# Deliverable D7.2 //

# Application of AdaptIVe Evaluation Methodology

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AdaptIVe
Automated Driving Applications and
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# 1 Summary

Since the last decade, development efforts by academia and industry for automated driving functions have increased significantly. Also, the European research project AdaptIVe is looking into this topic. Within AdaptIVe, 21 different automated driving functions for different speed ranges and target areas have been developed. They have been developed in three sub projects (SPs), addressing different automation scenarios:

**Sub project 4: Automation in close-distance scenarios**: Addresses manoeuvres at low speed (below 30 km/h) that are characterised by the presence of close obstacles, such as in parking manoeuvres.

**Sub project 5: Automation in urban scenarios**: Deals with driving scenarios in urban environments that are characterised by an average speed range of 0 to 70 km/h.

**Sub project 6: Automation in highway scenarios**: Addresses motorway scenarios (or motorway similar roads) considering velocities up to 130 km/h.

Due to the large operation spaces and various complex situations that are covered by these functions, efforts for evaluation are expected to increase significantly. In order to enable an efficient assessment of automated driving functions, within the subproject 7 a comprehensive evaluation methodology [Rodarius et al. 2015] addressing this challenge has been developed. The evaluation methodology foresees an evaluation in four different areas, as presented in Figure 1.1.

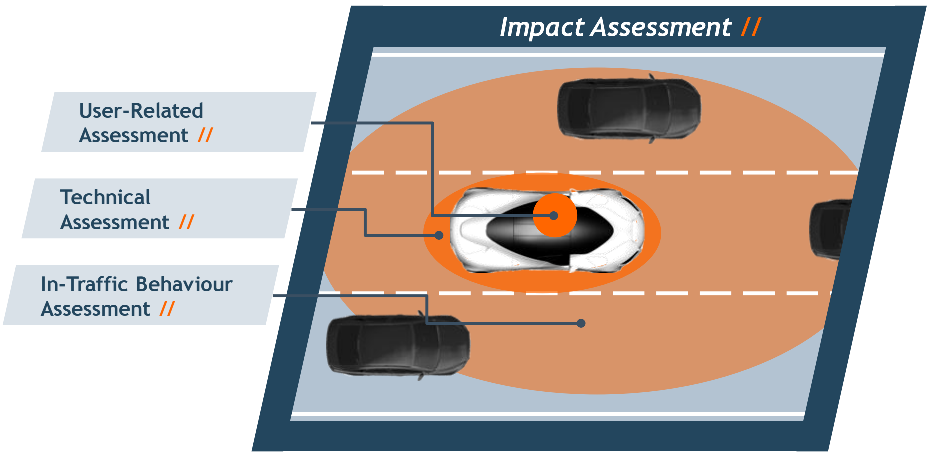


Figure 1.1: Evaluation areas in AdaptIVe

**Technical Assessment:** Evaluates the performance of the developed automated driving functions with respect to a defined baseline.

**User-related Assessment:** Analyses the interaction between the function and the user, trust, usability as well as acceptance of the developed functions.

**In-Traffic Assessment:** Focuses on the effects of the surrounding traffic on the automated driving function as well as the effects of the automated driving function on the surrounding non-users.

**Impact Assessment:** Determines the potential effects of the function with respect to safety and environmental aspects (e.g. fuel consumption, traffic efficiency).

While the results of the impact assessment are presented in the deliverable D7.3 [Fahrenkrog et al. 2017], the results of the technical, user-related and in-traffic assessment are presented in this document. The evaluation methodologies developed in previous research projects, e.g. PReVAL [Wilmik et al. 2008], ASSESS [Rodarius et al. 2011], interactIVe [Fahrenkrog et al. 2014] and U.S. research studies such as [McLaughlin et al. 2009] dealt mainly with active safety functions, for which the assessment focused mainly on testing of functions' use cases. For automated driving the assessment approach needs to be extended in order to ensure that the whole situation space which is addressed by the functions is covered. Therefore, in the developed evaluation approach the test resources are allocated based on the functions' classification in order to enable a holistic and efficient assessment. Hence, the automated driving functions are classified based on their automation level [SAE 2014] and their operation time in two different function types:

- Functions that operate only for a short period of time (seconds up to few minutes). Typical examples are automated parking functions and the minimum risk manoeuvre function. These functions are called "**event based**".
- Functions that, once they are active, can operate over a longer period of time (minutes up to hours). A typical example of this type of function is a "highway pilot". They are called "**continuously operating**" functions.

Based on a classification in "event based" or "continuously operating" of the assessed functions the test tools are assigned, e.g. a small field test for a continuous operating function.

Regarding the **technical assessment**, an evaluation method for assessing the technical performance for event based and continuous automated driving functions has been developed. Whereas for event based operating automated driving functions a conventional test case based approach has been used, the approach for continuous operating functions is different. Due to the huge variety of different driving situations these functions are dealing with, a small field test for assessment is used. The functions performance is assessed by clustering the driving data in "driving scenarios". Since basic requirements such as "safe driving" or "operate in mixed traffic conditions" imply that automated driving functions need to operate within the range of normal driving behaviour, human driving behaviour from Field Operational Tests (FOT) is used as a baseline. The application of the described assessment approach proved that the assessed automated driving functions are showing a control capability and variability that is very similar to human driving behaviour. There are two results that stand out: first, the time required for a lane change is much more uniform in automated driving and second, the automated driving functions show much less variability in headway keeping.

The **user-related assessment** was carried out for the “Supervised City Control” function providing automated speed control and lane keeping and for the “Highway Pilot” function also providing additionally automated lane change functionalities. Due to restrictions of driving by naive drivers in real traffic conditions, assessment activities concerning the “Supervised City Control” were limited to driving on a test track by a number of test drivers and answering afterwards a questionnaire. The tests of the “Highway Pilot” function took place on public motorways with naive drivers driving both with and without the system. Both systems received high System Usability scores. Some worries were expressed by the test persons about relying on the system in real traffic – whether the car constantly will be able to handle new and different situations consistently. The tests revealed that the system affected driving positively in several ways, however, concerning communication with other drivers it was revealed that the system did not react on other driver’s intention to make a lane change, especially in situations when they wanted to merge onto the motorway. In these situations, the test persons reacted better when driving without the system by reducing speed or by changing the lane.

In the **in-traffic assessment** a methodology to assess the in-traffic performance of an automated driving function with focus on the interaction with other traffic participants as well as non-automated traffic participants using real-life scenarios with Monte-Carlo simulations has been developed. The approach is mostly data-driven, such that the assessed performances resemble the performance in real-life traffic. Therefore, less open road tests are required. Through parameterization of the real-life scenarios, regular test cases are generated. Moreover, using the simulations of the regular test cases, new test cases can be generated to emphasize the performance critical situations. With two different scenarios, it is shown how the presented method can be applied to an example of a level 2 Supervised City Control. The probabilities of a collision and a near miss are computed based on regular test cases and critical test cases in which a preceding vehicle brakes. Using the generated critical test cases, the relative error of the probabilities was lowered three to four times. Furthermore, the performance of the system in a cut-in scenario is assessed. In addition, it is shown that the methodology can be used to assess the influence of an automated driving function on its surrounding traffic.