



# Telematics Module for Bachelor and Permeability



Co-funded by the  
Erasmus+ Programme  
of the European Union



### Project coordination

BGZ Berliner Gesellschaft  
für internationale Zusammenarbeit mbH  
[www.bgz-berlin.de](http://www.bgz-berlin.de)  
[www.car2lab.eu](http://www.car2lab.eu)

### Author

Prof. Dr. -Ing. Michael Lindemann

### Photo credit

Rear view of luxury car © Sergey Nivens - Fotolia.com

### Design

Franziska Zahn, Qin Feng, Elisabeth Schwiertz,  
Steven Gräwe, Martin Popp



Berlin, 2018

# Content

<b>1</b>	<b>Introduction</b>	<b>5</b>
<b>2</b>	<b>Definition of a Vehicle Telematics Module for Bachelor Students</b>	<b>6</b>
2.1	Requirements	6
2.2	Goal of the Course	6
2.3	Road Map	7
2.3.1	Phase 1: Introduction (Course 1 and 2)	7
2.3.2	Phase 2: Components (Course 3 to 7)	8
2.3.3	Phase 3: System (Course 8 to 10)	9
2.3.4	Phase 4: Project Tasks and Concepts	9
<b>3</b>	<b>Application Scenarios (Use Cases)</b>	<b>11</b>
3.1	Project 1: Fuel Laundering	11
3.1.1	Course Item 10/11: Project Definition and Concept Development	11
3.1.2	Course Item 12: Concept Validation	12
3.1.3	Course Item 13/14: Realization	12
3.2	Project 2: Driver Behavior Analysis	12
3.2.1	Course Item 10/11: Project Definition and Concept Development	12
3.2.2	Course Item 12: Concept Validation	13
3.2.3	Course Item 13/14: Realization	13
3.3	Project 3: Forecast of Engine Diagnostics or Errors	14
3.3.1	Course Item 10/11: Project Definition and Concept Development	14
3.3.2	Course Item 12: Concept Validation	14
3.3.3	Course Item 13/14: Realization	14
<b>4</b>	<b>Definition of Development Projects for the Telematics Box</b>	<b>15</b>
4.1	Extended Simulation Concept for Classroom Use	15
<b>5</b>	<b>University Entrance Qualification</b>	<b>18</b>
5.1	"Meister" Education	18
5.2	Technical College	18
5.3	Professional Qualification	18
<b>6</b>	<b>Permeability in the Educational System</b>	<b>19</b>
<b>7</b>	<b>Cooperation HE-VET</b>	<b>20</b>
7.1	Course Definition	20
7.2	Laboratories	20
7.3	Virtual Classrooms	20
7.4	Course Timing	20



## 1 Introduction

This report describes applications and usage of the Telematics Box (TB) developed in IO-02 for courses and education purposes in a bachelor program. Furthermore the final chapters deal with ideas how special courses can help to increase the permeability between higher education and vocational training.

The TB has a wide functionality and can be used with a static simulation and also in a vehicle environment. For usage in a higher education framework the TB can

a) either serve as the didactical core of a *Telematics Module* or

b) being used for further developments and extensions within a frame of *Student Projects*.

Both approaches are introduced in the following sections. The planning of the course/projects is shown as well as the experiences gained from October 2017 to July 2018 with students of the UAS HTW Berlin from the programs automotive engineering, mechanical engineering, and engineering informatics.

No matter how the TB is used for teaching purposes, some issues have to be taught for both approaches. The following figure illustrates common and different education parts of the Module or Project work.

