steered axles are considered in the methods elaborated for trailers and have been claimed by ACEA also for consideration at motor vehicles (however only for driven tandem axles which are not present in group 4 and 9)
- Method development for a comprehensive solution is estimated to be much more complex than for trailers as some additional factors come into play:
    - With motor vehicles there are more options as to which axle can be lifted or steered, as there is the additional degree of freedom "driven" / "non-driven" axle.
    - The simple method as used in the trailer tool (correction of the final value for FC/CO_2 with a bonus factor) is not applicable due to the variety of powertrain variants. Therefore, semi-physical methods would have to be developed, i.e. reduction of the rolling resistance and axle losses "in-side" the VECTO component models.

27

Vehicle parameters of final vehicle – Liftable + steered axles (2/2)

Options

- Option 1: No consideration
- Option 2: Simple consideration, e.g. only for driven tandem axles as proposed by ACEA, which would however affect other vehicle groups than "4" and "9" → this subject would need to be discussed separately
- Option 3: Comprehensive solution as described on bottom of the previous slide
    - Would require substantial method development
    - The related input in VECTO would be at the "primary manufacturer"* → to be defined how such should be handled in the Reg. 2019/1242 (include + adjustment, not consider → 2 sets of results, others?)

  → Not recommended at this stage

* Any changes in axle configuration and/or the TPMLM after the primary manufacturer would require a "restart" of the VECTO process at the primary stage. In current regulation this does not show up in the VECTO results in the CoC.

28

Feedback on vehicle parameters of final vehicle – Liftable+steered

- Slide 28: Which of the options to consider the impact of liftable and steered axle should be followed up from your point of view?

29

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

Vehicle parameters of the final vehicle – Tyres

Tyres

- Tyres might change from base / primary vehicle to final vehicle
- Following the approach as defined for heavy buses, a pure replacement will result in a "re-start" of the VECTO process at the primary vehicle. In order to reduce this consequence, it is proposed to adopt the provisions of heavy buses in this respect:

  > " ... as long as the tyres used in the primary vehicle simulation are with the vehicle when it is registered, sold or put into service additional tyre sets added to the vehicle do not require a new primary vehicle simulation"

- Slide 30: Any comment regarding the analysis and the proposal related to tyres?

30

ANALYSIS OF OPTIONS WHICH PROPERTIES / PARAMETERS OF THE COMPLETE(D) VEHICLE SHOULD BE CONSIDERED AND HOW

Attempt 2: Simplified process adapted to the situation of the sector

31

What properties of the complete(d) vehicle should be covered and how (1/2)?

Property	Simplest way how to cover	Challenges
Mass	"corrected actual mass" to be defined and to be specified	none
Air drag / Influence of aero features	Generic ΔCdxA scheme to be defined and applied in case of: • Roof spoiler present which was not on primary vehicle • Gap filler present which were not on primary vehicle • Side covers • Rear flaps (are those of real relevance?)	Elaboration of: • Proper definition for each of the devices • generic values • judgement that the approach works properly for not less than some 80% of the cases
Air drag / Influence of body dimensions	Simple generic formulas to consider body dimensions different to standard body • Total vehicle height • Body width (?) • Body lenght (?)	Elaboration of generic functions and judgement that those work properly for not less than 80% of the cases

32

What properties of the complete(d) vehicle should be covered and how (2/2)?

Property	Simplest way how to cover	Challenges
PTO	Not consider	
Liftable and steered axles	Not consider	
Tyres	" ... as long as the tyres used in the primary vehicle simulation are with the vehicle when it is registered, sold or put into service additional tyre sets added to the vehicle do not require a new primary vehicle simulation"	None

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

How could the approach look like?

- Minimising the effort in the official application – for primary vehicle manufacturers:
  - VECTO process as before, i.e. no differentiation of provisions whether VECTO is continued for the complete(d) vehicle or not
  - VIF is automatically written by the tool for all simulated rigid lorries and shall be provided to subsequent vehicle manufacturers
  - The CdxA value of the primary vehicle is written into the VIF (or the highest value in the bin used for monitoring, if the former is not preferred by the OEM).
  - In the certification of the air drag, the information must be included in the XML which of the defined "aero devices" is already included in the primary vehicle CdxA

How could the approach look like?

