AVL-DRIVE pre-study report

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Preface

This report present the work done by Mikael Nybacka from Luleå University of Technology and Division of Functional Product Development, David Holmlund from Arjeplog Test Management, and Christof Danner from AVL List GmbH in Graz.

We would like to thank some important people who have helped us during the three months of the pre-study project.

First we would like to thank the Centre for Automotive Systems Technologies and Testing – CASTT for funding part of this pre-study. Arjeplog Test Management – ATM for letting us use the test facilities and expertise during the pre-study. AVL List in Graz, Austria, for the technical support and of course for supplying us with the AVL-DRIVE system and the necessary equipment.

Secondly, we would like to thank Niclas Engström at Division of Machine Elements for lending us the VBOX3i. Benny Larsson for letting us rent the Audi Q5 for the period of the pre-study. Furthermore, we would like to thank everyone who has participated in the demonstrations of the AVL-DRIVE system, answered our survey and given us valuable feedback.

Last but not least, we would like to thank our family and friends for supporting us.

The pre-study project has been a great experience with a lot of new insight of what can be done in the future.

Mikael Nybacka, David Holmlund, and Christof Danner.
Luleå, September 24, 2009
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Abstract

This report presents a pre-study project of AVL-DRIVE conducted from 27th of July 2009 until 15th of October 2009.

The focus of the pre-study was to see how the system, as it is, could be used by the service providers and their customers during winter and summer testing in northern Sweden but also if the system could be extended and further developed to suit their needs.

The AVL-DRIVE system is designed for objective assessment and quality control of driveability based on human experience. Procedures for the objective assessment of the subjective perception of the driver have been used by AVL to define the evaluation method and formulas. Experiences acquired from internal and external vehicle benchmarks and driveability development projects are incorporated in the AVL-DRIVE system. AVL-DRIVE uses different sensors and CAN bus information to capture the most significant data and vehicle parameters, such as, accelerations, engine data, vehicle speed, and pedal position. These input quantities are collected by the DMU2 (DRIVE Main Unit 2, located in the car boot) and passed on to a PC (Notebook, located at the passenger seat) for further analysis. Ratings for all Driving Modes are displayed online during driving.

A rental car, Audi Q5 2.0 TFSI Quattro S-tronic, was equipped with the AVL-DRIVE system. The pre-study consisted of a number of tests, both on public roads including gravel and tarmac, but also on Arjeplog Test Management (ATM)/Bosch test tracks.

One use for the system as it is today could be to study the change in vehicle driveability after endurance tests or after longer periods of testing. This could be done by driving a set of specified driving cycles called Fahrmanöver-Katalog (FMK). Another idea put forward by an engineer at a service provider was to use the AVL-DRIVE system to compare certain driving maneuvers with a vehicle directly from the cold chambers and with the vehicle warmed up, to study the effects on driveability for cold car and systems. Also these tests do not require any Electronic Stability Control (ESP), Anti-lock Braking System (ABS), or Traction Control System (TCS) activity so the AVL-DRIVE system as it is could be used for this purpose. However, a handling version of the AVL-DRIVE that could also handle and assess ESP, ABS, and TCS interventions would be of great interest to the service providers and the automotive testing in general. This demands a great deal of development and research, but the technical foundation exists for this to be a reality.

Keywords

driveability, vehicle testing, winter test, handling criteria's.
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1 INTRODUCTION

This chapter will give an introduction of the automotive winter test industry in northern Sweden then follows a brief introduction to the project. At the end of the chapter the project goals are presented and an outline is presented for the reader.

1.1 Automotive winter test industry

In northern Sweden, the winter season starts in November and lasts until March, where temperatures in the range of −40 degrees Celsius are common in some areas [1]. The natural asset – cold weather – is available and has become a backbone in the business concepts of many companies particularly in services for winter vehicle testing. The municipalities of Jokkmokk, Arvidsjaur, Arjeplog, Älvsbyn constitute a vast region, with only 0.89 persons per square kilometer, and where collaboration is important to support the automotive test industry [2]. The collaborative effort involves providing overall services surrounding the test industry, e.g. logistics, accommodation, food, and leisure activities. A number of automotive winter test service companies are established in this region. The automotive winter test industry started somewhere between 1960 – 1970, with local people plowing test track on the frozen lakes [3]. The local people later became service providers for the automotive companies and started to build up land based tracks and facilities for the automotive industry.

Figure 1. State-of-the-art test facility Arjeplog 2007, ©Bosch with permission.

In the last years the winter test business in northern Sweden has grown with roughly 15% annually [3], where the largest company have 200 employees annually and a yearly turnover of 21 million EURO [4]. There are several
service providers in the regions of Jokkmokk, Arjeplog, Arvidsjaur, Älvsbyn, Kiruna and Sorsele. The service providers have different business strategies. One service provider could have only one customer whereas another might have a more open test track with a number of different customers. The technical knowledge also varies with some service providers’ offering large test tracks, facilities, test-drivers and engineers, and others offering large test tracks and facilities with a few test-drivers. There are also service providers that mainly take care of their customers’ facilities and tracks, and some service providers that offer something in-between.

![Figure 2. Ice tracks on a lake outside Arjeplog, ©Bosch with permission.](image)

### 1.2 Background to the project
AVL-DRIVE pre-study idea started from Lars Holmgren at ATM\(^1\) and his curiosity in the AVL-DRIVE system (see chapter 2) and if it could be used in the automotive winter test industry. To learn more about the system, Mikael Nybacka from LTU\(^2\) and David Holmlund from ATM visited AVL\(^3\) List in Graz for a quick introduction to the system. A pre-study project was formed between LTU, AVL and ATM to further test the AVL-DRIVE system at ATM/Bosch test tracks and public roads in northern Sweden. The focus of the pre-study was to see how the system, as it is, could be used by the service providers and their customers during winter and summer testing in northern Sweden.

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1. Arjeplog Test Management
3. wwwavl.com
Sweden but also if the system could be extended and further developed to suit
their needs. The pre-study project was conducted from 1st of August until 15th
of October 2009.

1.3 Goal
The goal with this pre-study project was to:

- Understand how the AVL-DRIVE system could be used for creating
  new services or enhancing current services.
- Get a general understanding how the AVL-DRIVE system could be
  extended and tailored to the winter test industries safety and handling
  tests.
- Find strategies for funding of a future research project between AVL,
  LTU and ATM.

