# DELIVERABLE REPORT

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| PROJECT ACRONYM: | **TRANSFORMERS** |
| PROJECT TITLE: | **CONFIGURABLE AND ADAPTABLE TRUCKS AND TRAILERS FOR OPTIMAL TRANSPORT EFFICIENCY** |
| PROJECT START DATE: | **01/09/2013** |
| PROJECT WEBSITE: | **WWW.TRANSFORMERS-PROJECT.EU** |
| COORDINATION: | **VOLVO (SE)** |
| PROJECT MANAGEMENT: | **UNIRESEARCH (NL)** |

# Executive summary

Investigating fuel saving and thus reducing the $CO_2$ emissions for long haul trucks is normally done by finding solutions that are focused on the pulling unit. In the project the focus is on implementing possible solutions on the semi-trailer part of the truck.

In the TRANSFORMERS project, three different innovations were developed into demonstrators, resulting in two demonstrator semi-trailers: the load optimization trailer and the energy efficiency trailer. The demonstrator tractor pulling units were slightly modified to provide additional communication with the semi-trailers. The vehicle characteristics of both tractor and semi-trailer demonstrators are described in deliverable D6.1 [6].

The developed and tested innovations in the TRANSFORMERS project are:

- Hybrid-on-Demand (HoD) on the "energy efficiency trailer"
- Improvement of semi-trailer aerodynamics on both trailers
- Improvement of loading capacity by an increased inner length and double floor on the "load optimization trailer"

Both trailers were subjected to different tests in order to measure the impact on fuel consumption and other relevant key performance indicators, as described in deliverable 1.2. Since the innovations differ significantly in characteristics and the input is required for simulations and evaluations, the test methods were developed per innovations and described in deliverable D6.5 [8].

The Hybrid-on-Demand (HoD) system on the energy efficiency trailer was tested in simulated heavy-traffic urban conditions on a test track, using a DAF tractor, and on Swedish public roads, using a Volvo tractor. The test results show a significant influence of the road types, since driving dynamics (stop-and-go) and elevation changes clearly influence the energy recuperation potential of the system. The test results in heavy-traffic urban conditions show a wide variation as a function of the payload in the semi-trailer. However, this difference is primarily caused by emptying or charging the battery during the tests and after correction of the fuel consumption results for the State-of-Charge difference before and after the test, the fuel consumption benefit is 5.9 to 6.6% compared to the system switched off.

On public country roads and highways, the HoD system behavior proves to be elevation profile dependent. Extensive tests were done on different routes on Swedish roads, which predominantly show a hilly and low traffic character. In the tests the payload was varied. When using 15 tons payload, the fuel consumption benefit on a route with highway only is 2.2%. For maximum payload 40 tonnes GCW conditions, the results vary between 3.3% for a route with highway (motorway) only to 3.8% for a route with a mix of country road and highway. All numbers are averaged results for 3 tests. Both urban and extra-urban tests were done with one control strategy of the HoD system ("case 3"). A quick check with an alternative control strategy reveals that there could be a significant improvement potential, which needs to be further investigated.

The aerodynamic measures were tested using the energy optimization trailer only, using both the DAF and Volvo tractors. The tests were done on test tracks with the aerodynamic measures set in all relevant settings, such as boat tail in and out and various roof positions. The tests were done with constant speeds above 60 km/h, since aerodynamic measures are not effective at low (i.e. urban) speeds. Using the Volvo tractor, fuel consumption benefit was measured of the aerodynamic measures in their relevant settings and at various constant speeds. The results show that fuel consumption reduction can reach 5.7% when driving at 80km/h. Around 50% of that benefit comes from the boat tail effect.

In the tests using the DAF tractor, the primary goal was not to determine the impact on fuel consumption, but to calculate the impact on air drag (Cd*A) of the vehicle combination by measuring the reduced torque required to drive at a constant speed of 90 km/h. During these tests, the aerodynamic measures were varied as well. The best results were obtained by the roof in tapered position and using the boat tail: 14.7% reduction of air drag. The impact of the boat tail varies from 5.1 to 8.6%, depending on the roof position. Lowering the trailer roof shows best results in the flat position: 6.3%. Note: these percentages show the impact on air drag, not on fuel consumption. The air drag results will be used for calculations on fuel consumption in the evaluation phase of the project and will be reported in deliverable D6.4 [7]. All results are compared to the energy efficiency trailer in

"high flat" position and without boat tail, since test results revealed that the initially intended reference trailer without aerodynamic measures was not usable as the reference trailer due to a too high rolling resistance. This means that the results shown have a "hidden" potential, since the impact of the aerodynamic bulk head and side wings are not taken into account.

The functional performance of the loading efficiency innovations were tested in a real-life situation in a distribution center of P&G and proved to work according the goals set by the key performance indicators. The inner length of the trailer increased in such a way, that an additional pallet can be placed. The flexible double floor can be used functionally, although more testing is needed in various real-life situations. The additional time required for loading the double floor was measured and this data will be used to calculate the impact on fuel consumption / CO2 emission and economic viability in deliverable D6.4 [7]. The aerodynamic measures of the load optimization trailer were not part of the test program with regards to the impact on air drag and fuel consumption and tested only in a functional way, without showing problems.

The results of the tests to assess the dynamic behavior of the vehicle combination with hybrid-on-demand system working were reported in deliverable D4.7 [5]. The results showed the dynamic behavior is close to the behavior of a standard tractor-semitrailer combination and no additional control measures are needed.

The data of the test results will be used to validate the models used for the technical optimization and impact assessment, and will be reported in deliverables D2.6 (holistic simulations[10]) , D6.3 (model validation [9]) and D6.4 (final report [7]).

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