- Minimising the effort in the official application – for body builders:
  - Standardised tool with a simple graphical user interface
  - Actions to be carried out in the tool by the body builder:
    - Import of VIF from previous manufacturer
    - Specification of mass, aero features (yes/no) and relevant overall vehicle dimensions
    - Based on this information the tool calculates the set of official CO_2 figures (using the factor method in the background) and writes the hashed output files
  - Process license provisions: In case of SMEs the tool may be operated by a technical service
  - Verification provisions for CdxA or whatever: No additional measures to existing type approval regulation (as for trailers)

CLIMA.C.4/SER/2019/0003 - Support Preparation of Legislation on Trailers Certification

How could a simple but still reasonable approach look like?

- Slides 32 to 35:
  - Any feedback or comments on the content?
  - Do you have any other ideas how the properties of the „complete(d) vehicle“ as to be registered on the road could be considered by Regulation (EU) in a simple way?

DISCUSSION + FEEDBACK

37

Discussion plus further feedback ...

- Was any relevant aspect regarding covering "complete(d)" rigid lorries by Regulation (EU) 2017/2400 and VECTO missed in the analysis? If yes, please specify.

38

Organisation of written feedback

- The presentation will be distributed after the meeting together with an MS Excel containing the questions asked.
- Please provide a consolidated feedback per stakeholder organization (CLCCR, ACEA, CLEPA, ETRMA, others?) + individual feedback if desired
- Feedback to be provided to Krisztian.UHLIK@ec.europa.eu and rexeis@ivt.tugraz.at
- Written feedback requested until **Friday 25th of March**

39

Annex B – Feedback to stakeholder meeting by CLCCR

Table 5: Feedback to stakeholder meeting by CLCCR

Name of the organisation or the company	*CLCCR*
Slides 7 and 8: Do you agree with the analysis on the relevance of individual vehicle groups for inclusion in a first phase for complete(d) lorries? Do you have other suggestions?	*The analysis of the dates in slide 7 is o.k. But we need a detailed look on the share of box shaped bodies in the specific vehicle classes 4 and 9. It is assumed that the integration of real box shaped bodies may be reduced on a table with important "max./min. extrema" for these vehicle groups and a second table with air drag reduction potentials of the main air drag parts.*
Slide 10: Do you agree that the multi-step approach as developed for heavy buses can be applied to rigid lorries with the above mentioned adaptions? If you see specific difficulties please specify. *The question only relates to the general approach (e.g. manufacturer definitions). Determination of specific parameters describing the vehicle is addressed later.*	*The manufacturers of heavy bus bodies and of truck bodies are not comparable. The truck body manufacturers are mostly very small SMT`s with regional businesses. The product "truck body" is compared to a bus body a very simple product and has only a small share of the costs of a completed heavy duty truck. So the body manufacturers can`t be responsible for the completed vehicle and the CIF do not help them in their businesses.*
Slide 12: Do you agree to the outlined boundary conditions from the vehicle manufacturing process?	*A detailed description of the process is needed. The proposal does not reflect the reality of the market. It appears to believe that bodybuilders buy chassis (with incomplete CoC), fit bodywork and then find a buyer for the truck! This is not the reality.*
Have you identified relevant points which have not been addressed?	*Please take into account small body manufacturers and keep the possibility to avoid additional calculations when real body is similar to standard body.*
Slide 15: Do you expect any difficulties with definition of corrected “actual mass” for a complete(d) lorry?	*Maybe additional auxiliaries and PTOs equipped by customers in a third step after certification would lead to a mismatch of certified data and data measured in the field (In-service verification)!*
Slide 16: Do you have any basic other ideas as the outlined method to determined CdxA for complete(d) lorries?	*Theoretically the approach is ok. But for practical handling we suggest a simple method to calculate air drag as used for trailers. Due to the limited variation in length, height and width in the field a more simplified approach may be the use of pre-calculated min/max values.*
Slide 17: What is the approx. share of vehicles < 3.9 meters total height on group 4 and 9 box body (curtain, dry box, conditioned, refrigerated) vehicles?	*<1% - In reality the number of vehicles below 3.9m height are not relevant in the field of closed box bodies designs.*