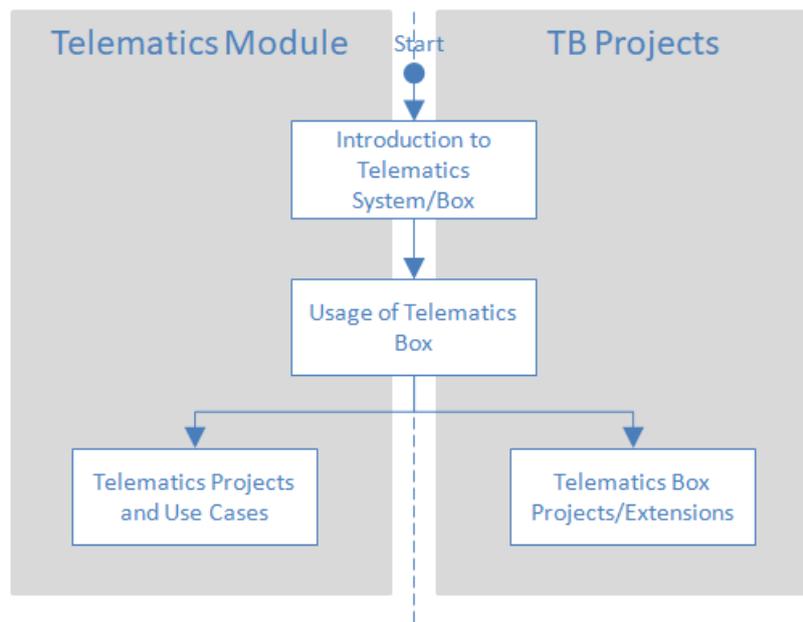


Fig. 1.1: Common and Project Specific Learning Units

## 2 Definition of a Vehicle Telematics Module for Bachelor Students

### 2.1 Requirements

The following course definitions are basing on the requirements summarized in Tab. 2.1.

Tab. 2.1 Requirements for the Bachelor Program

No.	Requirement
Degree	Bachelor
Program	Automotive Engineering
Term	5 or higher
Duration	16 weeks
No. of Students	15
Hours per week and semester	2
Program Form	Lectures, presentations, and student projects
Workload	5 CP

### 2.2 Goal of the Course

After having attended the course the students should be able to name the goals and ideas behind vehicle telematics systems. They should know how typical vehicle telematics systems are designed and which components are necessary to build them up. They should know how and which signals can be obtained from a real vehicle and how the signals can be transferred to a data server and how data can be post-processed. The students should be able to name different use cases of vehicle telematics.

## 2.3 Road Map

The road map corresponds strictly to the goal of the course described in 2.2. As the students already have extensive knowledge about automotive systems, the course needs not to start with the vehicle basics, but with detailed contents concerning the telematics and system components. The complete road map is shown in the following table:

Tab. 2.2: Contents of the Program Units/Road Map

Week No.	Phase	Contents
1	Introduction	What is Telematics? Traffic and Vehicle Telematics
2		Technical Setup: System Overview
3	Components	CAN-Bus I
4		CAN-Bus II: Practical Work with the CAN Bus
5		OBD Interfaces and Functions I
6		OBD Interfaces and Functions II: Practical Work with OBD
7		GPS
8	System	Telematics Box Setup and Practical Work in Classroom
9		Installation in Real Vehicle and Test
10	Projects	Definition of the Project Targets and Concepts for Realization
11		Presentation of Concepts (Together with Apprentices)
12		Realization of Concepts
13		Realization of Concepts
14		Realization of Concepts
15	Exam	Exam

The course consists of four main phases: The introduction phase, the components phase, the system phase, and the project phase. All phases are described in the following sections.

### 2.3.1 Phase 1: Introduction (Course 1 and 2)

During phase 1 the basics of telematics systems and especially vehicle telematics are explained. The introduction phase consists of two courses with 90 minutes each.

The content of the first phase comes along with the Learning Units No. 1 & 2 developed in this project. The following aspects are discussed/taught during the class.

#### **Course 1: Organisation and Basics (90 min.)**

- Organisation: Exam issues, introduction of the course, group assignment for student's presentations (CAN group, OBD group, and GPS group)
- Teacher Presentation "What is Telematics?"
- Discussing the difference between vehicle and traffic telematics

### ***Course 2: Telematics System Setup (90 min.)***

- Discussion: How can the vehicle telematics functions being realized?
- The students should learn by discussion which components are necessary to realize the requirements of a vehicle telematics system
- Examples of Typical Vehicle Telematics Systems
- Introduction of the Car-2-Lab-System

### **2.3.2 Phase 2: Components (Course 3 to 7)**

During this phase the students learn in detail about three elementary system components: the CAN bus, the OBD system, the GPS navigation. The students are divided in three groups with five members each. Each group presents one topic.

