
# Aerodynamic and Flexible Trucks for Next Generation of Long Distance Road Transport

**EUROPEAN COMMISSION**
**Horizon 2020 | GV-09-2017 | Aerodynamic and Flexible Trucks**
**GA - 769658**

| | | |
|---|---|---|
| Deliverable No. | AEROFLEX D6.1 | |
| Deliverable Title | Definition of use-cases | |
| Deliverable Date | 2019-07-31 | |
| Deliverable Type | REPORT | |
| Dissemination level | Public - PU | |
| Written By | Emiel van Eijk (TNO)<br>Paul Mentink (TNO)<br>Àlex Freixas (IDIADA) | 2019-03-07 |
| Checked by | Andreas Lischke (DLR)<br>Julius Engasser (MAN)<br>Per Elofsson (SCANIA)<br>Magnus Olbäck(VOLVO)<br>Giuseppe Cordua (IVECO) | 2019-03-31 |
| Approved by | Ben Kraaijenhagen (MAN) – Coordinator | 2019-07-29 |
| Status | FINAL | 2019-07-30 |

# Publishable Executive Summary

In AEROFLEX Work Package (WP) 6, the demonstration, validation and technical analysis of the feasibility of the developed AEROFLEX innovations are covered. The work in WP6 is reported in six deliverables, the first three cover the preparations, specification and alignment within the project and the last three cover the results. D6.2 (Assessment Framework) and D6.3 (Test program and protocol) describe HOW the technical assessment and on-road-tests will take place. The current document (D6.1) describes WHAT will be tested and is thus closely related to the mentioned deliverables. The document is the result of close cooperation with all other work packages. The main goals of the document are the following:

- Gather a detailed listing and definition of all Key Performance Indicators (KPIs) in the project and mark the ones relevant for the validation within the scope of WP6;
- Select at least 8 customer use-cases that will be used for technical assessment in WP6;
- Give a detailed overview of the selected customer use-cases;
- Identify what additional data will be needed from the other work packages regarding the selected customer use-cases in order to perform energy consumption and energy efficiency improvement analysis on these customer use-cases for the customer preferred vehicle configuration (future prime candidate) compared to the existing vehicle configuration (current prime candidate).

The innovations in the project comprise Advanced Energy Management PowerTrains (AEMPT) from WP2, advanced vehicle aerodynamics (AeroLoad) from WP3 and Smart Loading Units (SLU) from WP4. To complete the innovations in the project, there is the safe front-end design from WP5. However, this innovation is not part of the WP6 demonstration and validation (except for the effect of the innovation on the aerodynamic performance of the vehicle in the final technical assessment), but is included in the overview of KPI's for completeness. The summary of KPI's defined by the WP's are given in Table 0.1.

**Table 0.1: Overview of the KPI's defined by WP 1-5**

| Work package | Description | KPI (also) assessed in WP6? |
|---|---|---|
| **1** | Transport cost per kilometre<br>Transport cost per tour<br>Transport cost per ton per kilometre<br>Total Cost of Ownership (TCO)<br>TTW $CO_2$ emissions<br>WTW $CO_2$ emissions<br>Vehicle kilometres (vkm)<br>Modal split ratio [-] (weight-based) | No, these are assessed in WP1, only input to this assessment is delivered via D6.4/D6.5 and D6.6 |
| **2** | Fuel consumption [l/km]<br>Fuel efficiency [l/tkm]<br>Average speed [km/h]<br>Gradeability<br>Startability<br>Acceleration capability<br>Tail swing<br>Low speed swept path<br>Low speed swept path on EU circle<br>Static rollover threshold<br>Directional stability under braking<br>Rearward amplification<br>High speed transient off-tracking<br>Yaw damping<br>360° turning circle | Yes |
| **3** | Drag reduction – Tractor semi-trailer<br>Drag reduction – EMS1<br>Drag reduction – Demonstrator (EMS1) | No for the first two KPI's, but yes for the third. Additionally, the translation towards l/km is executed via physical testing (D6.4 and D6.5) and the final technical assessment (D6.6) |
| **4** | Fill speed<br>Payload capacity<br>Load factor | Yes and also the translation towards l/tkm is covered via the technical assessment (D6.6) with the support of WP4 |
| **5** | Reduction of serious and fatal injuries<br>Pedestrian safety – Head impact<br>Pedestrian safety – Run over | No, these KPI's are assessed within WP5 |

| Work package | Description | KPI (also) assessed in WP6? |
|---|---|---|
| | Pedestrian safety – Pelvis protection<br>Car occupants protection | |

