DRIVES

Development and Research on Innovative Vocational Education Skills

# Highly Automated Drive Engineer

Job Role Skill Set

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| Author(s): | Ádám Nyerges | | |
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More information about DRIVES project and contact:

www.project-drives.eu

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# INTRODUCTION

## 1.1 OBJECTIVE

The objective of this deliverable is to provide an introduction to described Job Role within the applied skills definition model.

## 1.2 PURPOSE OF THE DELIVERABLE

The purpose of this deliverable is to define skills definitions of the Highly Automated Drive Engineer job role within the ECQA skills definition model.

## 1.3 SCOPE OF THE DELIVERABLE

The deliverable contains

- Description of the content of the Job Role
- Description of used Skill Sets and skills definitions, coverage of Qualification Schemas

The deliverable does not cover:

- Course development, as this will be done after the skill definitions clearly outlined the set of required courses.

# 2 ECQA SKILLS DEFINITION MODEL

A skills definition contains the following items (see **Chyba! Nenalezen zdroj odkazů.**):

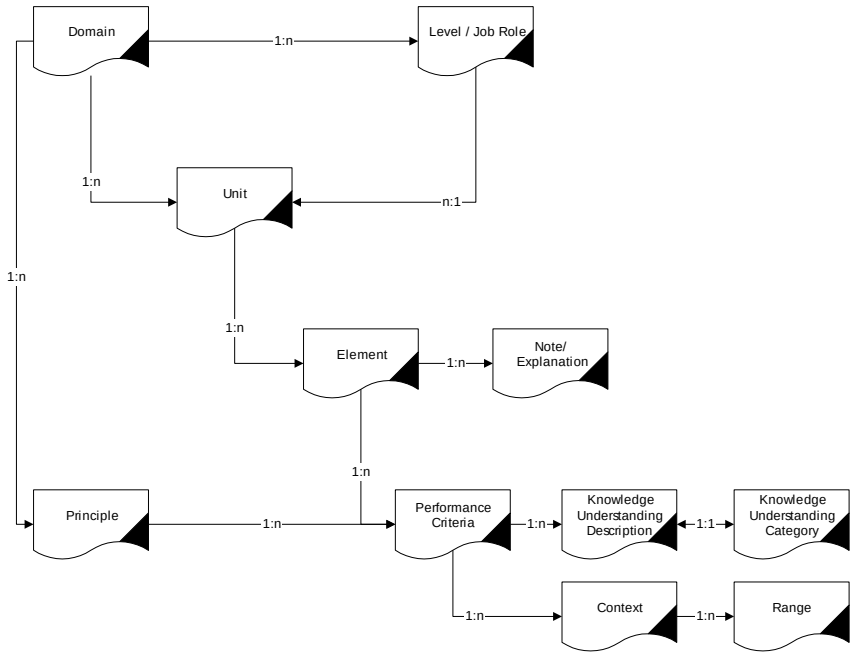



**Figure 1: The Skill Definition Model (1:n = one to many relationship)**

**Context**: A category of ranges; it represents some terminology used in a performance criterion that consists of different context, conditions or circumstances. A participant must be able to prove competence in all the different circumstances covered by the context.

**Domain**: An occupational category, e.g. childcare, first level management or software engineering.

**Element:** Description of one distinct aspect of the work performed by a worker, either a specific task that the worker has to do or a specific way of working. Each element consists of a number of performance criteria.

**Evidence:** Proof of competence.

**Knowledge and understanding category:** A category of knowledge and understanding descriptions.

**Knowledge and understanding description:** A description of certain knowledge and understanding. To be judged competent in a unit a participant must prove to have and to be able to apply all the knowledge and understanding attached to it.

**NVQ (UK based):** The National Vocational Qualification standard of England, Wales and N. Ireland.

**Performance criterion:** Description of the minimum level of performance a participant must demonstrate in order to be assessed as competent. A performance criterion may have relevant contexts.

**Principle:** A statement of good intentions; it underpins all competent domain practice.

**Range:** Description of a specific circumstance and condition of a performance criterion statement.

**Qualification:** The requirements for an individual to enter, or progress within a certain occupation.

**Job Role**: A certain profession that covers part of the domain knowledge. E.g. domain = Functional Safety, job role = Functional Safety Manager.

**Unit:** A list of certain activities that have to be carried out in the workplace. It is the top-level skill in the UK qualification standard hierarchy and each unit consists of a number of elements.

The rationales for developing the ECQA skills definition model is based on the skills definition proposed by the DTI (Department of Trade and Industry) in the UK for the NVQ (National Vocational Qualification) standards. These models have been re-used and slightly modified by other countries when they started employing skill cards [1], [2].

ECQA standards are used to describe the skills sets delivered within the DRIVES project (www.project-drives.eu). Further description and rationales are attached in annexes of this document. The ECQA structure was mapped in DRIVES project to DRIVES Reference and Recognition Framework with the links to ESCO[7], EQF[8], ECTS[9] and ECVET[10]. See more in deliverable DRIVES-D4.1.1 Reference and Recognition Framework – Analysis.pdf (www.project-drives.eu).

# 3 SKILLS DEFINITION FOR THE JOB ROLE "HIGHLY AUTOMATED DRIVE ENGINEER"

## 3.1 THE SKILLS HIERARCHY

Using the terminology outlined in the skills definition model and including the skills identified during the demand analysis at the beginning of the project, the following skills hierarchy for the job role "Highly automated drive engineer" has been designed.