Slide 18: Any ideas how to treat aero influence of removable add on parts like sun visors, horns, additional head lights, signal lights or bull bars on the complete(d) vehicles' air drag?	*The influence of that parts can`t be assessed, if they are mounted after the vehicle comes into operation. Similar challenge is seen when other tyres will be mounted. Such parts should be ignored for certification.*
Slides 16 to 20: Other questions as listed related to air drag are assumed to be subject to deeper analysis in a dedicated task force. If you already have specific comments or ideas please specify ...	*All open questions should be discussed with experts in a task force based on data and specific experience with the aerodynamic issue (experts from truck manufacturers, IDIADA, suppliers of aero-features).* *The main goal should be to simplify the process.*
Slide 22: What is the relevance of different PTOs for the targeted vehicle group (groups 4 and 9 with curtainsider, dry box, conditioned and refrigerated bodies)?	*A lot of cooling systems for refrigerated bodies on rigid trucks in RD are driven by a generator belt driven by the combustion engine. Unfortunately we cannot specify the power of these generators. In the case of truck bodies, today about 70% are equipped with separate diesel-driven cooling machines and 30% are equipped with cooling systems which generators driven by the engine of the lorry. Technology tends to use more and more cooling systems which are power-driven by the engine of the lorry. It is recommended to contact "Transfrigoroute Europe" and to check the requirements in the UNECE ATP handbook for the Transport of Perishable Foodstuffs. The influence of cooling system for refrigerated bodies are not neglectable in the CO2 balance but this aspect is considered and regulated in the ATP handbook.*
Slides 23 and 24: Please specify your favourite option if possible with an argumentation.	*Option 1 and please get in contact with "Transfrigoroute Europe". ATP is to be checked*
Slide 26: Any comments on the analysis regarding auxiliaries?	*Follow the approach for auxiliaries/PTOs as agreed in the current regulations for HDVs.*
Slide 28: Which of the options to consider the impact of liftable and steered axle should be followed up from your point of view?	*Question relates to truck manufacturers and not to body manufacturers.*
Slide 30: Any comment regarding the analysis and the proposal related to tyres?	*This is under the responsibility of truck manufacturers.*
Slides 32 to 35: Any feedback or comments on the content?	*Input parameters as described in slide 32/33 are to be considered taking into account limited capabilities of body manufacturers. Standardised tool with a simple graphical user interface is essential.*
Slides 32 to 35: Do you have any other ideas how the properties of the „complete(d) vehicle" as to be registered on the road could be considered by Regulation (EU) in a simple way?	*The simplest way is to take the CO2 value of the primary vehicle with the standard body as accepted for the real box body assumed that tolerances in dimensions are acceptable. But before that decision is made a "delta analysis/parameter study" should be made to analyse the CO2 emission delta between a best and worse case scenario.*

Was any relevant aspect regarding covering “complete(d)” rigid lorries by Regulation (EU) 2017/2400 and VECTO missed in the analysis? If yes, please specify.	*1. A analysis is needed to show the effect on CO2 emissions for real box shaped bodies of vehicle groups 4 & 9 compared with standard bodies as defined today.* *2. We assume that real bodies must be simulated in such accuracy/precision compared to the standard body, what most body manufacturers have never done before. Question: Is it possible to define a matrix with factors which describe the effects of the main parameters, e. g. dimension, aero devices?*
Any other topic you want to raise or ideas you like to share?	*1. The approaches for heavy buses and trailers are much to complicate for handling by the huge number of small SMT in Europe! Analyse the effects before discussing details for a regulation very intensively. Do we need such complexity in the CO2 certification process? Due to the large number of body manufacturers and their small product volume a detailed analysis of the final effect to incorporate these designs into the certification is needed. Furthermore the production of bodies on rigid lorries is not comparable with the process for the buses. We suggest to analyse in a cost-benefit study the role of the body manufacturers with regard to possible CO2 reduction.* *2. It is expected that the separate calculation of the body (closed box design) correlates closely with the calculation of the truck manufacturer with the standard body. Improvements based on other dimension contradicts the general use case of a closed box design. Improvements related to reduced air drag are limited especially in most business cases under the responsibility of the body manufacturer. We would suggest to retain the possibility to use the standard body as defined today as alternative for whose manufacturer with limited capacities. In addition we suggest to perform a parameter study for possible improvements based on the today existing restrictions on masses and dimensions. Length, height, weight are comparable over the whole vehicle fleet and base on the use case.* *3. Remark: In mission profile "LH" CO2 emission values are simulated for truck/trailer combinations only . In the current (EC) 2017/2400 the air drag influence of trailers is considered by a factor 1.5 for T2 and 1.3 for T1, because we didn`t have detailed information at that time when the regulation was developed. In the meantime much detailed knowledge (CFD models, CFD simulations, influence of volume vs. standard trailers etc.) was worked out for the trailer regulation. That means for a revised regulation the different complete(d) rigid trucks can be combined with "correct" specific "standard trailers" (centre axle trailer, 2-axle drawbar trailer, 3-axles drawbar trailer). The data of these e.g. three "standard trailers" can be taken out of the matrix for reference trailers used in the trailer regulation.*