### ***Course 3: CAN Presentation (90 min.)***

The first presentation is held by the CAN group and deals with the CAN bus functionality: Physical layer, safety mechanisms, frame protocol, application layer (data interpretation and dbc files).

### ***Course 4: CAN Experiments (90 min.)***

During course 4 the CAN group members introduce a CAN bus simulator with which the other course members have to read unknown CAN signals using a dbc file, and where special identifiers with a pre-defined contents have to be transmitted. This exercise is for understanding the OBD-via-CAN-protocol.

### ***Course 5: OBD Presentation (90 min.)***

The second presentation is held by the OBD group and deals with the basics of the OBD interface functionality: History, legal boundaries, norms, and regulations, physical layer, data protocol and modes, and diagnostic trouble codes (DTC).

### ***Course 6: OBD Experiments (90 min.)***

During course 6 the students work with an OBD simulator. The OBD over CAN communication should be used and the students work with a CAN diagnostic tool already used in Course 4 (CAN Experiments). Over CAN an OBD communication between an OBD simulator and an OBD scanner is established. Communication provides both data transfer in Mode 1 and DTC request in Mode 3. The tasks of the students is to capture the OBD communication, to decode the requests of the OBD scanner and to decode the replies of the OBD simulator (Control Unit, ECU).

### ***Course 7: GPS Presentation (90 min.)***

The third presentation is held by the GPS group and deals with the GPS system with focus on the positioning functionality: History of GPS, basics on geometry and location, running-time measurement, and signal interferences. For the GPS theory there is no additional practical exercise.

### 2.3.3 Phase 3: System (Course 8 to 10)

During phase 3 the telematics box is introduced to the students. They learn about the functionality of the box and its application using the simulator or applying it to a real vehicle.

#### ***Course 8: Presentation and Usage of Telematics Box (90 min.)***

The TB is introduced by the teacher. The following items are explained:

- Functionality and components of the TB
- Interfaces of the TB
- Integration into entire telematics system
- Classroom usage architecture: How can the system be used in a classroom

After the presentation the students get three different tasks which have to be solved using the telematics box (E.g. controlling a relais using the digital open-collector outputs, reading a signal from an additional 1-wire-sensor, or simulating a series of DTCs for severe engine failures). The students present their task solutions to the teacher and the other groups. After each presentation the realization is demonstrated with the TB.

#### ***Course 9: Installation in Vehicle and Test (90 min.)***

During course 9 the TB is installed into a real vehicle environment. Using a vehicle documentation and schematic diagrams the groups are tasked with finding the powertrain CAN and the correct switches and sensors to run the TB. After the setup the TB is tested in the vehicle. Consecutive measurements are captured at the university and analyzed afterwards.

### 2.3.4 Phase 4: Project Tasks and Concepts

During phase 4 the three student groups get sophisticated tasks to be realized with the TB. These so called micro projects could be e.g. detection of fuel laundering, driving behavior analysis, or forecast of engine diagnostics or errors.

#### ***Course 10: Definition of Micro Projects (90 min.)***

The teacher introduces to each group a project requirement list describing the tasks that has to be solved in the micro project. The students start to develop project concepts.

E.g.: One task can be the detection of fuel laundering. Thus the students have to define how a fuel laundering during drive can be detected. They have to state out which signals have to be measured, where the signals can be captured from, how the signals have to be processed and so on. Finally a concept for testing the micro project also has to be developed.

#### ***Course 11: Project Concepts and Presentations (90 min.)***

The students continue with the concept definition and give a concept presentation to the other groups.

### ***Courses 12: Project Concept Validation***

The students have to validate their approach for solving the project tasks. E.g. for driver analysis the students first have to develop artificial data sets for careful, sporty, or aggressive driver behavior by simulation means. Afterwards these data have to be evaluated with the developed evaluation algorithms for the proof of concept.

### ***Course 13 and 14: Realization of the Projects and Documentation (270 min.)***

The students have to realize their project by means of the TB. As all three groups need access to the TB it is necessary that they come to an agreement for a common project realization schedule.