It was also decided that some other parts should be studied:

- VBOX3i integration with AVL-DRIVE
- Long time logging of data with the AVL-DRIVE system
- “AVL-DRIVE for handling” prototype tested for handling maneuvers

1.4 Outline of the report
Chapter two presents the AVL-DRIVE system and AVL-DRIVE for Handling
prototype and the research that these build on. Chapter three presents the test
setup, from the vehicle to the different maneuvers that were driven. The results
are presented in chapter four in the form of figures, tables, and also service
providers’, engineers’, and others comments. Possible funding strategies will also
be presented in the last part of chapter four. The results will then be discussed in
chapter five and in chapter six, seven and eight the table of figures, tables and
the references are presented.
2 AVL-DRIVE

This chapter will describe the AVL-DRIVE system that was tested during this pre-study and the research that have been done concerning this system. The extension of DRIVE, AVL-DRIVE for Handling prototype will also be presented in this chapter.

2.1 System overview

The AVL-DRIVE system is designed for objective assessment and quality control of driveability based on human experience. Procedures for the objective assessment of the subjective perception of the driver have been used to define the evaluation method and formulas. Experiences acquired from internal and external vehicle benchmarks and driveability development projects are incorporated in the AVL-DRIVE system. Meaning that vehicle data from sensors has been logged at the same time as subjective ratings of a range of drivers has been collected. So, for each single operation mode all subjective assessments and the corresponding vehicle and engine data have been recorded. This data has been used together with a generic algorithm to train the neural net for the best correlation between subjective assessment and objective evaluation, [5].

AVL-DRIVE use different sensors and CAN bus information to capture the most significant data and vehicle parameters, such as longitudinal acceleration, engine speed, vehicle speed, and pedal position. These input quantities are collected by the DMU2 (DRIVE Main Unit 2, located in the car boot) and passed on to a PC (Notebook, located at the passenger seat) for further analysis.

The sensors, number 1, 4, 5, 6, in Figure 3 exist mainly to capture the influence on the driver.

Figure 3. The components of AVL-DRIVE system.[5]
The AVL-DRIVE system is available for various vehicle classes (Small, Medium, Large, Compact, Luxury, Sportive, SUV, Pick-up Truck, Light / Heavy duty truck, and Tractors) and the following transmission variants:

- MT (manual transmission)
- AMT (automated manual transmission)
- AT (automatic transmission)
- DCT (double clutch transmission)
- CVT (continuously variable transmission)
- Hybrids
- Electric Vehicles

More than 500 individual criteria (e.g. Kick, Surge, Engine speed fluctuation, Response delay, etc.) are defined for several driving modes (e.g. Drive away, Acceleration, Gearshift, etc.). The relevant parameters for the defined criteria of all detected driving modes are measured, calculated, weighted and displayed online while driving. The AVL-DRIVE system delivers objective ratings for driveability quality and vehicle character and - combined with an automatic classification of similar driving modes - enables a very quick vehicle analysis. The driveability itself is assessed at criteria level by means of a Drive Rating (DR) from 1 to 10 according to Figure 4, [5].

![AVL-DRIVE™ Driveability Assessment](image)

Figure 4. Table for drivability rating, provided by AVL.

For an example of how a hierarchy of main operation modes to criteria’s look like see Figure 5.
Figure 5. Tree of main operation modes, sub operation modes and criteria’s.[5]

Figure 6. Example of parameter calculation for single event.

Figure 6 shows how different parameters are calculated for a single event of a gearshift such as, the acceleration gradient for disengagement of the gear, traction interrupt time, zero acceleration time, acceleration gradient on engagement of the gear and the engagement shock.
2.2 Past research

A number of scientific papers have been published concerning the AVL-DRIVE system. The research of AVL-DRIVE started in 1997 and has since then been further enhanced in multiple research projects. List et. al. [6] first presented the AVL-DRIVE system and its ability to objectively and in real-time evaluate relevant drivability criteria's for use in a vehicle and on a high dynamic test bed. In 2000 Peter Schoeggl et. al. [7] presented the AVL-DRIVE system with a new subjective – objective approach where drivability is described by a high number of 275 single criteria’s, including vehicle dynamics, noise and vibration. Peter Schoeggl et. al. [8] presented a way of utilizing the AVL-DRIVE system to detect driver style, which can be used to let the driver create his or her own unique vehicle character. In 2005 Peter Schoeggl et. al. [9] presented a simulation methodology by interlinking of the AVL-tools CRUISE, VSM, and DRIVE, this allowed to semi automatically pre-optimize powertrain and vehicle parameters before hardware is involved. In 2009 Josef Zehetner et. al. [10] present an approach for a combined optimization of performance, emissions, fuel consumption and driveability using VSM and AVL-DRIVE.

2.3 AVL-DRIVE for Handling

In the AVL-DRIVE for Handling prototype the regular AVL-DRIVE system for longitudinal dynamics is extended with a lateral dynamics evaluation. The extended main operation mode “handling” has 8 sub-operation modes and 50 criteria’s that are evaluated.

Figure 7 show the main operation mode and sub operation modes of cornering and also displaying the criteria’s for sub operation mode “Turn in”.

![Figure 7. Main operation, sub operation mode and criteria for cornering.](image)

4 Vehicle Simulation Model
3 TEST SETUP

This chapter presents the test setup, from vehicle to the different maneuvers that were driven.

3.1 Vehicle

A rental car, Audi Q5 2.0 TFSI Quattro S-tronic, was equipped with the AVL-DRIVE system. The Audi Q5 is 2009 year’s model and it had a mileage of 14000km when starting the pre-study. The car was serviced the 18th of August 2009 at 19136km but no changes that should affect the drivability were done only oil change and general check of the vehicle was performed, the 13th of October when running the last test the car mileage was 23600km.

3.2 System and sensor mounting

The sensors listed in Figure 3 were mounted in the Audi Q5 together with a VBOX3i GPS system from Racelogic\(^5\). The sensors were placed on, the steering column just above the hook joint (5), passengers seat rail (2), driver seat headrest (1), driver seat rail (4), lower front left wishbone (3), battery minus pole (8) and also a CAN-bus connection (9). The numbers in parenthesis corresponds to the numbers in Figure 3 and some of the placements can be seen in Appendix A. The AVL-DRIVE system was not connected with the VBOX3i during the initial tests since there were problems with the connection but it were later connected to the AVL-DRIVE for the last FMK test 13th of October running the new version of the AVL-DRIVE software. The sensors were calibrated to the Audi Q5 using the specific test sequences specified by AVL. Test sequences include coast down test in neutral gear to find the roll resistance from tire interaction with road, air resistance, and resistance in driveline.

For the AVL-DRIVE for Handling prototype no extra sensors is needed in the current version, only more information is gathered from the vehicle CAN-bus.

The system usually takes 2 hours to mount for an experienced DRIVE mechanic. Mounting the system in the Audi Q5 in a hidden way, due to the car being a demonstration vehicle, and with the VBOX3i system took 5 hours.