These KPI's as defined by the individual WP's, are outlined and judged on applicability. As far as relevant for WP6 testing or the final technical assessment, these KPI's are correctly defined and can be used to be assessed in WP6. It is important to conclude that the overall transport efficiency targets (18-33%) are evaluated on customer use-case level, meaning the efficiency gain obtained at logistics level (see Figure 0-1). This means that whether the target is met is use-case dependent. Therefore, each (efficiency) result has to be accompanied with a clear description of the conditions under which this result is obtained. Consequently, a dynamic region of (not) meeting the "static" efficiency target will be obtained.

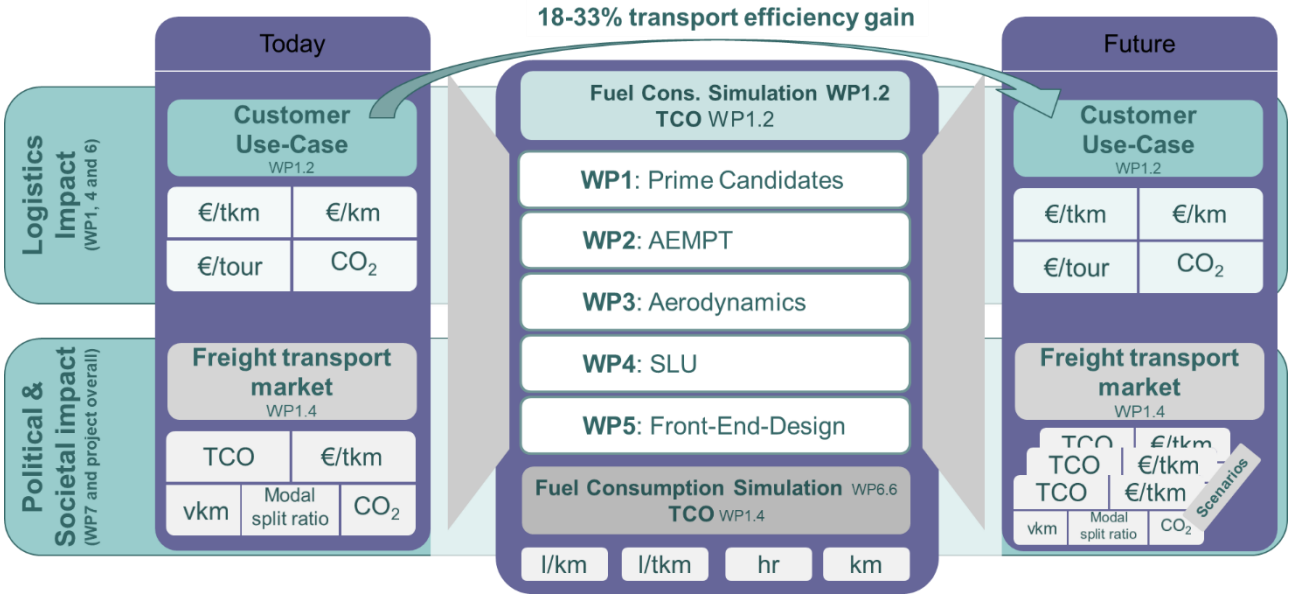


**Figure 0-1: Overview of the overall and technical assessment approach among the different WPs including separation between customer use-cases and freight transport market analysis**

A general observation made is that not all WP's have defined KPI's in terms of the overall project efficiency targets, e.g. improved energy consumption, energy efficiency and overall transport efficiency. This implies that to translate the results of the KPI's towards the overall project efficiency targets, separate activities have to be conducted. This especially holds for both the WP3 and WP4 KPI's. For WP3, a quantification towards energy consumption [l/km] instead of wind averaged $C_{dwa}A$ has to be made. For WP4 a similar translation has to be conducted for those KPI's. These translations will all be covered by the WP6 testing (D6.5) and final technical assessment activities (D6.6) and are described in D6.3 for the physical testing and D6.2 for the technical assessment. Support from the relevant work packages is needed to generate these results.