The project data have to be evaluated adequately and the documentation should clearly describe the problem of the project, the approach for the solution, and the results and evaluation of the measurements.

E.g. concerning the fuel laundering the report should state out how the fuel laundering can be simulated, how the captured data estimate the required amount of fuel and how it can be compared with the amount of fuel actually needed for the ride.

The groups get a group specific grade for the project report.

### ***Course 15: Exam***

The exam is a written test that deals with the basics of vehicle telematics including CAN, OBD, and GPS specific contents. The students get an individual grade (50 %) for the test. Together with group specific results (also 50 %) the final grades result.

### 3 Application Scenarios (Use Cases)

This chapter describes in detail the use case projects which had been realized by the bachelor students during an exemplary vehicle telematics course held at HTW Berlin from 10-04-2018 to 13-07-2018. The projects have been integrated in the course as described in 2.3.4.

#### 3.1 Project 1: Fuel Laundering

##### 3.1.1 Course Item 10/11: Project Definition and Concept Development

The project item is as follows: A forwarding company realizes that the fuel consumption of some vehicles has risen up significantly. The express agent is not able to prove a fraud directly, but he heard that the methods of the cheats have become more and more subtle: Using appropriate systems the drivers are able to take small amounts of fuel during drive, i.e. the fuel level is decreased slowly but significantly.

The task for the students now is to develop concepts to prove a fuel laundering using vehicle telematics methods.

For the concept development the following tasks had to be worked out by the students:

- Which driving scenarios and events have to be executed to simulate the fuel laundering issue described above with the Telematics Box?
- Which signals are necessary to prove the fuel laundering
- How does the data have to be evaluated to prove the fuel laundering?

This task was elaborated by a group of four students. They proposed to determine a theoretical fuel consumption value of the vehicle calculated by the current driving scenarios. The following signals are required:

- Engine Speed
- Vehicle Speed
- Acceleration Pedal
- Road Data (GPS Position)
- Set Gear
- Actual Fuel Consumption
- Ambient Temperature

The idea is to determine a vehicle load by the mentioned signals and to allocate the load and speed data to the current fuel consumption. For this relation a reference track should be driven in advance. If for further drive cycles significant deviations arise (i.e. the current fuel consumption is significantly higher than the reference value), than this might be due to fuel laundering.

### 3.1.2 Course Item 12: Concept Validation

The concept was tested using a real data template from the Telematics Box. First a data set was prepared to have a reference data set without fuel laundering.

Furthermore three other data sets haven been introduced with modified fuel consumption (increasing tendency).

The modified data tracks have been inserted into the Telematics Box data table and post-processed with Matlab/Simulink. It could be shown that the algorithm is able to show a significantly higher fuel consumption caused by fuel laundering.

### 3.1.3 Course Item 13/14: Realization

To apply the developed method to the Telematics Box the signals listed in 3.1.1 are required.

The Telematics Box should be used with a vehicle or with a real-time driving simulator. As actually neither a vehicle nor the RT driving simulator has been available, the real test still is outstanding.

## 3.2 Project 2: Driver Behavior Analysis

### 3.2.1 Course Item 10/11: Project Definition and Concept Development

The project item is as follows: A vehicle manufacturer would like to get information about the costumers drive behavior. He distinguishes between three driver classes: careful driver, defensive driver, sporting driver. These data are indispensable for the manufacturer to take the drivers behavior for future vehicle development into consideration and to select appropriate test drivers if necessary.

The task for the students now is to develop concepts to classify the drivers according to the mentioned behavior classes using vehicle telematics data.

For the concept development the following tasks had to be worked out by the students:

- Which driving scenarios and events have to be executed to simulate the driving behaviors described above with the Telematics Box?
- Which signals are necessary to classify clearly the driving behavior?
- How does the data have to be evaluated to provide a classification?