3.3 The different tests

The pre-study consisted of a number of tests, both on public roads including gravel and tarmac, but also on ATM/Bosch test tracks.

3.3.1 Endurance tests

To test the systems functionality and usefulness during summer endurance tests, the Audi Q5 was driven on the same test routes as an ongoing endurance test.

\(^5\) www.racelogic.co.uk
This means that the car was driven a distance of approximately 500km per day. The endurance test is run on 70% gravel roads, with a number of stops during the day. Two days were driven without audio system on and two days with audio system since the estimation of noise in the coupé is an unreliable measurement factor due to the gravel road and will not be included. Week two was driven on tarmac public roads to study the long-time stability of logging data.

3.3.2 Comfort vs. Dynamic
To compare different settings of the Audi drive select system, namely comfort mode and dynamic mode, four tests were performed on tarmac test track with the same maneuvers as in the Fahrmanöver-Katalog (FMK) explained in 3.3.3. This was also performed in order to compare driveability assessments for endurance tests and the specified maneuvers in benchmark guide in Table 1 driven on ATM/Bosch test tracks.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Name</th>
<th>Engine Speed</th>
<th>AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coast down</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>2</td>
<td>Acceleration Full load Monitoring</td>
<td>CAN</td>
<td>Off</td>
</tr>
<tr>
<td>3</td>
<td>Warm up city driving</td>
<td>DIG/CAN</td>
<td>On</td>
</tr>
<tr>
<td>4</td>
<td>Engine start, idle all, throttle response, engine stop</td>
<td>DIG/CAN</td>
<td>On/off</td>
</tr>
<tr>
<td>5</td>
<td>Constant speed</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>6</td>
<td>Drive away, vehicle stop, D</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>7</td>
<td>Drive away, vehicle stop, S</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>8</td>
<td>Drive away, vehicle stop, M</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>9</td>
<td>Drive away, hill climbing, D, S</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>10</td>
<td>Idle maneuvering</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>11</td>
<td>0 to 100kph</td>
<td>CAN</td>
<td>Off</td>
</tr>
<tr>
<td>12</td>
<td>Acceleration, part load, rising pedal</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>13</td>
<td>Acceleration, part load, constant pedal</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>14</td>
<td>Tip in, tip out</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>15</td>
<td>Gearshift D</td>
<td>CAN</td>
<td>On</td>
</tr>
<tr>
<td>16</td>
<td>Gearshift S</td>
<td>CAN</td>
<td>On</td>
</tr>
</tbody>
</table>

3.3.3 FMK test
At the end of each of the two first weeks the Audi Q5 was driven on the ATM/Bosch tarmac split-μ test tracks with a number of selected test maneuvers in the “vehicle configuration and benchmark guide” from AVL. A last FMK was also driven the 13th of October. This was done to study eventual changes in the vehicle during the endurance tests.

The maneuvers used for the FMK were 6, 9, 10, 11, 14, and 15 in Table 1.
3.3.4 Handling
A further development of the AVL-DRIVE system called AVL-DRIVE for Handling was driven on gravel handling tracks at ATM/Bosch to study the captured events from different handling maneuvers.

Two laps were driven with Audi Drive Select set in comfort mode the first lap and dynamic mode the second lap.

3.3.5 Cold climate test
The 13th of October after the FMK manoeuvres it was decided to perform a cold test to compare some chosen FMK manoeuvres with the same manoeuvres but with a cold car the morning after at the 14th of October. The manoeuvres that were run were manoeuvres 10, 15, 16 in Table 1. The temperature in the morning was -12 degrees Celsius.
4 RESULTS

This chapter presents the results of the pre-study. The results are split into several subsections for better overview. Some of the results presented are the different endurance tests both with and without noise assessment, test track tests, FMK drivability data over time, VBOX3i integration, long time logging and the handling version of AVL-DRIVE.

4.1 Different endurance tests

In order to study the use of the AVL-DRIVE system for driveability assessment during endurance tests and as a system to capture and analyze abnormal behavior during the tests a number of runs were conducted as explained in 3.3.1. Table 2 shows the total driveability assessment of the vehicle including compensation for noise and vibrations. First and second row are with audio system off, the other two with audio system on. Figure 8 show the endurance test route for the first test day the 3rd of August, the other test routes can be seen in Appendix B.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Date</th>
<th>AVL-DRIVE rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2009-08-03</td>
<td>5.23</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2009-08-04</td>
<td>5.16</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2009-08-05</td>
<td>5.27</td>
<td>With audio system on</td>
</tr>
<tr>
<td>4</td>
<td>2009-08-06</td>
<td>5.41</td>
<td>With audio system on</td>
</tr>
</tbody>
</table>

As can be seen in the table the effect on driveability with the audio system turned on is not that large due to the very predominant noise of the gravel-
road. Even though the endurance routes were different for each day they were still driven on 70% gravel roads.

In general it has to be noted that AVL-DRIVE is weighting bad ratings higher in order to easier detect weak points, so the very bad noise ratings distort the overall results.

### 4.2 Endurance test with noise vs. no noise

Since noise from driving on 70% gravel roads in the endurance tests are very high and predominant of other noises from powertrain. The total driveability rating reported in Table 2 were manually re-simulated using AVL-DRIVE software excluding the influence of noise and vibration on affected operation modes. Table 3 show different main operation modes from the endurance test reported at first row in Table 2. Table 3 shows rating with compensation for noise and vibration, with noise and vibration measured but not compensated for, and without measuring noise and vibration. The compensation is used to filter the measured vibration and noise in the vehicle using the road disturbance as input.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Main operation mode</th>
<th>Rating with compensation</th>
<th>Rating without compensation</th>
<th>Rating without noise and vibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Drive away</td>
<td>6.85</td>
<td>6.85</td>
<td>6.85</td>
</tr>
<tr>
<td>2</td>
<td>Acceleration</td>
<td>7.95</td>
<td>7.98</td>
<td>7.98</td>
</tr>
<tr>
<td>3</td>
<td>Tip-In</td>
<td>6.61</td>
<td>7.31</td>
<td>7.91</td>
</tr>
<tr>
<td>4</td>
<td>Tip-Out</td>
<td>8.66</td>
<td>8.69</td>
<td>8.69</td>
</tr>
<tr>
<td>5</td>
<td>Motoring</td>
<td>6.08</td>
<td>7.89</td>
<td>7.89</td>
</tr>
<tr>
<td>6</td>
<td>Gear shift</td>
<td>8.11</td>
<td>8.15</td>
<td>8.15</td>
</tr>
<tr>
<td>7</td>
<td>Constant speed</td>
<td>4.13</td>
<td>7.59</td>
<td>7.59</td>
</tr>
<tr>
<td>8</td>
<td>Idle</td>
<td>7.38</td>
<td>7.09</td>
<td>7.09</td>
</tr>
<tr>
<td>9</td>
<td>Vibrations</td>
<td>7.84</td>
<td>7.65</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>Noise</td>
<td>3.19</td>
<td>3.06</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Total drive rating</td>
<td>5.23</td>
<td>5.57</td>
<td>7.53</td>
</tr>
</tbody>
</table>