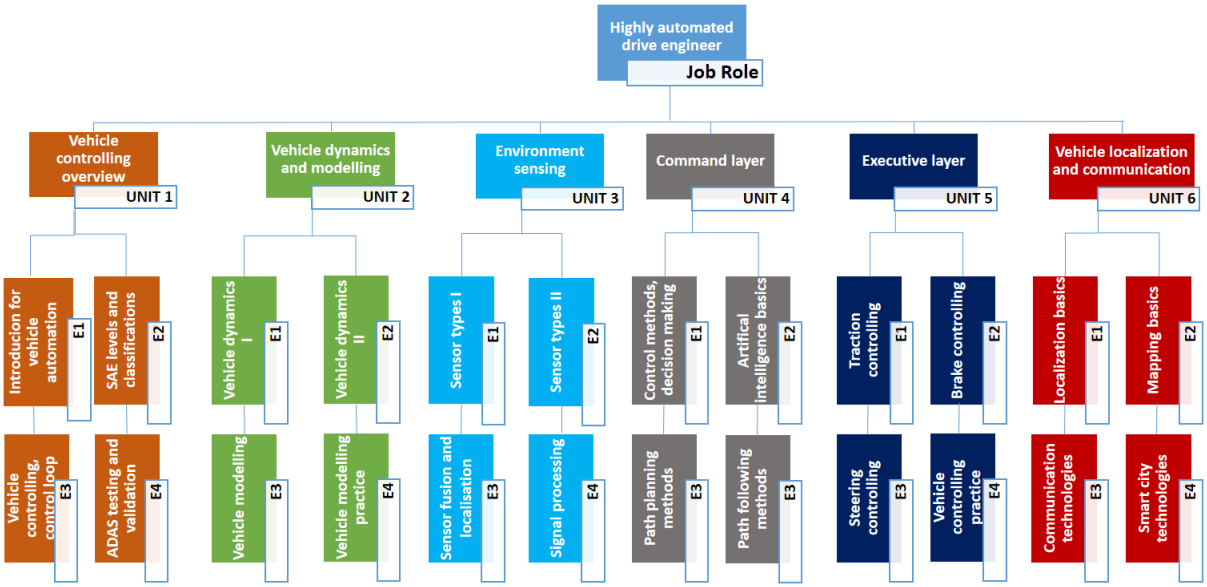



Figure 2: The Skills Set for Highly automated drive engineer

## 3.2 THE SKILLS DESCRIPTIONS – JOB ROLE HIGHLY AUTOMATED DRIVE ENGINEER

**Domain Acronym:** Engineering

**Domain title**: Highly automated drive engineer

**Domain Description**:

The automation of road vehicles and road transport is in a high focus in the last decade and it will be one of the most important development area in the next years. Due to the complexity of this science field it is important to have engineers who have an overview of the whole area.

Several engineer disciplines can develop connected and automated driving, like control engineers, software engineers, electric engineers, transport engineers, mechanic engineers and mechatronic engineers. However, for effective development a mixture of these science areas is necessary.

The purpose of this job role is to give a standard overview and control modelling skills for all of the mentioned engineer types. The job role can provide basic knowledge for those engineers who work in automated driving development to understand other engineer's "language" and the common development aim.

The job role skillcard starts with a general overview of connected and automated driving. It presents examples for automated in-vehicle functions and it presents the standardised SAE classification. The second unit presents the basics of vehicle dynamics and modelling which is important for example software or electric engineers, who had never studied about vehicles earlier. The next three unit presents the main parts of an automated vehicle's control loop. The learning elements contains general knowledge, modelling sciences and also examples for vehicle controlling. Finally the last unit presents an outlook about vehicle localization and communication technologies.

**Job Role Acronym:** ADCEUR

**Job Role Title**: Highly automated drive engineer

**Public description**:

The automation of road vehicles and road transport is in a high focus in the last decade and it will be one of the most important development area in the next years. Due to the complexity of this science field, it is important to have engineers who have an overview of in-vehicle control systems.

Highly automated drive engineers understand the control structure of automated vehicles, they can place the human driver in the control loop of the vehicle. They know the functions of the control loop layers and they can design the control architectures of these vehicles.

The Skill card comprises the following thematic learning units:

1. Vehicle control overview
2. Vehicle dynamics and modelling
3. Environment sensing
4. Command layer
5. Executive layer
6. Vehicle localization and communication

## 3.3 UNIT ADCEUR.U1 VEHICLE CONTROL OVERVIEW

**Acronym**: ADCEUR.U1

**Title:** Vehicle control overview

**Description:**

The aim of the first unit is to give a general overview of connected and automated driving. At the first two elements the unit presents the motivations to develop automated vehicles and the well-known standardized SAE levels (Society of Automotive Engineers). The third and the fourth elements presents the general approach of vehicle controlling and the testing and validation process of the new functions in these vehicles.