The overall project target Smart Loading Units – Separate Platforms (SP) is the only target not directly captured by one of the (WP4) KPI's. The definition from the grant agreement for this target needed clarification. During several WP-related discussions, it has been concluded what is meant with separate platforms: with separate platforms it is meant that EMS vehicles have the ability to split up in different vehicles or can split towards different modalities. The fact of codified and craneable loading units (intermodal loading units) allow for easy swopping of loading units to platforms (e.g. truck with swap body frame, semi-trailer, wagon) and modalities (e.g. truck, train). The same holds for the craneable semi-trailer platforms. The assessment of this SP target is done via WP4 inputs of changes in logistics operation due to this innovations supported by simulations in the WP6 final technical assessment.

Two sorts of use-cases are used throughout the project to assess and validate the developed innovations. Test use-cases are use-cases that will be tested in practice. They are described in detail in D6.3 and consist of the following:

- Fuel consumption tests at steady-state speed on test track;
- Fuel consumption tests on the public road;

- Air drag on test track;
- Vehicle dynamic measurement on test track and;
- Terminal loading tests at a customer's depot.

Customer use-cases are detailed descriptions of common logistics missions, gathered through interviews with logistic parties in WP1. They are used to analyse the potential effect of AEROFLEX innovations in daily logistics operations. Customer use-cases are used in total cost of ownership studies in WP1 and energy consumption and efficiency in WP6.

A subset of the customer use-cases - as collected during expert interviews with Logistic Service Providers (LSP's) and shippers by WP1 – is selected for further analysis in task 6.6. The customer use-cases are selected in close collaboration with all other work packages and based on two criteria. First of all, all innovations developed in the other work packages need to be assessed with the selected use-cases. Especially for the innovations of WP4 (Smart Loading Units), the selection of the right customer use-cases is important. Second of all, a large variation of customer use-cases should be selected in order to test the limits of the developed innovations. Therefore, the selected use-cases should include at least a variation of the following criteria:

- Goods categories;
- Trip lengths;
- Geographic regions in Europe;
- Elevation profiles;
- Prime candidates for new vehicle configurations;
- Multi-modality;
- Handling units;
- Logistic concepts

Based on these criteria the customer use-cases are selected as depicted in Table 0.2. The use-case names are taken from the convention defined in deliverable D1.2. Subsequently, these selected customer use-cases are described in depth including the overview of the (additional) information needed to properly execute the final technical assessment. Arrangements with the work packages have been established to share this data.

Moreover, due to the more stringent privacy legislation [1] (EU General Data Protection Regulation 2018), company information as well as detailed geographical information of trips is excluded from the reports.

[1] General Data Protection Regulation, Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), https://ec.europa.eu/commission/priorities/justice-and-fundamental-rights/data-protection/2018-reform-eu-data-protection-rules_en, February 2019

**Table 0.2 Summary of the selected customer use-cases**

| Name | Description | Goods categorie | Location | Total distance | Total elevation change | WP4 innovations | Current Prime Candidate | Desired future Prime Candidates |
|---|---|---|---|---|---|---|---|---|
| UC8 | Germany short distance, heavy load | 3: Metal ores and other mining and quarrying products; peat; uranium and thorium ores | Western Europe | 115 km | 1700 m | | Truck-trailer | Tractor-semitrailer |
| UC10 | Germany flat paletized | 4: Food, beverages and tobacco | Western Europe | 500 km | 5400 m | | Tractor-semitrailer | Tractor-semitrailer-dolly-semitrailer/Tractor-semitrailer-fulltrailer |
| UC15a | Austrian mountains | 20: Other goods n.e.c. | Western Europe | 630 km | 20000 m | | Rigid truck | Truck-trailer-(trailer) |
| UC19 | Germany - Spain | 12: Transport equipment | Southern Europe | 1300 km | 29500 m | | Tractor-semitrailer | Truck-dolly-semitrailer |
| UC20 | Turkey - Sweden shortsea, long distance | 4: Food, beverages and tobacco | Eastern Europe | 2960 km | 39000 m | 3. Horizontal Collaboration | Tractor-semitrailer | Tractor-semitrailer/ Tractor-linktrailer-semitrailer/Truck-dolly-semitrailer |
| UC22 | Germany - England shortsea intermodal | 18: Grouped goods: a mixture of types of goods which are transported together | Western Europe | 1330 km | 16300 m | | Tractor-semitrailer | Tractor-semitrailer-dolly-semitrailer/Tractor-semitrailer-fulltrailer |
| UC31 | Netherlands - Sweden truck-train intermodal | 18: Grouped goods: a mixture of types of goods which are transported together | Northern Europe | 830 km | 6600 m | 1. Multimodal Clusters2.0 | Tractor-semitrailer | Tractor-semitrailer-dolly-semitrailer |
| UC99 | Germany heavy and light weight | 18: Grouped goods: a mixture of types of goods which are transported together | Western Europe | 720 km | 14000 m | 2. Heavy and light weight palletized goods | Tractor-semitrailer | Tractor-semitrailer-dolly-semitrailer |