This task was elaborated by a group of four students. After intensive investigation of technical literature the following algorithm is proposed:

Determine two features

- a)  $Q1 = \text{Vehicle Speed(normalized)}/\text{Engine Speed(normalized)}$
- b)  $Q2 = \text{Throttle change(normalized)}/\text{Engine Speed Change(normalized)}$

Compare the features and some additional signals with the corresponding table:

Tab. 3.1: Features and Classification of Driver Behavior

Signal	Careful	Defensive	Sporty
Long. Acceleration	$\leq 1 \text{ m/s}^2$	$]1; 3] \text{ m/s}^2$	$>3 \text{ m/s}^2$
Lat. Acceleration	$\leq 1 \text{ m/s}^2$	$]1; 3] \text{ m/s}^2$	$>3 \text{ m/s}^2$
Q1	$>1.3$	$[0.9; 1.3]$	$<0.9$
Q2	$>1.3$	$[0.9; 1.3]$	$<0.9$
Engine Load	$<20 \%$	$[20; 50] \%$	$>50 \%$

Each measurement value then is allocated to a certain driver class. This is done for whole driving scenario. The class with the highest number of events represents the driver behavior.

**3.2.2 Course Item 12: Concept Validation**

The concept was tested using a real data template from the Telematics Box. Different driving behaviors have been simulated using the simulation software Assetto Corsa from Kunos Simulazioni using a plugin called Acti. With Acti the simulator data can be stored for further processing. For each driver type two data sets haven been generated. Additionally to that two data sets have been generated with no unique behavior, i.e. neither sporting, nor careful, nor defensing.

The gained data tracks have been inserted into the Telematics Box data table and post-processed with Matlab/Simulink. I could be shown that the algorithm is able to classify correctly the driver behavior types.

**3.2.3 Course Item 13/14: Realization**

To apply the developed method to the Telematics Box the following boundary conditions have to be met:

1. The required measurement signals are available
2. The signals are captured with a constant sample rate of 2 Hz
3. The signals are plausible and do not show any lacks

The Telematics Box should be used with a vehicle or with a real-time driving simulator. As actually neither a vehicle nor the RT driving simulator has been available, the real test still is outstanding.

### 3.3 Project 3: Forecast of Engine Diagnostics or Errors

#### 3.3.1 Course Item 10/11: Project Definition and Concept Development

The project item is as follows: A mass-air-flow (MAF) meter shall be supervised continuously. Even the tendency of an upcoming defect of the MAF shall be signalized.

For the concept development the following tasks had to be worked out by the students:

- How does a MAF meter behave when losing its functionality slightly and how can it be seen in typical vehicle data?
- Which driving scenarios and events have to be executed to simulate errors of a MAF meter with the Telematics Box?
- Which signals are necessary to foresee a fail of the MAF sensor?
- How does the data have to be evaluated to classify the grade of defect?

This task was elaborated by a group of five students. After intensive investigation of technical literature the following algorithm is proposed:

A MAF sensor coming up to show worse measurement results leads to a significant increase of the specific fuel consumption. Thus the current fuel consumption has to be compared with the nominal fuel consumption under the same conditions. The higher the deviation is the worse is the state of the MAF sensor.

#### 3.3.2 Course Item 12: Concept Validation

The concept was tested using a real OBD data template from the Telematics Box. To simulate different states of the MAF sensor the fuel consumption of the data set has been increased stepwise. To determine the fuel consumption of the vehicle all operating states consisting of an engine speed between 700 and 750 rpm, a coolant temperature between 87 °C and 90 °C, and a vehicle speed of 0 kph have to be evaluated.

The gained data tracks have been inserted into the Telematics Box data table and post-processed with Matlab/Simulink. It could be shown that the algorithm is able to estimate the state of the MAF sensor.

#### 3.3.3 Course Item 13/14: Realization

To apply the developed method to the Telematics Box the following signals are required:

1. Fuel Consumption
2. Coolant Temperature
3. Engine Speed
4. Vehicle Speed

The Telematics Box should be used with a vehicle or with a real-time driving simulator. As actually neither a vehicle nor the RT driving simulator has been available, the real test still is outstanding.

## 4 Definition of Development Projects for the Telematics Box

Whereas the bachelor module described in detail in chapter 2 is predestinated for automotive engineering students, the box can also be used for further developments together with other students from other bachelor programs like engineering informatics or mechanical design.