Seen in Table 3 and Figure 9 is that the driveability rating, with compensation of road input, for the main operation modes. Tip-in, Motoring, and constant speed are worse then without compensation. Also seen is that the main operation modes, idle, vibration and noise is rated better with compensation then without. What should be noted is that the system was not developed for driving on gravel road, so in order for it to be useful for endurance tests on gravel roads the system has to be further developed for this purpose. The rough road influences are compensated within a defined range. Out of this range the ratings are suppressed during this fault, [8].
Figure 9. Comparison of the influence of noise and vibration.

Figure 10. Comparison of Acceleration – Full load 0-100kph with Comfort and Dynamic setting in Audi Q5.
4.3 Comfort vs. Dynamic
To compare different settings of the Audi drive select system, namely comfort mode and dynamic mode, two tests were performed on tarmac test tracks with the same maneuvers as in the FMK explained in 3.3.3. These tests were performed to study change in the vehicle performance due to the different settings of the Audi drive select system. Meaning, that if switching on the Dynamic mode in the Audi we should expect a better performance assessment. One example of the differences between Comfort mode and Dynamic mode in these tests is displayed in Figure 10, and the rest of the results can be seen in Appendix C. One can clearly see that the Dynamic mode in the Audi has a better assessment for the 0-100kph sub-operation mode, both with and without kick-down.

4.4 FMK over time
At the end of the two first weeks the Audi Q5 was driven on the ATM/Bosch test tracks with a number of selected test maneuvers in the “vehicle configuration and benchmark guide” from AVL. This was done to study eventual changes in the vehicle during the endurance tests. Table 4 shows the driveability assessments for the two FMK tests.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Date</th>
<th>AVL-DRIVE rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2009-07-30</td>
<td>7.65</td>
<td>FMK1</td>
</tr>
<tr>
<td>2</td>
<td>2009-08-07</td>
<td>7.58</td>
<td>FMK2</td>
</tr>
<tr>
<td>3</td>
<td>2009-08-14</td>
<td>7.63</td>
<td>FMK3</td>
</tr>
<tr>
<td>4</td>
<td>2009-10-14</td>
<td>7.41</td>
<td>FMK4</td>
</tr>
</tbody>
</table>

Table 4. FMK test over time with AVL-DRIVE rating.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Main operation mode</th>
<th>FMK1</th>
<th>FMK2</th>
<th>FMK3</th>
<th>FMK4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Drive away</td>
<td>7.49</td>
<td>7.44</td>
<td>7.42</td>
<td>7.54</td>
</tr>
<tr>
<td>2</td>
<td>Acceleration</td>
<td>7.74</td>
<td>7.31</td>
<td>7.34</td>
<td>7.20</td>
</tr>
<tr>
<td>3</td>
<td>Tip-In</td>
<td>7.55</td>
<td>7.48</td>
<td>7.47</td>
<td>7.34</td>
</tr>
<tr>
<td>4</td>
<td>Tip-Out</td>
<td>9.14</td>
<td>8.92</td>
<td>8.70</td>
<td>7.99</td>
</tr>
<tr>
<td>5</td>
<td>Motoring</td>
<td>7.51</td>
<td>7.96</td>
<td>8.17</td>
<td>7.37</td>
</tr>
<tr>
<td>6</td>
<td>Gear shift</td>
<td>7.56</td>
<td>7.57</td>
<td>7.48</td>
<td>7.68</td>
</tr>
<tr>
<td>7</td>
<td>Constant speed</td>
<td>9.21</td>
<td>8.43</td>
<td>8.55</td>
<td>8.11</td>
</tr>
<tr>
<td>8</td>
<td>Idle</td>
<td>7.66</td>
<td>7.37</td>
<td>8.29</td>
<td>7.63</td>
</tr>
</tbody>
</table>

Table 5. Comparison of main operation modes for FMK1 and FMK2.

What can be seen from Figure 11 and Table 5 is that the largest differences between FMK’s are the main operation modes Acceleration, Tip-out, motoring and constant speed.

- **Constant speed**: quite bad “surge” ratings decrease the results of FMK3.
- **Tip Out**: massive jerks (oscillations of powertrain) decrease the results of FMK4.
• **Motoring**: bad results of FMK1 from insufficient calibration before measurement (during installation and start up).
• **Acceleration**: bad “surge” rating (FMK4) from ice and snow.

![Figure 11. Driveability comparison of FMK1 – FMK4.](image)

What should be noted is that the Audi had only run 14000Km when the first FMK was driven, 16000Km for the second, 18000Km for the third and 23600Km for the last FMK. There are some events that are rated lower for each FMK; these are:

• Main operation mode tip-out
• Sub-operation mode “creep/crawl” of main operation mode “Drive away”
• “traction reduction criteria” for the sub-operation mode “Upshift during part load”

The sub-operation modes, shock, engagement steadiness, and clutch surge for Drive away Normal showed considerable decrease in drive rating for FMK4. One criterion "response delay" for the sub-operation modes "Drive away – launch" and “Drive away – normal” showed an increasing drive rating. All of these mentioned above can be seen in Appendix D. However, as previously mentioned FMK1 had insufficient calibrations and FMK4 had bad jerks ratings due to snow and ice, which can be seen in Figure 12.
4.5 VBOX3i integration with AVL-DRIVE
In the new version of AVL-DRIVE it is possible to integrate GPS data with the measurements. There were some problems of setting up the connection between the VBOX3i and the DMU2. However, the problem was solved at the end of the pre-study.

4.6 Long time logging
Long time logging with the AVL-DRIVE system was of interest since the drive cycle in our case is about two hours and the driver do not want to start and stop measurements during the test drive. It is also a request to not have to turn on and off the measurements for four hours.