### 3.3.1 Unit ADCEUR.U1 - Element 1: Introduction for vehicle automation

**Acronym:** ADCEUR.U1.E1

**Element Title**: Introduction for vehicle automation

**Element Note**:

This element gives general knowledge about the background of vehicle control, the safety impacts and basics of connected vehicles.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U1.E1.PC1** | The student understands the main challenges in road transport. |
| **ADCEUR.U1.E1.PC2** | The student understands the main motivations for improving road safety. |
| **ADCEUR.U1.E1.PC3** | The student knows the released and applied vehicle automated functions. |
| **ADCEUR.U1.E1.PC4** | The student understands the difference between vehicle automation and road transport automation. |
| **ADCEUR.U1.E1.PC5** | The student understands the complexity of automated vehicle testing and validation (from simulation tests to public road tests). |
| **ADCEUR.U1.E1.PC6** | The student understands the legal and ethical implications of vehicle automation. |

Table 1: Performance Criteria Example for the Element ADCEUR.U1.E1

### 3.3.2 Unit ADCEUR.U1 - Element 2: SAE levels and classifications

**Acronym:** ADCEUR.U1.E2

**Element Title**: SAE levels and classifications

**Element Note**:

This element gives information and examples about the standardised SAE (Society of Automotive Engineers) vehicle automation levels.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U1.E2.PC1** | The student knows about why need SAE (Society of Automotive Engineers) levels in automotive industries. |
| **ADCEUR.U1.E2.PC2** | The student knows about general information of automation, SAE levels. |
| **ADCEUR.U1.E2.PC3** | The student knows about examples of each SAE levels. |
| **ADCEUR.U1.E2.PC4** | The student understands ADAS (advanced driver assistant systems) systems of SAE levels. |
| **ADCEUR.U1.E2.PC5** | The student understands how can classify ADAS systems to levels. |

Table 2: Performance Criteria Example for the Element ADCEUR.U1.E2

### 3.3.3 Unit ADCEUR.U1 - Element 3: Vehicle controlling

**Acronym:** ADCEUR.U1.E3

**Element Title**: Vehicle controlling

**Element Note**:

This element presents the control loop of automated vehicles, its elements and their architecture.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U1.E3.PC1** | The student knows the control architecture of vehicle automation. |
| **ADCEUR.U1.E3.PC2** | The student has a basic understanding on how the layers of vehicle automation connect to each other. |
| **ADCEUR.U1.E3.PC3** | The student knows the tasks of the layers. |
| **ADCEUR.U1.E3.PC4** | The student knows the functions and responsibilities of the layers. |
| **ADCEUR.U1.E3.PC5** | The student is able to categorize the hardware components of automated vehicles based on the control architecture. |

Table 3: Performance Criteria Example for the Element ADCEUR.U1.E3

### 3.3.4 Unit ADCEUR.U1 - Element 4: ADAS testing and validation process

**Acronym:** ADCEUR.U1.E4

**Element Title**: ADAS testing and validation process

**Element Note**:

This element presents the testing and validation process of connected and automated vehicles.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U1.E4.PC1** | The student knows the ADAS (adaptive driver assistant systems) testing and validation pyramid. |
| **ADCEUR.U1.E4.PC2** | The student is able to present simulation test examples. |
| **ADCEUR.U1.E4.PC3** | The student is able to present laboratory test examples. |
| **ADCEUR.U1.E4.PC4** | The student is able to present typical proving ground elements and test examples. |
| **ADCEUR.U1.43.PC5** | The student knows the requirements and the importance of public road tests. |

Table 4: Performance Criteria Example for the Element ADCEUR.U1.E4

## 3.4 UNIT ADCEUR.U2 VEHICLE DYNAMICS AND MODELLING

**Acronym**: ADCEUR.U2

**Title:** Vehicle dynamics and modelling

**Description:**

The aim of the second unit is to present the vehicle dynamics basics for those students, who have never studied vehicle engineering. The unit starts with simple, mechanical tyre and vehicle models. At the end of the unit the students will be able to implement complex vehicle models in simulation environment. The unit ends with a homework.

### 3.4.1 Unit ADCEUR.U2 - Element 1: Vehicle dynamics 1

**Acronym:** ADCEUR.U2.E1

**Element Title**: Vehicle dynamics 1

**Element Note**:

This element gives general knowledge about vehicle dynamics, it basically focuses on the tyre properties, behaviour, and its effects on the vehicle controllability.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U2.E1.PC1** | The student knows the vehicle motion types. |
| **ADCEUR.U2.E1.PC2** | The student understands the effect of the tyre behaviour on the vehicle motion. |
| **ADCEUR.U2.E1.PC3** | The student understands the longitudinal slip curve of tyres. |
| **ADCEUR.U2.E1.PC4** | The student understands the lateral slip of tyres. |
| **ADCEUR.U2.E1.PC5** | The student understands the friction circle of tyres with stable and unstable zones. |
| **ADCEUR.U2.E1.PC6** | The student is able to implement tyre model in a simulation model. |

Table 5: Performance Criteria Example for the Element ADCEUR.U2.E1

### 3.4.2 Unit ADCEUR.U2 - Element 2: Vehicle dynamics 2

**Acronym:** ADCEUR.U2.E2

**Element Title**: Vehicle dynamics 2

**Element Note**:

This element gives knowledge about vehicle behaviour, vehicle motion equations and modelling.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U2.E2.PC1** | The student knows the effect of the vehicle's centre of gravity on the vehicle's behaviour. |
| **ADCEUR.U2.E2.PC2** | The student is able to calculate the changes of weight forces on the wheels due to vehicle motion. |
| **ADCEUR.U2.E2.PC3** | The student is able to describe the typical acting forces on the vehicle in a general case. |
| **ADCEUR.U2.E2.PC4** | The student knows the vehicle's behaviour on lateral and longitudinal slip limit. |
| **ADCEUR.U2.E2.PC5** | The student knows the meaning of understeered and oversteered behaviour of vehicles and the student knows the vehicle parameters that are determined its steering behaviour. |
| **ADCEUR.U2.E2.PC6** | The student is able to model vehicle motion equations. |