# Contents

# Figures



# Tables

# List of abbreviations

| Abbreviation | Explanation |
|---|---|
| 6YO | Six Year Old (human body model) |
| ABS | Anti-lock Braking System |
| AEB | Autonomous Emergency Braking |
| AE-MDB | Advanced European Mobile Deformable Barrier |
| AEMPT | Advanced Energy Management PowerTrain |
| CARE | Community database on Accidents on the Roads in Europe |
| CFD | Computational Fluid Dynamics |
| CO2 | Carbon Dioxide |
| EC | European Commission |
| EMS | European Modular System |
| EU | European Union |
| EuroNCAP | European New Car Assessment Program |
| FIMCAR | Frontal Impact and Compatibility Assessment Research |
| FMVSS | Federal Motor Vehicle Safety Standards |
| FTL | Full Truck Load |
| GCW | Gross Combination Weight |
| GDPR | General Data Protection Regulation |
| HBM | Human Body Model |
| HIC | Head Injury Criterion |
| HSTO | High Speed Transient Offtracking |
| IoT | Internet of Things |
| ISO | International Standards Organization |
| KPI | Key Performance Indicator |
| KSI | Killed or Seriously Injured |
| l/km | liter per kilometer |
| l/tkm | liter per ton-kilometer |
| LSP | Logistic Service Provider |
| LSU | Loading Space Utilization |
| LTL | Less than Truck Load |
| N/A | Not Applicable |
| NCW | Net Combination Weight |

| Abbreviation | Explanation |
|---|---|
| NST | Standard goods classification for transport statistics |
| PBS | Performance-Based Standards |
| PC | Prime Candidate |
| RA | Rearward Amplification |
| SID | Side Impact Dummies |
| SLU | Smart Loading Units |
| SMART | Specific, Measurable, Acceptable, Realistic, Time constrained |
| SP | Separate Platforms |
| SPW | Swept Path Width |
| SRT | Static Rollover Threshold |
| SW | Software |
| TCO | Total Cost of Ownership |
| TF | TRANSFORMERS |
| TS | Tail Swing |
| TTW | Tank-To-Wheel |
| UC | Use-case |
| VEG | Van Eck Group |
| VRU | Vulnerable Road Users |
| WoldSID | Worldwide harmonized Side Impact Dummy |
| WP | Work Package |
| WTW | Well-To-Wheel |

# 1 Introduction

The general objective of WP6 is to demonstrate, validate and analyse the feasibility of the AEROFLEX innovations. The innovations being part of WP6 are the WP2 distributed powertrain technology called Advanced Energy Management PowerTrain (AEMPT), WP3 advanced vehicle aerodynamics (AeroLoad) and WP4 Smart Loading Units (SLU). The innovations of the extended front-end design from WP5 is treated here as part of WP3 innovations, since it influences the aerodynamics of the vehicle. The safety assessment aspect is out-of-scope for WP6. The assessment activities of the innovations require clearly defined conditions, e.g. inputs being performance indicators and use-cases, as well as the assessment framework and applied methodology. This deliverable treats the performance indicators and use-cases, whereas the assessment framework itself is covered in D6.2. For a complete overview of the WP6 deliverables and its relations Figure 1-1 is included.