The mean logging time of the long logging tests was approximately 90 minutes and after this the measurements stopped due to the amount of data. The error message from the system when it stopped logging was “Unable to gather data from DRIVE Main Unit 2, check the connection between the DRIVE Main Unit 2 and your PC and restart AVL-DRIVE if necessary”. There was no problem with the physical connection between the DMU2 and the laptop. However, restarting the measurement was enough to continue measuring. In the meantime there are already research running to reduce the data as well as other optimization for long-term measurements.
4.7 Handling

Some tests on the handling track were performed using the AVL-DRIVE for handling to capture the lateral influence of driveability. Two laps on the handling track with one lap in comfort mode of the Audi QS and one with dynamic mode. The track surface is gravel and thus some interventions of the ESP were recorded due to exceeded slip. This results in some of the ratings not being reliable. The detected interventions can be seen by the blue text in Figure 13, these are not included in the driveability rating by default. However, the following figures shows that the AVL-DRIVE for Handling prototype works and detected a number of handling events.

![Figure 13. Driveability rating with handling, Dynamic mode.](image)

Studying Figure 13 for Dynamic mode and Figure 14 for the Comfort mode there are some difference in driveability rating. With Dynamic mode set in the Audi the, Drive away, Acceleration, Tip-out, Gearshift and Idle are rated lower while the Handling is rated better.
4.8 Cold test

A comparative test was performed from the cold climate test defined in 3.3.5. The different driveability ratings of the sub-mode “Gear shift – Upshift during part load acceleration” between warm car and cold can be visualized in Figure 15. It can be seen that there is a predominant difference between the cold car and the warm car. The traction reduction gives the largest difference in driveability rating, where the cold car gives a lower rating than the warm. Traction reduction is measured during upshift from minimum longitudinal acceleration to the point where a steady acceleration arises. However, shock, kick, jerks, speed decrease and shift duration is better in the cold compared to the warm car. No additional analyses were performed due to time limitations but the additional results seen in Appendix E shows that the AVL-DRIVE in its current form are capable to assess the difference in the vehicle driveability during cold starts. Further, to produce these results was quick with only a short test on the evening and a short test the next morning at -12 degrees Celsius. Further tests of a cold start from a cold chamber at a test track would be very interesting to perform and analyse.
4.9 Survey results
To understand what the service providers and their engineers say about the AVL-DRIVE and AVL-DRIVE for handling. The survey in Appendix F was given to all who had the opportunity to receive a presentation and also see and test the systems. A total of six persons answered the survey where three where managers of test sites, and two engineers from test sites.

In general the views are quite positive about the AVL-DRIVE system where many think the system is very helpful when they saw it perform in the vehicle, Figure 16. However, the view of the systems usefulness in its current form, longitudinal drivability, is different by the respondents as seen in Figure 17. One respondent pointed out that most of the testing is done on ice, snow, and gravel roads, and since the AVL-DRIVE system do not assess handling or ESP/ABS/TCS intervention it is seen as having little use in winter testing if not developed further for this purpose. On the question, “How useful would it be for you, your organization and your customer to use an extended DRIVE-system that could handle safety and handling tests?” it was very obvious that all the participants perceived that the system would be very useful, either for themselves, their organizations or their customers, see Figure 18.
On a scale of 1-7 how helpful do you think the AVL-DRIVE system WAS DURING THE TEST RUN?

- University lector: 3, 5, 6, 7
- Section manager, research institute: 0, 2, 4, 6
- Manager3, service provider: 6
- Test Engineer2, service provider: 6
- Manager2, service provider: 6
- Assistant manager, service provider: 6
- Manager1, service provider: 6

On a scale of 1-7 how helpful do you think the AVL-DRIVE system in its current status COULD BE FOR SERVICE PROVIDERS?

- University lector: 3, 5, 6, 7
- Section manager, research institute: 0, 2, 4, 6
- Manager3, service provider: 6
- Test Engineer2, service provider: 6
- Manager2, service provider: 6
- Assistant manager, service provider: 6
- Manager1, service provider: 6
- Test Engineer, service provider: 6

Figure 16. Helpfulness of AVL-DRIVE during test run.

Figure 17. How helpful could AVL-DRIVE be?
When asked about what is most helpful with using AVL-DRIVE for endurance testing, the respondents said:

“Possibility to find a specific problem by simple sorting in software. Also the possibility to connect DRIVE to GPS and show data in Google Earth for example.”

“That the system is Objective.”

“That our drivers have "evidence" for what they feel and note down by hand today.”

“Subjective assessment of a system - a template that can be run on different models and compare results of the tests.”

“A way to confirm what test drivers feel.”

“Possibility to log large amount of data and automatically weight the data to a performance measure.”
“Everybody has an opinion of what is good. It is good to be able to benchmark that to reality (sensor data) and over a large range of people. It is very useful in simulation. Make an adjustment and see if it increases "driveability" without getting into a car. We do not understand what the compromises for a specific performance (which we are focusing on) but the system can look at it all. ”

Furthermore, the respondents where asked about how they think that the AVL-DRIVE system in its current status could enhance the testing and services during winter and summer testing. The following where the answers:

“During winter time the system is not useful since it cannot "handle" ESP/ABS/TCS. When almost all testing done up here during summer times is durability testing, mostly driven on gravel roads there is a need to develop the compensation of uneven roads even further. Now the system only use one accelerometer sensor on one wheel to detect irregularities, but I believe it takes more to be able to fully compensate. Other functions seem to work well.”

“In this version most probably not.”

“Larger opportunities to do a test case, not just supply test drivers.”

“Secure the confidence between our drivers and our customers.”

“In its current form nothing that our customer have use for in the tests conducted in Sweden.”

“Helps to quantify long test results that should be communicated to OEM.”

“I did not feel it did what I would want but everything is there to do it. I would invest in it.”

Since the system in its current status cannot handle low friction and lateral dynamics the respondents felt that it would not be of much use.

For the endurance tests and use of AVL-DRIVE it is important to know how much the test protocols could be changed. Thus the following question were posed: “Is it possible to incorporate a number of specified test sequences during endurance tests, or is the test-protocol to strict? Is it possible with short evaluations every 5000Km?”

This was what some of the respondents said:

“If the manufacturers were prepared to pay for it would be fine. But then you have to prove that it is "profitable".”

“It could exist a possibility.”

“Probably yes”

“For our customer the ESP-tests is the biggest part, here different test protocols similar to lane-change (Single, double) over-, understeering be interesting”

“It can answer a lot of questions. From initial wear to mixed tires performance.”

To know more about what specific tests that the respondents believed that a future developed AVL-DRIVE for handling system could be useful the
following question where posed: “In what specific tests do you think a DRIVE handling system could be useful and why?”. These where the answers:

“To easier and quicker find errors or weak areas in ABS/TCS/ESP would shorten the development time. Especially on the development of new systems (platform development) where it is important with the functionality in its whole instead of exact calibration for a certain type of car or model.”

“Development of systems related to ABS and ESP.”

“ESP/ABS tests and test of complete car.”

“Is there any limit? Everything we do for our customer is good to document.”