Table 6: Performance Criteria Example for the Element ADCEUR.U2.E2

### 3.4.3 Unit ADCEUR.U2 - Element 3: Vehicle modelling

**Acronym:** ADCEUR.U2.E3

**Element Title**: Vehicle modelling

**Element Note**:

This element contains how to implement vehicle models for automated vehicle simulation.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U2.E3.PC1** | The student knows the types of vehicle models. |
| **ADCEUR.U2.E3.PC2** | The student knows the kinematic equations of the steering system of passenger car, and use it for vehicle modelling. |
| **ADCEUR.U2.E3.PC3** | The student knows the application fields of vehicle models. |
| **ADCEUR.U2.E3.PC4** | The student is able to choose the necessary vehicle model for the purpose, knows the advantages and leverages of vehicle models. |
| **ADCEUR.U2.E3.PC5** | The student is able to write the kinematic and dynamic equations of a vehicle. |

Table 7: Performance Criteria Example for the Element ADCEUR.U2.E3

### 3.4.4 Unit ADCEUR.U2 - Element 4: Vehicle modelling practice

**Acronym:** ADCEUR.U2.E1

**Element Title**: Vehicle modelling practice

**Element Note**:

This element contains a detailed example for automated vehicle modelling. By the example the student will able to build simpler vehicle models for controlling aims.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U2.E4.PC1** | The student knows the basics of vehicle modelling software. |
| **ADCEUR.U2.E4.PC2** | The student is able to write the equations which are required for implementation. |

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U2.E4.PC3** | The student is able to build the equations in the simulation software. |
| **ADCEUR.U2.E4.PC4** | The student is able to show the differences between vehicle models. |
| **ADCEUR.U2.E4.PC5** | The student has to solve a vehicle modelling homework. |

Table 8: Performance Criteria Example for the Element ADCEUR.U2.E4

## 3.5 UNIT ADCEUR.U3 ENVIRONMENTAL SENSING

**Acronym**: ADCEUR.U3

**Title:** Environmental sensing

**Description:**

The third unit presents vehicle sensors and their properties. In the first two elements the typical sensor technologies and their operation are presented. In the second half of the unit the optimal sensor architecture will be presented where the safety issues and the handling of signal disturbances will also be taken into consideration.

### 3.5.1 Unit ADCEUR.U3 - Element 1: Sensor types 1

**Acronym:** ADCEUR.U3.E1

**Element Title**: Sensor types, challenges

**Element Note**:

This element presents vision process based sensors types, their operation and the challenges of their application.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U3.E1.PC1** | The student knows the main challenges in environment sensing. |
| **ADCEUR.U3.E1.PC2** | The student knows the operation of vision process based sensors (for example mono/stereo cameras, etc.). |
| **ADCEUR.U3.E1.PC3** | The student understands the issues how to process the signals of the vision process based sensors. |

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U3.E1.PC4** | The student knows the typical applications for vision process based sensors. |

Table 9: Performance Criteria Example for the Element ADCEUR.U3.E1

### 3.5.2 Unit ADCEUR.U3 - Element 2: Sensor types 2

**Acronym:** ADCEUR.U3.E2

**Element Title**: Sensor types 2

**Element Note**:

This element presents reflection based sensors types, their operation and the challenges of their application.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U3.E2.PC1** | The student knows the operation of reflection based sensors like RADARs, LIDARs. |
| **ADCEUR.U3.E2.PC2** | The student understands the issues how to process the signals of reflection-based sensors based sensors. |
| **ADCEUR.U3.E2.PC3** | The student knows the typical applications for vision process based sensors. |

Table 20: Performance Criteria Example for the Element ADCEUR.U3.E2

### 3.5.3 Unit ADCEUR.U3 - Element 3: Sensor fusion and localization

**Acronym:** ADCEUR.U3.E3

**Element Title**: Sensor fusion and localization

**Element Note**:

This element introduces environment sensing based on sensor fusion, and optimal sensor architectures.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U3.E3.PC1** | The student understands the typical safety issues due to disturbances and malfunctions in environment sensing. |
| **ADCEUR.U3.E3.PC2** | The student knows typical sensor architectures for highly automated vehicles. |
| **ADCEUR.U3.E3.PC3** | The student knows examples for typical sensor localization layouts in highly automated vehicles. |
| **ADCEUR.U3.E3.PC4** | The student knows examples where sensor fusion can guarantee safety drive. |

Table 31: Performance Criteria Example for the Element ADCEUR.U3.E3

### 3.5.4 Unit ADCEUR.U3 - Element 4: Sensor signal processing

**Acronym:** ADCEUR.U3.E4

**Element Title**: Sensor signal processing

**Element Note**:

This element considers the signal processing background of environment sensing, and high-definition mapping solutions. It also considers handling disturbances in environment sensing process.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U3.E4.PC1** | The student knows the definition of signal uncertainty. |
| **ADCEUR.U3.E4.PC2** | The student understands the handling of signal uncertainties with probability theory. |
| **ADCEUR.U3.E4.PC3** | The student understands the signal processing (for example localization) with particle filters. |
| **ADCEUR.U3.E4.PC4** | The student understands the signal processing with linear estimation. |

Table 42: Performance Criteria Example for the Element ADCEUR.U3.E4

## 3.6 UNIT ADCEUR.U4 COMMAND LAYER

**Acronym**: ADCEUR.U4

**Title:** Command layer

**Description:**

The most scientific part of the job role is the fourth unit. In these elements the main software of the automated vehicles will be presented. The unit starts with conventional control methods. On the second step the basics of the artificial intelligence will be presented. Finally the path planning and the path following control algorithms will be explained.

