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

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Publishable Executive Summary

The final technical assessment plays an important role in the AEROFLEX project. Not only as a deliverable in itself but also as input to the impact analysis related to European freight transport performed by Work Package (WP) 1 and the book of recommendations written by WP7. The final technical assessment plays an important role in the translation of the results of the individual work packages to the overall project results. Since the last inputs are only expected shortly before the due date of the project, it is of great importance that the approach of this technical assessment is known and agreed upon by all project partners well before the final critical months of the project so that these months can be used efficiently for performing the actual assessments. This alignment within the project is the main goal of the actions performed in task 6.2 and this report.

Based on the role of the final technical assessment within the project and the relation to other WP's, the functional description of the final technical assessment can be summarized in one sentence:
To assess the efficiency improvement potential of AEROFLEX innovations in typical European long-haul road operations, building on the reference and demonstrator test results, using realistic simulations and providing input to the impact assessment of the EU freight transport and book of recommendations.
Following this functional description, a set of requirements to the final technical assessment is derived, grouped in the following categories:

- Type of results
- Representation of AEROFLEX innovation
- Definition of European long-haul road operations
- Usage of on-road test results
- Representativity of simulations
- Input to other WP's

The assessment framework is designed in such a way that it enables ***calculating the energy efficiency for any given vehicle, equipped with any given AEROFLEX innovation or combination of innovations, used in any given transport application.*** A stepwise assessment approach is proposed, shown in Figure **Error! No text of specified style in document.**-1. A transport application or use-case can be described by a set of origins and destinations; the cargo that is shipped between each origin-destination and the vehicles that are used to ship the cargo. Based on an origin-destination a route profile is generated. The route profile is a distance-based profile of the route including slope, direction and speed limit. The vehicle with the cargo (payload) is simulated over this route to generate a mission profile; a time-based profile including slope of the road and speed of the vehicle. Since this mission profile depends on the weight of the vehicle combination, the Smart Loading Units (SLU) innovations are an input to this model. These innovations influence the weight of the vehicle combination by increasing the load factor. This mission profile is the basis on which the road load (power required at the wheels) is calculated with a physical model (road load model in the figure). This model calculates the power at the wheels from the drag, inertia, gradient and rolling resistance working at the wheels. Drag resistance depends on the shape of the vehicle which is influenced by the aerodynamic features designed in WP3 (AeroLoad). From the wheel power demand, the fuel power demand is calculated (power required from the fuel) with the powertrain model. This model includes the engine and drivetrain efficiency and, if equipped, the efficiency of the hybrid systems. The specifications of the hybrid systems are an input from WP2, where the Advanced Energy Management Powertrain (AEMPT) related innovations are developed. Using the same mission profiles for these calculations allows for a fair comparison between different scenarios (e.g. AEROFLEX innovations equipped to the vehicles). From the fuel power demand, the fuel consumption (l/km) and fuel efficiency (l/tkm) is calculated. Multiplying the results with the number of vehicles used allows for fuel efficiency comparisons between different vehicle fleets (for example to calculate the fuel efficiency effect of logistic innovations that increase the payload capacity of a vehicle).