“Subjektive assessment of ABS, TCS, and ESP. E.g. Stability under split-mu braking. TCS - how soft/hard it behaves during accelerations, ESP - assessment of intervention - hardness, comfort.”

“Long tests and identification of problems and errors.”

“The system could be adapted to the safety tests, e.g. According to ISO-standards.”

“High to split-mu, stability in curves while accelerating or braking.”

It is seen that almost exclusively the respondents felt that a future developed system could be very helpful when it comes to tests of ESP/ABS/TCS systems.

None of the respondents had any system that objectively could assess vehicle and systems when it comes to handling tests. They only have data logging equipment. One of the respondents did not know due to that their customers bring with them all the equipments.

When asked the following question, “What expectations do you / your customers have on a… (What should they include and how should they function?)”, three examples where given:

- **Data logging system:**
  “It should be fast and be able to log large amounts of data”
  “Logging at errors, logging under short time 60sec, longtime logging (limitation due to lot of data)”
  “Easy to use. Simple and quick to connect and start measurement.”
  “Accurate, easy to use. Analyze the data to point out problems in a sea of signals.”

- **Objective driveability analyzer:**
  “Have no use for it in the tests that are conducted here”
  “Simple to use”
  “Interesting theme but at this time nothing that the customers need.”
  “Possibility to self define limits for red, yellow, and green”
  “It provide a feedback if the changes made to the software improved driveability”

- **Objective evaluation tool for the performance of safety systems:**
  “Quick and especially easy to use. That it will give a good view of the system status compared with the goals. It should be quick to analyze data.”
  “Interesting theme but at this time nothing that the customers need.”
“The tool should present results on two levels: 1. detailed collected data, 2. safety indicators that describe the performance in summarized form.”
“When discussing with customers you have something to work with rather than feelings and perceptions.”

A general view is that the systems in the test vehicles must be very easy to use and work with.

A final comment from the survey about the AVL-DRIVE system is the following:

“Very interesting, the question is how we can sell it to our customers and if the prize can be discussed in some way?”
“If implementation of ESP, ABS, TCS works then AVL-DRIVE could be an interesting system, naturally also a cost issue.”
“It should be exciting to see a developed version that could log the driver behavior.”
5 DISCUSSION
This chapter discusses the results and different aspects of the pre-study project. The chapter also elaborates on the usability of the AVL-DRIVE system for automotive testing in northern Sweden. Finally the development of AVL-DRIVE for handling is discussed.

5.1 Differences between data
In the results presented in chapter 4 there are some noted differences in the data. The system should cancel out the effects of the drivers influence on the data so difference may come from different numbers of events assessed. Meaning, if a driver drives hard more tip-in and tip-out events will be assessed compared to a driver that has a more gentle driving approach. This is why AVL has developed the Benchmark guidance maneuvers in order to compare vehicles with each other and in the process making sure that the same amount of events are assessed and that all the criteria’s needed are assessed.

Another note to the data for the FMK tests is that the FMK1 test had insufficient calibration during installation and startup and that FMK4 test had bad surge rating from ice and snow on the track. So in order to make use of the FMK before and after, e.g. endurance tests, it should be performed on the same tracks and with the same maneuvers.

One thing that often occurred during driving was the error message “Gearshift Detection Aborted”, or a message saying there is a problem calculating shift time due to ratio-problems. This was due to the system being able to see the trigger signal for the gearbox to change gear, but it could not detect any difference in gear ratio. Since the car had a Dual Clutch Transmission (DCT) it can occur, during downshifts, that the gearbox get the signal to downshift, and does so, but because the vehicle is rolling the clutch does not always need to close. If the clutch is open, there is no change in ratio between wheels and engine. This can be visualized in the AVL-DRIVE software looking at the synchron speeds versus engine speed and gear.

It should also be noted that the AVL-DRIVE system has a built in function for assessing the reliability of the weightings and the ratings of the system itself. This was not discussed about during the presentations but it is a great feature, which is why it is noted here.

5.2 Usability of AVL-DRIVE for service providers
When discussing the AVL-DRIVE for handling prototype with service providers and engineers, the interest in such a system is remarkably positive. However, for the service providers to start finding a suitable business model of using this system some demonstrations of its usability and some sort of license or rental agreement is needed.
One use for the system as it is today could be to study the change in vehicle driveability after endurance tests or after longer periods of testing. This could be done by driving a set of specified driving cycles specified in [11], called FMK in this report. An adapted FMK that were used during this study and explained in 3.3.3 takes 3.5 hours for an experienced test driver. Running an adapted FMK before testing starts to get a starting reference of drivability for the test vehicle and then at the end of the test running a second adapted FMK will make it possible to analyze changes of the vehicle due to, e.g. degradation or system malfunction. The drivability data from the two adapted FMK tests can be compared and in the AVL-DRIVE software, Report Generator, where it is easy to see the difference in main operation modes. To get a better understanding of which criteria changed the most it is possible to step down to the sub-operation modes and to the different criteria’s that show the largest discrepancy.

The use of the system during endurance tests does not give much help with only the AVL-DRIVE. A GPS system needs to be installed and connected to the AVL-DRIVE in order to track where a certain detected event occurred. Also AVL-DRIVE needs to be able to log data more stable and for longer periods of time then it currently can. Another possible development of the system for endurance tests would be to notify the driver of a bad driveability rating in a clear way in the PDA. This so that the driver, if needed, has the possibility to reproduce the event that caused the bad driveability. To help the test drivers it would help to make the start and stop of measurements easier or even automatic, so that when the ignition is turned off the measurement will turn off. If the system will be further developed for endurance tests it is also a request that the system should start logging faster than five minutes. Further the noise measurement should not be used during endurance tests since it do not give any useable information in these tests, and since the AVL-DRIVE system was not developed for this purpose. The rough road influences are compensated within a defined range. Out of this range the ratings are suppressed during this fault, [8].

5.2.1 Service providers view
When discussing with people during the demonstrations of the system some ideas and thoughts came up that were not written down in the surveys.

One idea was to use the AVL-DRIVE system to compare certain driving maneuvers with a vehicle directly from the cold chambers and with the vehicle warmed up, to study the effects on driveability for cold car and systems. Also these tests do not require any ESP, ABS, or TCS activity so the AVL-DRIVE system as it is could be used for this purpose. The overall view from the service providers was positive, especially concerning the handling part and eventual development for ESP, ABS, and TCS, as this is the main part of the work in northern Sweden. Furthermore service providers’ carry out durability tests for OEMs. They would appreciate a tool not only for evaluation but also for documentation of irregularities over a longer period – which AVL-DRIVE was not designed for originally.
5.2.2 AVL's view
This pre-study was the first step into winter testing. Up to now AVL-DRIVE was basically used under warm / normal conditions.