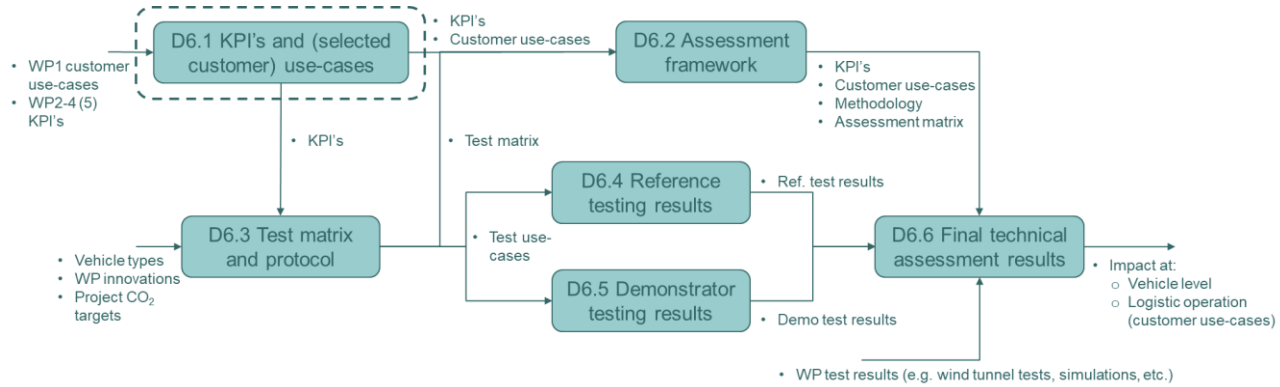


**Figure 1-1: Overview of the interaction between the WP6 deliverables. The dotted box marks the deliverable being covered in this report.**

The work in WP6 is reported in six deliverables, the first three cover the preparations, specification and alignment within the project and the last three cover the results. D6.2 (Assessment Framework) and D6.3 (Test Program and Protocol) describe HOW the technical assessment and on-road tests will take place. The current document (D6.1) describes WHAT will be tested and is thus closely related to the mentioned deliverables. The document is the result of close cooperation with all other work packages. The main goals of the document are the following:

- Gather a detailed listing and definition of all Key Performance Indicators (KPIs) in the project and mark the ones relevant for the validation within the scope of WP6;
- Select at least 8 customer use-cases that will be used for technical assessment in WP6;
- Give a detailed overview of the selected customer use-cases;
- Identify what additional data will be needed from the other work packages regarding the selected customer use-cases in order to perform energy consumption and energy efficiency improvement analysis on these customer use-cases for the customer preferred vehicle configuration (future prime candidate) compared to the existing vehicle configuration (current prime candidate).

The Key Performance Indicators contain the criteria at which the performance of the innovation(s) will be assessed as well as the reference conditions (e.g. vehicle type and topology) and a target value for the KPI. Therefore, the definition of clear KPI's is important. For the final technical assessment this is important too, because it describes the inputs for the assessment as well as the comparisons and targeted result.
In addition, the assessment inputs are made complete by a description of the conditions under which the performance of the innovations are assessed, e.g. route, payload, ambient conditions, traffic conditions etc. For this use-cases are defined. A use-case according to software engineering definitions encompasses as list of actions or event steps defining the interactions between the user and a system to achieve a goal. Here, the system is the vehicle type with particular topology in its operating conditions achieving a certain performance that need to be compared with either the target value from the KPI and/or project efficiency targets. Two types of use-cases are defined within WP6, being:

- Test use-cases
- Customer use-cases

Test use-cases are part of the WP6 test matrix (see deliverable D6.3 for details) and cover the type of tests being executed by physical testing of reference and demonstrator vehicles at or around IDIADA test facilities. These test

use-cases are tests under more controlled environmental conditions with limited external disturbances targeting for high measurement accuracies and reproducibility. These measurement results serve as model identification and validation source used for the final technical assessment (D6.6).
Customer use-cases on the other hand are real logistics operations of conventional vehicle combinations at different Logistics Service Providers (LSP) or shippers using different types of goods. A subset of all the customer use-cases, obtained by expert interviews in WP1, are used in the WP6 final technical assessment. With this, the performance of the AEROFLEX innovations are assessed for real logistics operations. The selection towards this subset of customer use-cases is part of this report.
In this report the focus of the use-cases is only on the customer use-cases and the criteria for their selection as well as details of the selected customer use-cases are described.

The report is organized as follows. chapter **Error! Reference source not found.** starts with the overview and judgement of the KPI's. Successively, chapter **Error! Reference source not found.**, both includes the overview of the selection of the customer use-cases as well as the detailed description of these customer use-cases. Finally, chapter **Error! Reference source not found.** describes the conclusions of this work and provides an outlook to upcoming activities and deliverables.