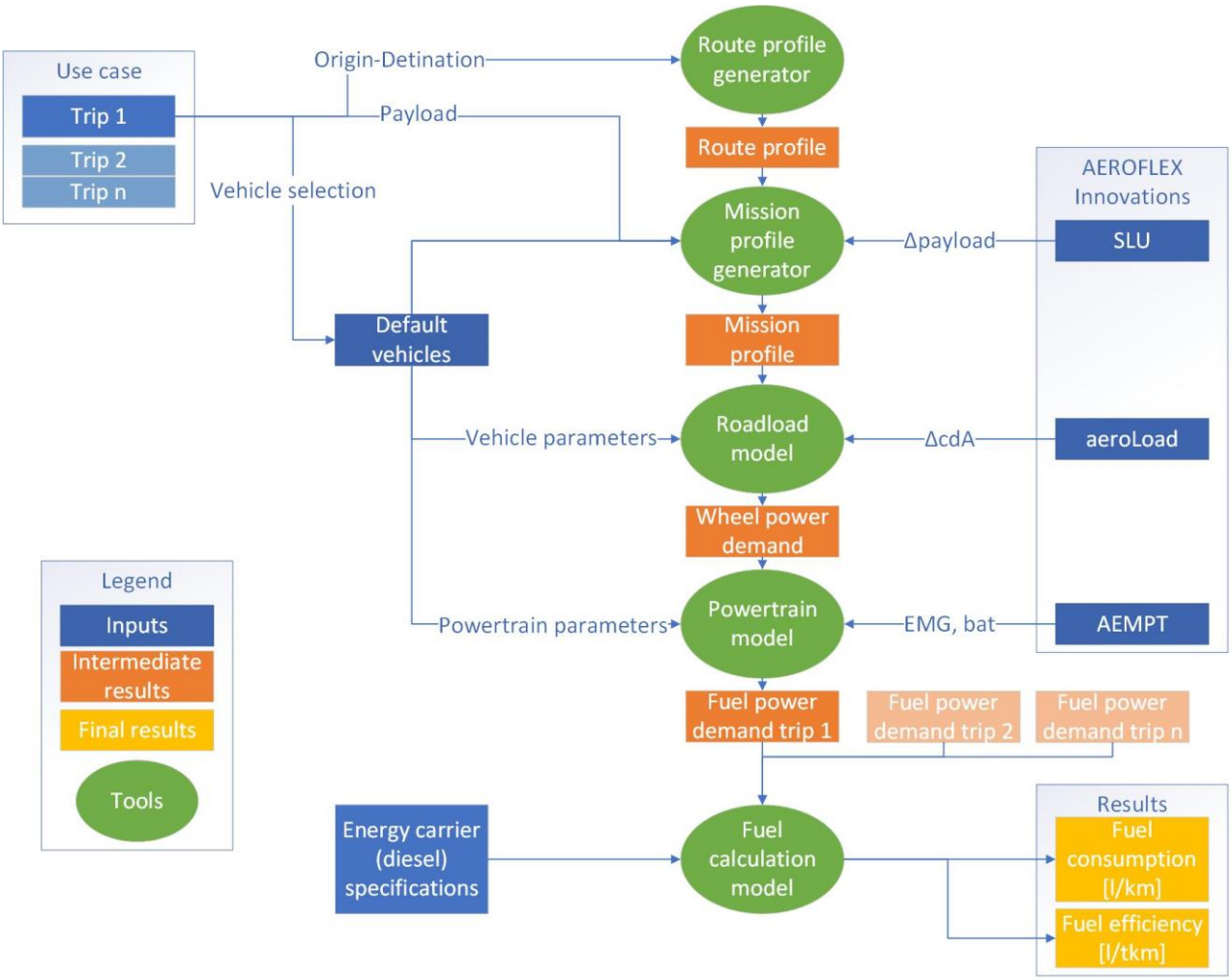

Figure Error! No text of specified style in document.**-1 Stepwise approach used for the assessment of a use-case**

The assessments that will be performed with the assessment framework and the deliverables in which the results will be shown are summarized in Figure **Error! No text of specified style in document.**-2. In the pilot assessment, which is subject of the current deliverable, the assessment framework is demonstrated on the Fraga-route[1] and a customer use-case. In the calibration and validation phase, the reference and demonstrator tests on the Fraga route and highspeed test-track are simulated in order to tune the model and test its validity. In the sensitivity analysis, the representativity of these routes is tested. The final technical assessment consists of two parts. First, the demonstrator vehicles are tested on different missions and compared to the reference vehicles. Second, the customer use-cases are simulated. Here, real logistic use-cases are used to compare the currently used vehicles to future prime candidates with and without AEROFLEX innovations[2] applied. The selected customer use-cases provide a large variation in typical transport applications and routes. This allows for an assessment of the AEROFLEX innovations in various situations including e.g. flat and hilly routes, free flowing and congested roads, fully loaded and empty vehicles, motorways and urban roads.

[1] The Fraga-route is a route in the South of Spain that is used by IDIADA for the on-road tests of reference and demonstrator vehicles.

[2] Innovations developed within the project, i.e. Advanced Energy Management Powertrain, Aerodynamic features, Smart Loading Units, Innovative Front-end design (see section **Error! Reference source not found.**)