The study gave a good overview about what the companies up in Northern Sweden need and how the actual AVL-DRIVE could be used therefore. So with just some small changes it could on the one hand be a documentation tool for durability tests, on the other hand an evaluation tool for “cold weather” application and calibration of powertrain.

The next step – evaluation of Handling and Safety Systems – is a very challenging one! Although the methodology for evaluation will stay the same the necessary information’s will increase extremely. New sensors will be needed (e.g. gyro or GPS-systems for vehicle movements) as well as internal information has to be created like friction estimation, tire models, etc.

Development partners are welcome from all parties – OEMs, suppliers of safety systems, scientific institutions – to handle this huge amount of work.

As it is of enormous importance regarding the new regulations about compulsory ESP usage in passenger vehicles as well as in trucks – funding from EU could be applied for. The AVL-DRIVE would be a good tool for the service providers to use during summer (benchmarks) and winter tests (cold test and development of powertrain). A future developed application for ABS, ESP and TCS would be a huge benefit for the service providers and automotive industry correspondingly.

5.2.3 LTU and ATM’s view
The current version of AVL-DRIVE could be used for the purpose of analyzing degradation of the vehicle and systems as described above in 5.2 or for cold tests of powertrain. However, the cost of the system compared to the usage and return on investment would probably not be satisfactory for only this usage. If the system could also be used during summer time by the service providers to run benchmark tests or general driveability tests for their customers, the return on investment would be more promising. Further, different demonstrations of the system as it are today for cold weather applications should be performed with a real test vehicle from a service providers’ customer. This could really show the customer the benefit of using such a system and thus give a better base for a return on investment calculation. However, this requires that the service providers start discussions with their customers and preferably AVL to arrange such a demonstration. From the cold test performed it can be concluded that it was fast and easy to do, and this should be studied further during winter in a real case with a real test vehicle.

A handling version of the AVL-DRIVE that could also handle ESP, ABS, and TCS interventions would be of great interest to the service providers and the automotive testing in general as many of them has pointed out in the survey results. This since most of the testing in north of Sweden concerns ESP, ABS and TCS.
5.3 AVL-DRIVE for handling

The AVL-DRIVE for handling system that was briefly tested at the end of the pre-study, will give more interesting information to the driveability assessment of the vehicle. Especially concerning the use of AVL-DRIVE for Handling to study the change of the vehicle lateral dynamics after certain tests. This due to the fact that more criteria’s will be assessed and thus capturing a wider range of possible problem areas. To fully make use of the AVL-DRIVE for Handling the system has to be developed further to assess also the intervention of the ESP, ABS, and TCS systems in vehicles. This since almost 95% of the tests performed in the area concerns the development of ESP, ABS, and TCS systems.

5.3.1 ESP, ABS, and TCS assessment

The technology of AVL-DRIVE and especially the fuzzy-logic part is very well suited for capturing certain driving events in real-time, such as sine with dwell, steep-steer maneuvers or split-μ braking. These technologies together with other algorithms for analyzing data can be used to objectively assess ESP, ABS, and TCS interventions. Further, as pointed out before there will be a need for additional sensors and algorithms to assess the state of the vehicle in more detail. Therefore some papers that present different criteria’s for objectively assess vehicle handling that are of interest to the continuation of this pre-study. Mavros [12] present a methodology for objective assessment of the response of a vehicle subjected to transient-handling maneuvers and define a non-dimensional measure called normalized yaw impulse. Laine et. al. [13] presents modified criteria’s of the FMVSS 126 (sine with dwell) maneuver for ESP tests of heavy vehicle combinations.

Concerning assessing and evaluating ESP, ABS, and TCS intervention with AVL-DRIVE technology we propose to start with defining test maneuvers and the criteria’s that are used during ESP, ABS, and TCS development. This by conducting, reference studies, surveys and interviews with the automotive industry during the winter test season of 2009/2010. These results should be correlated with the criteria’s that already has been developed for the AVL-DRIVE for handling prototype. Further, it would be wise to start with ABS since this is the most established/oldest system and then move on to TCS that is also an established system. These will be easiest to implement due to its many models existing in literature and simulation software and AVL’s experience in engine and powertrain for TCS. ESP will demand a larger effort due to the demand of estimating the state of the vehicle including used and maximum friction, which also will require more information of the vehicle that is tested. However, this system is one of the most important systems to evaluate since it will be mandatory in all cars and trucks.

The objective evaluation of ESP, ABS, and TCS systems using AVL-DRIVE for Handling would be a good tool for test engineers to develop these active safety systems more efficiently. As they have pointed out in the survey results, “A way to confirm what test drivers feel.” and “That our drivers have "evidence" for what they feel and note down by hand today.” would clearly be of help when service providers take over more of the testing from their customers. This since...
many customers is still unsure if they can “trust” the competence of the test drivers in Sweden.

5.3.2 Subjective assessment of handling
The last step is to start building up a knowledge base of the subjective assessment of handling and ESP, ABS, TCS interventions using the standard maneuvers like, sine with dwell, split-mu braking, and 10%-20% split-mu hill tests. Utilizing skilled test drivers from the north Sweden test region is a good start for the development of the knowledge base, however, this is a huge task that need considerable amount of funding. King et. al. [14] present a study of subjective assessment of vehicle and propose a way of linking subjective-objective assessments. This paper shows some interesting results of subjective assessment of handling and how one could set up a questionnaire for capturing the subjective ratings. These references and others need to be accounted for in the start of the project in order to find a suitable approach.
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Appendix A

This appendix shows the different sensors placements in the Audi Q5.

Figure 19. Chassis 3-axis sensor, passenger seat rail.

Figure 20. Current sensor, battery minus pole.

Figure 21. Vibration sensor, steering column.
Figure 22. 1-axis acceleration sensor and microphone, driver’s headrest.

Figure 23. DMU2 located in the trunk below the floor.

Figure 24. 1-axis accelerometer on front left lower wishbone.
Appendix B

This appendix shows the different routes driven during the endurance tests.

Figure 25. Endurance test, 3rd of August 2009.

Figure 26. Endurance test, 4th of August 2009.
Figure 27. Endurance test, 5th of August 2009.

Figure 28. Endurance test, 6th of August 2009.
Appendix C

This appendix shows the difference between Comfort and Dynamic setting in the Audi Q5 while driving FMK maneuvers on tarmac test track.

Figure 29. Comparison of acceleration main mode.

Figure 30. Comparison of acceleration – full load 0-100kph.
Figure 31. Comparison of sub-mode full load acceleration.
Appendix D

This appendix shows the comparison of FMK1 – FMK4.