Annex C – Feedback to stakeholder meeting by ACEA

Table 6: Feedback to stakeholder meeting by ACEA

Name of the organisation or the company	*ACEA*
Slides 7 and 8: Do you agree with the analysis on the relevance of individual vehicle groups for inclusion in a first phase for complete(d) lorries? Do you have other suggestions?	*"- Agree with TUG: if necessarry at all: only groups 4 and 9 - In general not fair to adress only few vehicle groups when the overall aim is to catch CO2 reduction potential in the n-stage vehicle market - Disturbances between single vehicle markets must not happen, when only few groups are being regulted"*
Slide 10: Do you agree that the multi-step approach as developed for heavy buses can be applied to rigid lorries with the above mentioned adaptions? If you see specific difficulties please specify. *The question only relates to the general approach (e.g. manufacturer definitions). Determination of specific parameters describing the vehicle is addressed later.*	*Agree - How to compare OEMs AirDrag measurement with standard body to BB CST or even CFD simulation to lead to a fair and scientific reasonable correction factor? - Feasible for interim and final manufacturer?"*
Slide 12: Do you agree to the outlined boundary conditions from the vehicle manufacturing process?	*"- In any case, a primary lorrie needs to have a VIF, MRF and CIF -However, a downstream BB has to simulate the completed vehicle and generate new hashes for the n-stage CoC - In case there is only one OEM for Chassis and actual body (complete vehcile) therefore only one set of hasehes would be preferred to reduce burden"*
Have you identified relevant points which have not been addressed?	*"- Main differences from Rigid lorry to Bus: - utilization target, variety and flexibility of outer body constructions and mounts possible for one and the same rigid vehicle - strong impact of rigid lorry base vehicle on total air drag for complete(d) rigid lorry - Compared to rigid lorries, for Buses we understand that the real body influences certainly the fuel consumption of the whole vehicle compared to a standard body. Both businesses shall be compared in this stakeholder group - Difficulties with structures and processes in rigid lorry bodybuilder business are even higher than for Buses - In general, when simplifying everything, why at all doing such a regulation - When a lorry can do the same job as a tractor trailer*