### 3.6.1 Unit ADCEUR.U4 - Element 1: Control methods, decision making

**Acronym:** ADCEUR.U4.E1

**Element Title**: Control methods, decision making

**Element Note**:

This element presents control and decision making methods that are used during vehicle control, and it considers cooperative and distributed vehicle control strategies.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U4.E1.PC1** | The student knows the basic vehicle control types. |
| **ADCEUR.U4.E1.PC2** | The student knows automated vehicle functions and their hierarchy. |
| **ADCEUR.U4.E1.PC3** | The student knows the conventional vehicle control methods to guarantee stability. |
| **ADCEUR.U4.E1.PC4** | The student knows the up-to-date soft computing based control methods. |
| **ADCEUR.U4.E1.PC5** | The student is able to present cooperated and distributed control strategies from highly automated vehicles. |

Table 53: Performance Criteria Example for the Element ADCEUR.U4.E1

### 3.6.2 Unit ADCEUR.U4 - Element 2: Artificial intelligence basics

**Acronym:** ADCEUR.U4.E2

**Element Title**: Artificial intelligence basics

**Element Note**:

This element presents the basics of the application of artificial intelligence in automated vehicles. The element presents the basic knowledge about neural networks.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U4.E2.PC1** | The student knows the hierarchy of artificial intelligence disciplines. |
| **ADCEUR.U4.E2.PC2** | The student knows the meaning of neural networks. |
| **ADCEUR.U4.E2.PC3** | The student understands the general model and its elements of neural networks. |
| **ADCEUR.U4.E2.PC4** | The student knows the different types of learning methods in artificial intelligence. |
| **ADCEUR.U4.E2.PC5** | The student knows the use possibilities of neural networks for automated vehicle control. |

Table 64: Performance Criteria Example for the Element ADCEUR.U4.E2

### 3.6.3 Unit ADCEUR.U4 - Element 3: Path planning methods

**Acronym:** ADCEUR.U4.E3

**Element Title**: Path planning methods

**Element Note**:

This element presents path planning algorithms, and structure of path planning solutions.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U4.E3.PC1** | The student knows the tasks of path planning functions. |
| **ADCEUR.U4.E3.PC2** | The student understands the basic path planning algorithms. |
| **ADCEUR.U4.E3.PC3** | The student is able to analyse the situation of the vehicle. |

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U4.E3.PC4** | The student is able to select or create a path planning algorithm that is appropriate for the purpose. |
| **ADCEUR.U4.E3.PC5** | The student knows the steps of the generation of motion vector, which includes the coordinates and velocities of the vehicle. |

Table 75: Performance Criteria Example for the Element ADCEUR.U4.E3

### 3.6.4 Unit ADCEUR.U4 - Element 4: Path following methods

**Acronym:** ADCEUR.U4.E4

**Element Title**: Path following methods

**Element Note**:

This element presents typical vehicle models and controllers that are used for path following and trajectory following algorithms.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U4.E4.PC1** | The student knows the different path following algorithms. |
| **ADCEUR.U4.E4.PC2** | The student is able to select or create a path following algorithm appropriate to the purpose. |
| **ADCEUR.U4.E4.PC3** | The student knows the application limits, advantages, drawbacks of the different algorithms. |
| **ADCEUR.U4.E4.PC4** | The student is able to visualize the geometric relations and logical connections of the algorithms. |
| **ADCEUR.U4.E4.PC5** | The student knows the vehicle dynamic basics which are used for path following. |

Table 86: Performance Criteria Example for the Element ADCEUR.U4.E4

## 3.7 UNIT ADCEUR.U5 EXECUTIVE LAYER

**Acronym**: ADCEUR.U5

**Title:** Executive layer

**Description:**

In the fifth unit the in-vehicle actuators will be presented. The motion of the vehicle can be determined by the traction force on the wheels, by the brake force on the wheels (these are the longitudinal control of the vehicle) and by the steering system (lateral control). The unit also presents the basic operation and also the up-to-date control systems in these topics. The unit ends with a practice lesson with a homework for the students. The aim of the unit is to summarise the second, the third, the fourth and the fifth units.

### 3.7.1 Unit ADCEUR.U5 - Element 1: Traction controlling

**Acronym:** ADCEUR.U5.E1

**Element Title**: Traction controlling

**Element Note**:

This element presents the control of traction force on automated vehicles. It contains the control of internal combustion engines, electric engines and transmission systems.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U5.E1.PC1** | The student knows the operation of powertrain control systems for internal combustion engines, for electric engines and for hybrid powertrain systems. |
| **ADCEUR.U5.E1.PC2** | The student understands the challenges for traction control systems in different powertrain systems. |
| **ADCEUR.U5.E1.PC3** | The student knows the operation of transmission control systems. |
| **ADCEUR.U5.E1.PC4** | The students understands the different control types for transmission systems. |