Note that the large difference in tip out compared to tip in for FMK4 could be because of the different track conditions.

Figure 32. Comparison of main operation modes.

Figure 33. Comparison Upshift during part load acceleration.
Figure 34. Comparison drive away.

Figure 35. Comparison drive away normal.
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Figure 37. Tip out after acceleration, showing bad jerk rating for FMK4 due to ice/snow on track.
Appendix E

Results of cold climate test that show the difference between a selection of FMK manoeuvres between cold and warm car.

Figure 38. Downshift during braking, cold vs. warm.

Figure 39. Upshift during part load acceleration, cold vs. warm.
Figure 40. Downshift during motoring, cold vs. warm.

Figure 41. Engine start with closed pedal, cold vs. warm.
Appendix F

This appendix shows the survey used in this pre-study.

Survey of AVL-DRIVE system usability

Hope you have time to read this short introduction text and answer the ten questions below. It is suggested that you skim through this survey and questions before you test the AVL-DRIVE system or follow in the test vehicle with it mounted. Below follows a short description of what this pre-study project is about and then some questions that we hope you could help us answer.

Description:
AVL-DRIVE pre-study idea started from Lars Holmgren at ATM and his interest in the system and if it could be used in the industry. Lars contacted LTU and CASTT for setting up a meeting with AVL to see and test the system during one day. Mikael Nybacka and David Holmlund visited AVL in Graz 2009-05-07 for further discussion about the system and what it was capable of. During the meeting Mikael and David discussed the possibilities of using the technology for safety and handling tests during winter tests. Mikael Nybacka wrote a proposal to AVL for running a pre-study project to understand how the system could be used, both as it is and how it could be extended to facilitate handling and safety tests.

The aim with this pre-study survey is to:

• Understand how the system could be used for creating new services or enhancing current services for automotive testing.
• Get a general understanding how the AVL-DRIVE system could be extended and tailored to the winter test industries safety and handling tests.

AVL-DRIVE system is designed for objective assessment and quality control of drivability based on human experience. Experiences acquired from internal and external vehicle benchmarks and drivability development projects are incorporated in the AVL-DRIVE system. The system uses various sensors and CAN bus information to capture the most significant data and vehicle parameters, such as longitudinal acceleration, engine speed, vehicle speed, pedal position and vibrations. More than 500 individual criteria (e.g. Kick, Surge, Engine speed fluctuation, Response delay . . .) are defined for several driving modes (e.g. Drive away, Acceleration, Gearshift, . . .). The relevant parameters for the defined criteria of all detected driving modes are measured/calculated and weighted online during a test ride. The AVL-DRIVE system delivers objective ratings for driveability quality and vehicle character and - combined with an automatic classification of similar driving modes - enables a very quick vehicle analysis.  

For more information see: AVL-DRIVE product guide or www.avl.com

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6 For more information see: AVL-DRIVE product guide or www.avl.com
Questions:

1. What is your job title? (e.g. Test engineer, test driver, supervisor ABS, Manager)
   
   Vad är din jobbtitel? (T.ex. testingenjör, testförare, projektledare ABS, Chef)

2. On a scale of 1-7 how helpful do you think the AVL-DRIVE system WAS DURING THE TEST RUN? (1 is not at all and 7 are very helpful)
   
   På en skala från 1-7 hur hjälpsamt tycker du att AVL-DRIVE systemet VAR UNDER TESTET? (1 betyder inte alls och 7 betyder väldigt hjälpsamt)

3. On a scale of 1-7 how helpful do you think the AVL-DRIVE system in its current status COULD BE FOR SERVICE PROVIDERS? (1 is not at all and 7 are very helpful)
   
   På en skala från 1-7 hur hjälpsamt tycker du att AVL-DRIVE systemet I nuvarande form SKULLE KUNNA BLI FÖR TESTENTREPRENÖRER? (1 betyder inte alls och 7 betyder väldigt hjälpsamt)

4. What do you think is most helpful when using the AVL-DRIVE system during endurance testing?
   
   Vad tycker du är mest hjälpsamt när man använder AVL-DRIVE systemet under utmattningstester (tester på publika vägar)?
5. How do you think the AVL-DRIVE system in its current status could enhance the testing and services during summer and winter testing?

Hur tycker du att AVL-DRIVE systemet i nuvarande form kan förbättra och utveckla testningen och tjänsterna under sommar- och vintertester?

6. Is it possible to incorporate a number of specified test sequences during endurance tests, or is the test-protocol to strict? Is it possible with short evaluations every 5000Km? (e.g. tip-in and tip-out, gear shifting sequences, etc.)

Är det möjligt att lägga till ett antal specifika testsekvenser under utmattningstesterna, eller är testprotokollet för strict? Är det möjligt att göra korta utvärderingar efter 5000Km? (T.ex. tip-in och tip-out, växlingsekvenser, mm.)

7. How useful would it be for you, your organization and your customer to use an extended DRIVE-system that could handle safety and handling tests? (Meaning to be able to rate the subjective safety and handling criteria’s)

Hur användbart skulle det vara för dig, din organisation och era kunder att använda ett vidareutvecklat AVL-DRIVE system som hanterar dynamiska- och säkerhetstester? (Kunna få en estimerad bedömning på subjektiva kriterier som säkerhet och dynamik)

For You: För Dig:
☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5  ☐ 6  ☐ 7

For your Organization: För din Organisation:
☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5  ☐ 6  ☐ 7

For your Customers: För din Kund:
8. In what specific tests do you think a DRIVE handling system could be useful and why?
I vilken eller vilka typer av tester tror du att ett DRIVE handling system skulle kunna vara till hjälp och varför?

9. Do you have any software or system that could give you an objective value of how safe your test vehicle is when it comes to handling tests? E.i. from logged data or from sensors. And if yes, what system or software is it?
Har ni andra mjukvaror eller system som kan ger ett objektivt värde på hur säker testbilen är när det gäller dynamiska tester? T.ex. från loggad data eller sensorer. Om ja, vilket system eller mjukvara har ni?
10. What expectations do you / your customers have on a… (What should they include and how should they function?)

Vilka förväntningar har ni eller era kunder på… (Vad ska de ha och hur ska de fungera?)

a. data logger system

b. objective driveability analyzer / objektivt analysverktyg av körbarhet

c. objective evaluation tool for the performance of safety systems / objektivt utvärderingsverktyg för prestandan hos säkerhetssystem

Other comments: Övriga kommentarer:

Please fill in the empty fields in this document and leave it to David Holmlund or send it to the address below.

Mikael Nybacka, E211A
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Thank you for your help in this pre-study project it is greatly appreciated.