The TB supports both a static simulation mode for classroom use and a vehicle installation for mobile use. Concerning the functionality the usage in the classroom is quite limited as no dynamic vehicle data are available. E.g. just constant vehicle and engine speeds can be defined or static OBD diagnostic trouble codes (DTCs) can be generated. Thus it would be very helpful for further investigations and applications to extend the functionality of the simulation by dynamic components.

### 4.1 Extended Simulation Concept for Classroom Use

The extended simulator mode should enable the user to generate dynamic vehicle data to pretend a real vehicle operation.

During the real vehicle mode of the TB data like vehicle position, vehicle speed, Engine speed, consumption values, acceleration pedal, actual gear, brake pedal etc. are generated continuously.

The data are captured directly from the sensors, over the OBD interface and/or over the powertrain CAN and fed into the TB.

The TB transfers all raw data to a project server.

A user- software of a mobile webbased server (at Car2Lab VIOS) accesses the server data base and visualizes the data (e.g. vehicle tracking, supervision of driving values, standing times and so on).

The idea for the dynamic simulator is to get the vehicle data not from a real vehicle but from a simulated dynamic vehicle model. Thus different systems have to be replaced by appropriate simulated components to pretend a real vehicle.

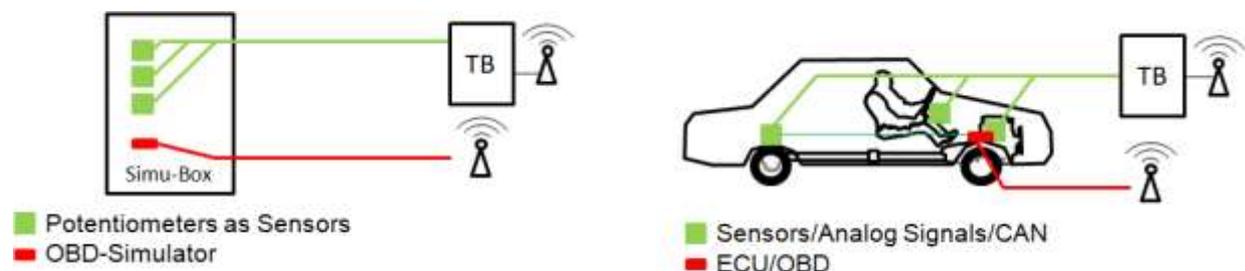


Fig. 4.1: Telematics Box with static Simulator (left) and in a real vehicle environment (right)

Fig. 4.1 shows the current possibilities to use the TB: Either in static simulation mode or in a mobile mode applied to a real vehicle. Thus the real vehicle and all its functionality have to be replaced by simulation components. The resulting system making use of the vehicle simulator is illustrated in Fig. 4.2.

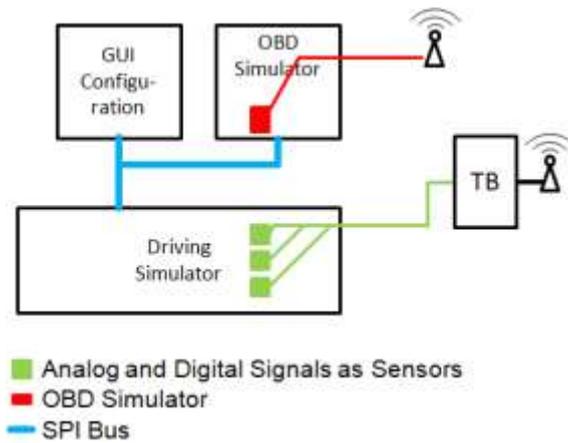


Fig. 4.2: Dynamic Vehicle Simulator Concept for Use with Telematics Box

The real time driving simulator provides all necessary vehicle data in real time and sends these data to analog outputs, to a powertrain CAN, and an OBD output. The core of this box (the real-time driving simulator basing on an Arduino Due controller board) as well as the GUI to parameterize the vehicle were developed by engineering informatics students. The OBD simulator was developed by mechanical engineering students. The overview diagram of the simulator and the outline are shown in the following Fig. 4.3 and Fig. 4.4.