Table 97: Performance Criteria Example for the Element ADCEUR.U5.E1

### 3.7.2 Unit ADCEUR.U5 - Element 2: Brake controlling

**Acronym:** ADCEUR.U5.E2

**Element Title**: Brake control

**Element Note**:

This element presents the control possibilities of different vehicle brake systems. It contains the basic hydraulic systems and also the up-to-date brake-by-wire systems which can guarantee stable vehicle behaviour with active controlling.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U5.E2.PC1** | The student knows the typical brake system designs for different vehicle types. |
| **ADCEUR.U5.E2.PC2** | The student knows the control model and design of an ABS (anti-lock braking system). |
| **ADCEUR.U5.E2.PC3** | The student knows the control model and design of an ASR (anti-slip regulation) system. |
| **ADCEUR.U5.E2.PC4** | The student knows the control model and design of an ESC (electronic stability control) system. |
| **ADCEUR.U5.E2.PC5** | The student knows the components of brake-by-wire systems. |
| **ADCEUR.U5.E2.PC6** | The student knows brake system examples for automated vehicles. |

Table 18: Performance Criteria Example for the Element ADCEUR.U5.E2

### 3.7.3 Unit ADCEUR.U5 - Element 3: Steering controlling

**Acronym:** ADCEUR.U5.E3

**Element Title**: Steering controlling

**Element Note**:

This element presents the requirements of vehicle steering systems and the control possibilities in automated vehicles with steering systems.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U5.E3.PC1** | The student knows the typical steering actuator designs for different vehicle types. |

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U5.E3.PC2** | The student knows the basic and the extended applicable steering functions. |
| **ADCEUR.U5.E3.PC3** | The student understands the steering control architectures. |
| **ADCEUR.U5.E3.PC4** | The students understand the steering feel control approaches. |

Table 19: Performance Criteria Example for the Element ADCEUR.U5.E3

### 3.7.4 Unit ADCEUR.U5 - Element 4: Vehicle controlling practice

**Acronym:** ADCEUR.U5.E4

**Element Title**: Vehicle controlling practice

**Element Note**:

This element presents vehicle models and controllers which used in automated vehicles in practice and simulation. The element will give a homework to every student.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U5.E4.PC1** | The student knows the simulation tools which are required for creating vehicle control algorithms. |
| **ADCEUR.U5.E4.PC2** | The student knows longitudinal vehicle controller algorithms. |
| **ADCEUR.U5.E4.PC3** | The student knows lateral vehicle controller algorithms. |
| **ADCEUR.U5.E4.PC4** | The student is able to implement a longitudinal and lateral controller in simulation environment, and use it on vehicle model. |
| **ADCEUR.U5.E4.PC5** | The student is able to evaluate the performance of vehicle controllers. |

Table 20: Performance Criteria Example for the Element ADCEUR.U5.E3

## 3.8 UNIT ADCEUR.U6 VEHICLE LOCALIZATION AND COMMUNICATION

**Acronym**: ADCEUR.U6

**Title:** Vehicle localization and communication

**Description:**

The purpose of the last unit is to give general knowledge about vehicle localization systems and about V2X communication systems. These topics could be an independent job role. In the unit the only aim is to give some complement information, an overview to the students. The unit ends with Smart City technologies which is the most complex area of connected and automated driving.

### 3.8.1 Unit ADCEUR.U6 - Element 1: Localization basics

**Acronym:** ADCEUR.U6.E1

**Element Title**: Localization basics

**Element Note**:

This element presents the basics of GNSS technologies (global navigation satellite systems). It also contains the localization requirements for automated vehicle controlling.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U6.E1.PC1** | The student understands the issues of localization from geodetic approach. |
| **ADCEUR.U6.E1.PC2** | The student knows the modelling of Earth's surface. |
| **ADCEUR.U6.E1.PC3** | The student knows the most common standardized reference systems. |
| **ADCEUR.U6.E1.PC4** | The student knows the currently used satellite based methods for localization. |
| **ADCEUR.U6.E1.PC5** | The student understands the issues of satellite based measurements and the student knows the possible additional measurements. |

Table 21: Performance Criteria Example for the Element ADCEUR.U6.E1

### 3.8.2 Unit ADCEUR.U6 - Element 2: Mapping basics

**Acronym:** ADCEUR.U6.E2

**Element Title**: Element 2: Mapping basics

**Element Note**:

This element presents high-definition mapping technologies, static and semi static maps, dynamic and semi dynamic maps.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U6.E2.PC1** | The student understands the role of mapping in automated driving. |
| **ADCEUR.U6.E2.PC2** | The student knows the typical map and projection types that are used for automated driving. |
| **ADCEUR.U6.E2.PC3** | The student knows the surveying process for traffic environment digitization. |
| **ADCEUR.U6.E2.PC4** | The student knows the properties of photogrammetry and remote sensing. |
| **ADCEUR.U6.E2.PC5** | The student knows the properties of mobile mapping. |
| **ADCEUR.U6.E2.PC6** | The student knows the up-to-date approaches for environment mapping for automated vehicles. |

Table 22: Performance Criteria Example for the Element ADCEUR.U6.E2

### 3.8.3 Unit ADCEUR.U6 - Element 3: Communication technologies

**Acronym:** ADCEUR.U6.E3

**Element Title**: Element 3: Communication technologies

**Element Note**:

This element consider the necessity of communication, gives general information about communication. This element presents 4G/5G and WiFi communication technologies, and the field of use of this technologies in vehicles.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U6.E3.PC1** | The student knows the use cases and necessity of V2X technologies (vehicle-to-everything). |
| **ADCEUR.U6.E3.PC2** | The student knows the motivation of V2X. |
| **ADCEUR.U6.E3.PC3** | The student has knowledge about Wi-Fi and GSM based V2X technologies. |