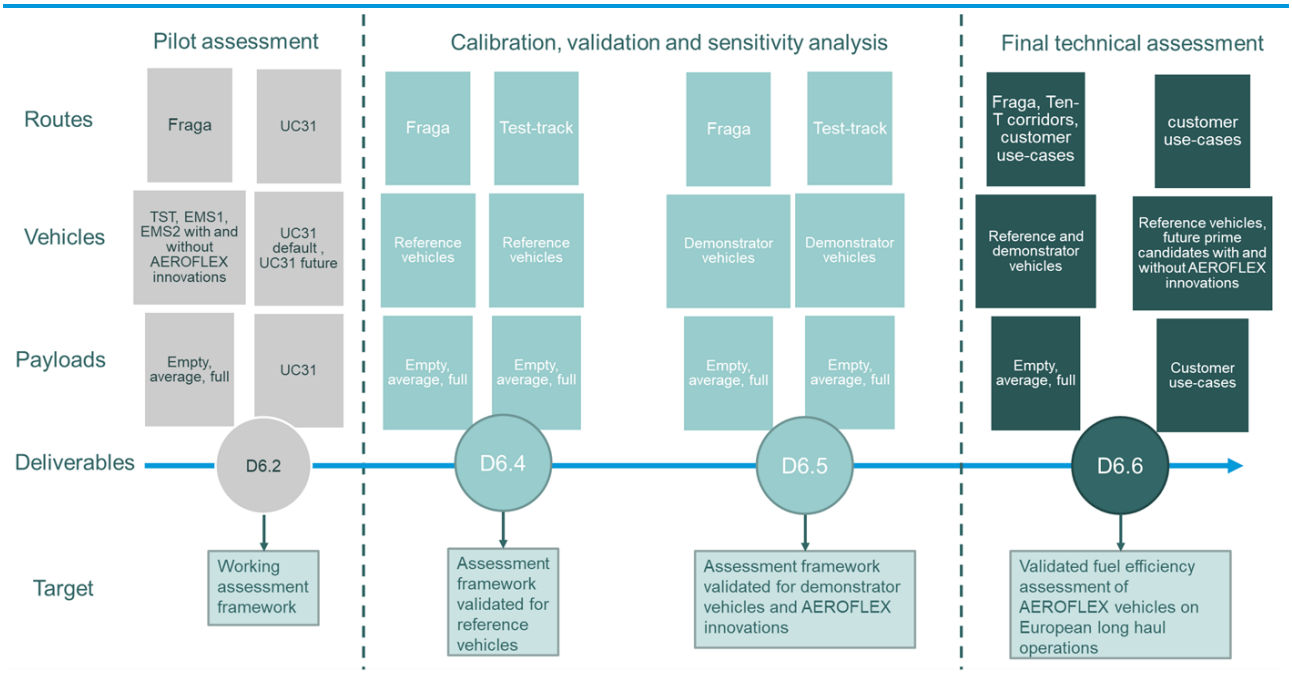

Figure Error! No text of specified style in document.**-2 Assessment matrix, the results of the technical assessments will be delivered in D6.2 (due 2019-11), D6.4 (2020-3). D6.5 (2021-1) and D6.6 (2021-3)**

The assessment framework is tested on the Fraga route and a customer use-case as a pilot assessment case. The Fraga-route is used, since it is a well-known route within the project and it plays an important role in the reference and demonstrator tests as well. The Fraga-assessment shows that the assessment framework can produce sensible results when comparing different vehicles with different payloads and innovations on a single route. Calibration and validation of the models are required to show how well the absolute fuel consumption results meet the measured values. Therefore, the results of the pilot assessment are not yet representative for the final result of the assessment and are therefore not mentioned in this summary. The customer use-case assessment shows that it is possible to compare the currently used vehicle configuration with a future vehicle configuration. However, the result strongly depends on the assumptions made about the applicability of AEROFLEX innovations and (future) regulations. In the final technical assessment multiple assessment scenarios should be defined in close cooperation with project partners and stakeholders from the transport sector.

Finally, it can be concluded that all requirements can be met by the assessment framework and the planned assessments. Table **Error! No text of specified style in document.**-1 lists all requirements and the chapter in which the conformity to the requirement is described. The final technical assessment can only be completed when the following conditions are met:

- Test results will be shared within a week after completion of the tests;
- Adaption of the hybrid powertrain model to simulate multiple hybrid systems working in parallel;
- Inclusion of formulas from the VECTO model to calculate wind-averaged C_d*A values;
- Calibration of the models with the test results;
- Validation of the models with the test results;
- Sensitivity analysis on the representativeness of the Fraga route for the customer use-cases;
- Innovations and parameters for the innovations will be shared before the reference tests are finished;
- Before the General Assembly in May 2020, a decision should be made on the innovations applied on the future prime candidates for the customer use-cases.

Table Error! No text of specified style in document.**-1 Requirements to the final technical assessment**

Group	Requirements	Chapter /reference
Fuel Efficiency	• The assessment framework should enable the calculation of fuel consumption in litres of fuel; • The assessment framework should enable the calculation of travel distance in kilometres; • The assessment framework should enable the calculation of travel time in hours;	**Error! Reference source not found.**
AEROFLEX innovations	• The assessment framework should allow for the simulation of hybrid drivetrains; • The assessment framework should allow for the simulation of torque management systems; • The assessment framework should be able to simulate passive flow control systems; • The assessment framework should be able to simulate active flow control systems, where the aerodynamics of the vehicle depend on speed or direction of the vehicle; • The assessment framework should allow for fleet level simulations.	**Error! Reference source not found.**
Typical European long-haul road transport operations	• The assessment matrix should consist of selected use-cases for typical long-haul road transport in Europe, representing at least major goods categories and applications.	(Eijk, Mentink, & Freixas, 2019)
Test results	• The assessment framework should be calibrated with reference and demonstrator test results; • The assessment framework should be validated with reference and demonstrator test results.	**Error! Reference source not found.**
Realistic simulations	• The sensitivity analysis should include variation of traffic conditions • The sensitivity analysis should include variations in weather conditions • The sensitivity analysis should include variations in road conditions • The sensitivity analysis should include variations in vehicle characteristics	**Error! Reference source not found.**