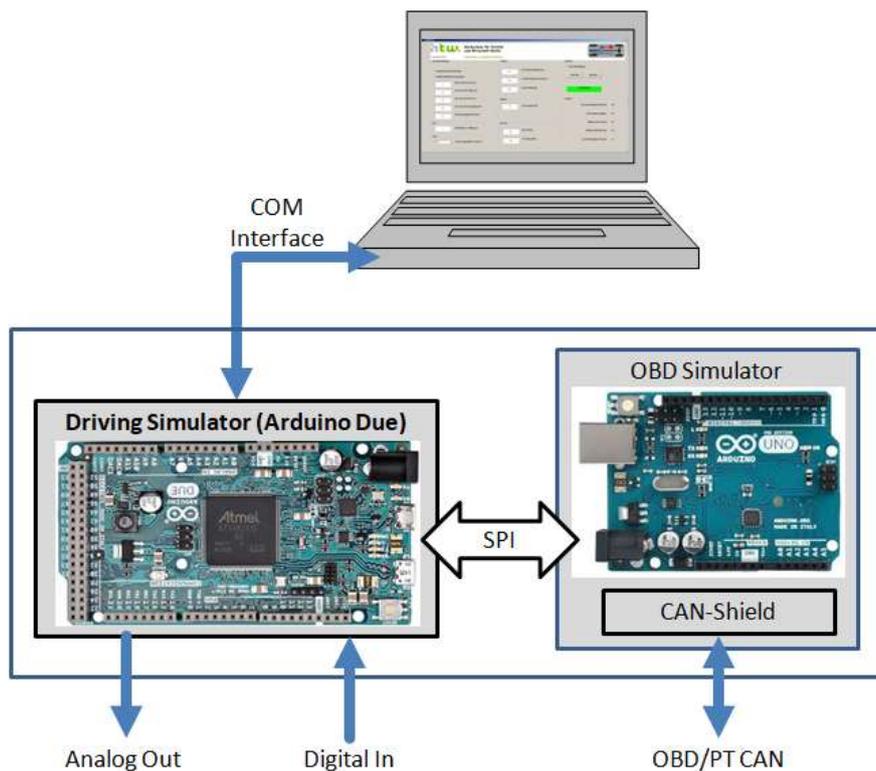


Fig. 4.3: Overview of Real-Time Driving Simulator Components

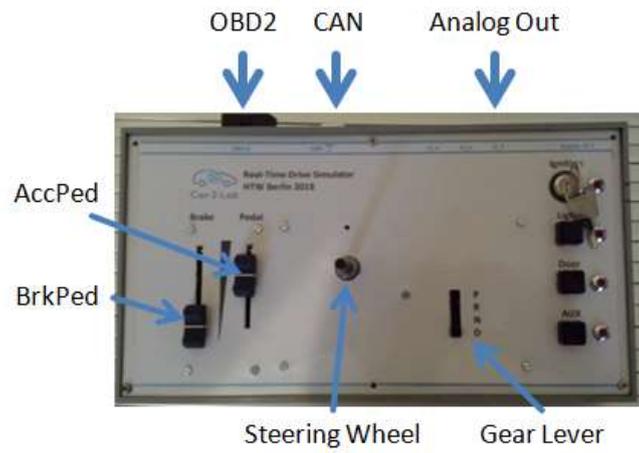


Fig. 4.4: Outline of Real-Time Vehicle Simulator Box with Interfaces

## 5 University Entrance Qualification

The German/Berlin education system offers three ways to enable VET students to entrance the university. These possibilities are described in §11 of the Berlin Law on Higher Education.

### 5.1 "Meister" Education

The so called "Meister" degree can be passed after a usually three-year lasting vocational training. The first vocational training is passed with a journey-level status. This education is mostly practical and only basics in theory are imparted.

To gain the "Meister" degree a further vocational training is required with focus on four main items: Technical and practical skills, theoretical skills, business knowledge, and pedagogy.

The grade of the "Meister" is comparable to the Bachelor degree, and enables the students to enter a university and to start with a technically related Bachelor program. Nonetheless it is not possible to apply for a Master program.

### 5.2 Technical College

The technical college provides a professional education in a more theoretical way. The double qualified education gives the opportunity to get both a vocational training and an entrance qualification for university of applied sciences.