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U6.E3.PC4** | The student is able to solve traffic and infrastructural problems using V2X technologies. |
| **ADCEUR.U6.E3.PC5** | The student knows the architecture of C-ITS systems (communication-information technology support). |

Table 23: Performance Criteria Example for the Element ADCEUR.U6.E3

### 3.8.4 Unit ADCEUR.U6 - Element 4: Smart City technologies

**Acronym:** ADCEUR.U6.E4

**Element Title**: Element 2: Smart City technologies

**Element Note**:

This element presents Smart City ICT (information-communication technologies), C-ITS (communication-information technology support) technologies, features for automated driving.

**Performance Criteria**:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

| Performance Criterion | Evidence Check: The student can demonstrate |
|---|---|
| **ADCEUR.U6.E4.PC1** | The student knows the typical realizable automated in-vehicle smart city features. |
| **ADCEUR.U6.E4.PC2** | The student knows the typical transport organization smart city features. |
| **ADCEUR.U6.E4.PC3** | The student knows the typical e-mobility smart city features. |
| **ADCEUR.U6.E4.PC4** | The student knows the typical interface technologies between vehicles and transport infrastructure in smart cities. |

Table 24: Performance Criteria Example for the Element ADCEUR.U6.E4

# ANNEXES

The annex provides overview of used skills set, coverage of Qualification Schemas and Legal background for Certification

# ANNEX A ECQA DESCRIPTION

## ECQA – EUROPEAN CERTIFICATION AND QUALIFICATION ASSOCIATION

ECQA standards are used to describe the skills sets delivered within the DRIVES project (www.project-drives.eu). ECQA is the pilot Certification body, which structure is mapped to DRIVES Reference and Recognition Framework providing the EU-wide overview of training courses and possible certifications, and micro-credentials. DRIVES Reference and Recognition Framework provides links to ESCO[7], EQF[8], ECTS[9] and ECVET[10]. See more in deliverable DRIVES-D4.1.1 Reference and Recognition Framework – Analysis.pdf (www.project-drives.eu).

Europe Wide Certification

The ECQA is the result of a number of EU supported initiatives in the last ten years where in the European Union Life Long Learning Programme different educational developments decided to follow a joint process for the certification of persons in the industry.

Through the ECQA it becomes possible that you attend courses for a specific profession in e.g. Spain and perform a Europe wide agreed test at the end of the course.

Access to a Vast Pool of Knowledge

ECQA currently supports 27 professions in Europe and with the continuous support until 2012 by the European Commission the pool is growing to 30 certified professions in Europe. ECQA offers certification for professions like IT Security Manager, Innovation Manager, EU project manager, E-security Manager, E-Business Manager, E-Strategy Manager, SW Architect, SW Project Manager, IT Consultant for COTS selection, Internal Financial Control Assessor (COSO/COBIT based), Interpersonal Skills, Scope Manager (Estimation Processes), Configuration Manager, Safety Manager, and so forth.

The ECQA guide can be downloaded at www.ecqa.org -> Guidelines.

Defined procedures are applied for:

- Self assessment and learning

- http://www.ecqa.org/fileadmin/documents/Self_Assessment/eucert-users-self-assessment-learning-guide-v5-doc.pdf
- Exam performance
- http://www.ecqa.org/fileadmin/documents/ECQA_Exam_Guide_Participant_v2.pdf

## ECQA SKILLS DEFINITION MODEL

The ECQA skills definition model, used for Job Role definition, is described in section 2 of this document.

## ECQA SKILL SET STRATEGY

Imagine that in the future Europeans will have a skill set like a card with a chip which stores your skill profile to fulfil specific professions, job roles, and tasks. It's working like an ID card. This future scenario requires -

- A standard way to describe a skill set for a profession, job, or specific task.
- A standard procedure to assess the skill and to calculate and display skill profiles.

Such a common set of skill sets in Europe is needed due to the free mobility of workers. European countries such as UK, The Netherlands, and France already have well established open universities which support APL (Accreditation of Prior Learning). In APL the skills of students are assessed, already gained skills are recognised, and only for the skill gaps a learning plan is established. The skill assessment bases on defined skill units and a skill profile displaying how much of the skill units are covered.

In a previous project CREDIT (Accreditation of Skills via the Internet) [1] in which some of the project partners were involved such an Internet based skills assessment system has been built. Therefore another possible scenario of the future is that representative educational bodies per country in Europe maintain skill profiles in databases which can be accessed via defined ID codes for people.