	combination, they will be treated by different regulations. Will this not disturb the market "
Slide 15: Do you expect any difficulties with definition of corrected "actual mass" for a complete(d) lorry?	*How can small BB define the corrected mass within +/-3% ?* *A clear definition on how to do the correction is missing.* *To be checked with CLCCR.*
Slide 16: Do you have any basic other ideas as the outlined method to determined CdxA for complete(d) lorries?	*We see very little added value to this effort, considering that box bodies are currently already well taken into account in the current regulation 2017/2400 with standard bodies.* *It would also be a great amount of added work for bodybuilders, considering their situation we think this added regulatory burden is not really realistic.* *If CFD should be used, it means that the OEM has to send highly confidentially CAD data which we cannot accept.* *If standard correction should be made based on highest value in each bin, the result would only mean an increased inaccuracy.* *Otherwise the OEM has to send the actual CdxA value which is highly sensitive and not acceptable.*
Slide 17: What is the approx. share of vehicles < 3.9 meters total height on group 4 and 9 box body (curtain, drybox, conditioned, refrigerated) vehicles?	*No statistics from the OEM´s, maybe CLCCR can provide this information.*
Slide 18: Any ideas how to treat aero influence of removable add on parts like sun visors, horns, additional head lights, signal lights or bull bars on the complete(d) vehicles' air drag?	*We do see two ways, one is doing a CST, which seems to us impossible to be performed by small BB.* *If CFD should be used, it means that the OEM has to send highly confidentially CAD data which we cannot accept, also very difficult to capture these add-on with CFD in an accurate way.* *We do see the point with only consider the parts that provides positive impact, but due to complexity and possible shift on these adding parts into the aftermarket, we beleive they should be kept outside from the declaration regulation as of today*
Slides 16 to 20: Other questions as listed related to air drag are assumed to be subject to deeper analysis in a dedicated task force. If you already have specific comments or ideas please specify ...	*The air drag influence for Urban delivery (sub-group 4 UD) is limited.* *Otherwise see comments above.*
Slide 22: What is the relevance of different PTOs for the targeted vehicle group (groups 4 and 9 with curtainsider, drybox, conditioned and refridgerated bodies)?	*We agree, that for groups 4 and 9 PTO´s as suggested, are of low importance and should not be considered.*
Slides 23 and 24: Please specify your favourite option if possible with an argumentation.	*Option 1 is the preferred one. As stated in the TUG document option 2 demands consideable work load and development work compared to added value.*

Slide 26: Any comments on the analysis regarding auxiliaries?	*OK as proposed in the TUG document.*
Slide 28: Which of the options to consider the impact of liftable and steered axle should be followed up from your point of view?	*We agree on the reasoning on page 27 and 28 in the TUG document. Liftable axles should be discussed separatley since it impacts other groups than 4 and 9 as well. Therefore Option 1 is preferred.*
Slide 30: Any comment regarding the analysis and the proposal related to tyres?	*No comments, OK with the proposal.*
Slides 32 to 35: Any feedback or comments on the content?	*" - PTO idling losses are not smart or feasible to consider due to the very minor impact on overall CO2 results* *- Liftable axles have a certain potential see already utilized in the field by customers, see row 16 (slide 28).* *- Tyres need to stay out of scope as already commented by TUG* *- Omission of any verification provisions for e.g. CdxA is not fair or understandable. How to track changes or ensure series stability here?"*
Slides 32 to 35: Do you have any other ideas how the properties of the „complete(d) vehicle“ as to be registered on the road could be considered by Regulation (EU) in a simple way?	*"- So many small workshops will be affected (changing weight, axles, etc.)* *- Making the whole procedure more complicated and not feasible* *- A simple way is in our point view neither possible nor given"*
Was any relevant aspect regarding covering “complete(d)” rigid lorries by Regulation (EU) 2017/2400 and VECTO missed in the analysis? If yes, please specify.	*"- Which accuracy of corrected fuel consumption would European Commission like to achieve with real body compared to standard body determination?* *- Responsibilities in terms of simulation and CO2 standards must be splitted between to the primary OEM and the complete(d) manufacturer.* *- Family concpet* *- Differentiation between multi stage approach and trailer approach"*

Any other topic you want to raise or ideas you like to share?	*"- SUMMARY OF COMMISSION PRESENTATION 18.02.22 - Classes 1, 2, 3, 11, 16 not to be considered - PTOs not to be considered - Power consumption of refrigerator body drive unit not to be considered - Changed axles and their weight may not be considered - Tires not to be considered - Air-Drag for final bodies do not reflect aftermarket add on parts. CFD or CST to be decided - COP not to be considered? (violating (EU) 2018/858) - Why should bodies be declared at all? What is the remaining market volume and what happens to the not declared vehicles taking (EU) 2019/1242 into consideration? - family concept" proposal from Betterflow is from what we heard not feasible due to the very high variety of produced Trucks in Europe" ACEA conclusion: We see issues with addressing the only vehicles that actually are well represented by the todays VECTO scheme. The shown increased complexity, work load and most likely increased inaccuracy (e.g. using aero bins), will in our view not add value to the current procedure.*