Another way is to visit a sixth form centre that also gives an entrance qualification for universities.

### 5.3 Professional Qualification

Even the professional qualification enables students with a journey-level status to access a university of applied sciences. An additional requirement is that the bachelor program technically relates to the vocational training and the student shows at least three years of practice. These students have to prove a certain number of successfully passed exams (credit points) during their first two terms.

## 6 Permeability in the Educational System

A single module (just like telematics) is not sufficient to provide all the basic knowledge necessary to get the university entrance qualification. Nonetheless such kind of modules can help to teach elementary skills like mathematics and physics.

Usually students tend to be successful in their studies if they meet the following requirements:

- They have a deep interest in technology, i.e. mechanics, electrics, electronics, and informatics
- They have mathematical skills
- They have an affinity to physics

These requirements are needed to be able to pass all the modules that are offered in a Bachelor program like automotive engineering. Nonetheless not every module in a Bachelor program requires basic mathematical knowledge.

And here our research project may help to provide additional capacities to vocational students and to gain credit points for a likely further study at a university:

Typically the Bachelor programs in automotive engineering in Germany have election modules in higher terms. These modules usually deal with specific automotive contents giving a broad overview over a certain topic.

Another branch of alternative modules (let us call them training modules with a higher practical relation) can be implemented as an adequate substitute for the standard election modules. This branch may for example consist of

- Basics in Telematics
- High Voltage Training in Vehicles
- Engine Diagnostics
- ...

If these training modules are offered in cooperation with vocational education institutes and universities both vocational and higher education students can attend these courses. They can gain credit points, and especially vocational students get the chance to get in contact with universities and HE students in advance.

If the vocational student continues its education on a university these courses (assumed that they are successfully passed) are fully eligible as election modules. Ideally all universities in Germany (e.g. all Bachelor programs in automotive engineering) offer such kind of alternative branch.

The benefit for the students is also that they may need to spend less time at the universities as they passed these courses already before having begun with their studies.

## 7 Cooperation HE-VET

It is highly recommended that both universities and vocational schools cooperate offering additional training courses for vocational students. Cooperation between universities and vocational schools (in the following called "partners") can be established in these issues:

### 7.1 Course Definition

As a result of this project it could be seen that the learning units for the telematics module for the vocational and the university students are quite comparable. The partners can work together on different curriculums for different applications (e.g. telematics, or alternative drives) with a high practical part.

### 7.2 Laboratories

The partners have different kinds of laboratory equipment: At the university the more theoretical/programming/software parts can be handled whereas at the vocational schools the hands-on practice can be performed.

### 7.3 Virtual Classrooms

On many even theoretical parts can be worked on in virtual classrooms. Both pure theory and also theoretical project development in work groups can be done in a virtual classroom. Furthermore e.g. for the telematics unit an evaluation of measurements data takes a certain capacity of the course. This also can be done in a virtual way with data evaluation software.

### 7.4 Course Timing

Both university and vocational students and teachers as well just have room for working on additional topics after their obligatory training. Thus it is recommended that these additional modules are performed in the afternoon/evening or at weekends.



## Project partnership:

### Germany



BGZ Berliner Gesellschaft für internationale Zusammenarbeit mbH  
Pohlstraße 67  
DE - 10785 Berlin  
Telefon: +49 (30) 80 99 41 11  
Telefax: +49 (30) 80 99 41 20  
info@bgz-berlin.de  
www.bgz-berlin.de  
www.car2lab.eu



[www.kfz-innung-berlin.de](http://www.kfz-innung-berlin.de)



[www.htw-berlin.de](http://www.htw-berlin.de)



[www.viom.de](http://www.viom.de)

### Denmark



[www.aarhustech.dk](http://www.aarhustech.dk)



[www.teknologisk.dk](http://www.teknologisk.dk)

### Italy



[www.confartigianatovicenza.it](http://www.confartigianatovicenza.it)



[www.sangaetano.org](http://www.sangaetano.org)

### Poland



[www.mechatronika.pl](http://www.mechatronika.pl)



[www.samochodowka.edu.pl](http://www.samochodowka.edu.pl)

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.