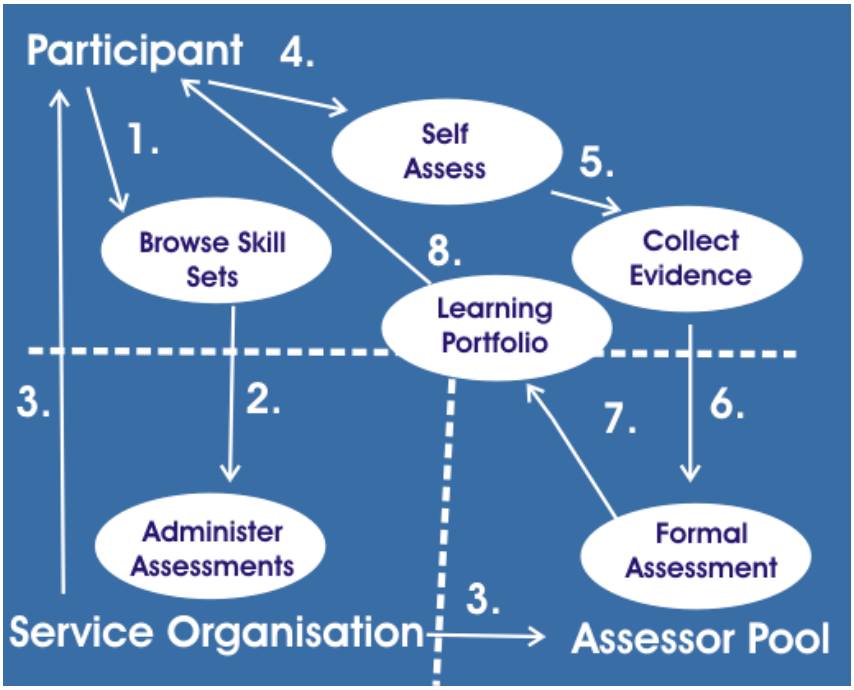
## ECQA SKILLS ASSESSMENT MODEL

**Step 1** – Browse a Skills Set: You select a set of skills or competencies, which are required by your profession or job using national standards or your company standards. You browse different skills cards and select a job role you would like to achieve.

**Step 2 – Register for Self Assessment with a Service Unit** : This can be a service unit inside your own company (e.g. a personnel development department) or a skills card and assessment provider outside

your company which offers skills assessment services. In case of the Safety Manager Project the registration will automatically assign a predefined service unit.

**Step 3 – Receive an Account for Self-Assessment and Evidence Collection** : With the registration you automatically received an account to login to the working space in which you can go through the steps of online self assessment and the collection of evidences to prove that you are capable of certain performance criteria.




Picture 1: Basic steps of the skills assessment model

**Step 4 – Perform Self Assessment:** You log into the system , browse through the skills required and self assess performance criteria, whole elements or whole units with a standard evaluation scale of non-applicable, not adequate, partially adequate, largely adequate, and fully adequate. A skills gaps profile can be generated and printed illustrating in which areas your self assessment shows improvement potentials.

Testing of Skills (Addition to Step 4) – The system provides a multiple-choice test for each performance criteria so that you can check your capabilities as realistically as possible.

**Step 5 – Collect Evidences:** Before you want to enter any formal assessment you need to prove your skills by evidences. Evidences can be any electronic files (sample documents, sample graphics, results of some analysis, etc.) or any references with details (e.g. a certificate received from a certain

institution). Evidences you can then link to specific performance criteria or whole elements of skills units.

Testing of Skills (Addition to Step 5) – In traditional learning schemes people have always needed to go to a learning institution (university, accreditation body, professional body, etc.) to take exams and they received a certificate if they pass. This traditional approach however is insufficient when it comes to measuring experience and (soft) skills learned on the job and fails to give recognition to skills gathered on the job. The APL (Accreditation of Prior Learning) approach, by contrast, collects so called evidences. Evidences can be certificates obtained in the traditional way, but also references from previous employers, materials from previous projects in which the person took ownership of results (e.g. a test plan) to prove their capability, as well as any kind of proof of competence gathered on the job. The assessors will then evaluate the evidences provided and not only rely on certificates and exams.

**Step 6 – Receive Formal Assessment:** Formal assessors are assigned by the service unit to the skills assessment. Once formal assessors log into the system they automatically see all assigned assessments. They select the corresponding one and can see the uploaded evidences. They then formally assess the evidences and assess the formal fulfilment of performance criteria, whole elements or whole units with a standard evaluation scale of non-applicable, not adequate, partially adequate, largely adequate, and fully adequate. In case of missing competencies they enter improvement recommendations, a well as learning options.

**Step 7 – Receive Advise on Learning / Improvement Options:** After the formal assessment the participants log into the system and can see the formal assessment results from the assessors, can print skills gaps profiles based on the assessor results, and can receive and print the improvement recommendations and learning options. If required, the generation of learning options can also be automated through the system (independent from assessor advises).

## ECQA CERTIFICATE TYPES

In the standard test and examination procedures for levels of certificates are offered:

- Course Attendance Certificate
  - Received after course attendance
  - Modular per Element
- Course / Test Certificate
  - Test in a test system (European pool of test questions)
  - 67% satisfaction per element

- Summary Certificate
    - Overview of covered elements where the student passed the test, all elements shall be covered
    - Generation of certificate
- Professional Certificate
    - Uploading applied experiences for review by assessors
    - Rating by assessors
    - Observation of 2 years

The certificates show credited elements in comparison to all required.

# ANNEX B ECQA COVERAGE OF QUALIFICATION SCHEMAS

## MAPPING BASED ON NVQ QUALIFICATION LEVELS

**Qualification / training levels:** Five levels of qualification / training are defined by European legislation and this structure can be used for comparability of vocational qualifications from the different European countries.

- Level 1: semi-skilled assistant performing simple work
- Level 2: basic employee performing complex routines and standard procedures
- Level 3: skilled professional with responsibility for others and performing independent implementation of procedures
- Level 4: middle management & specialist performing tactical an strategic thinking
- Level 5: professional / university level

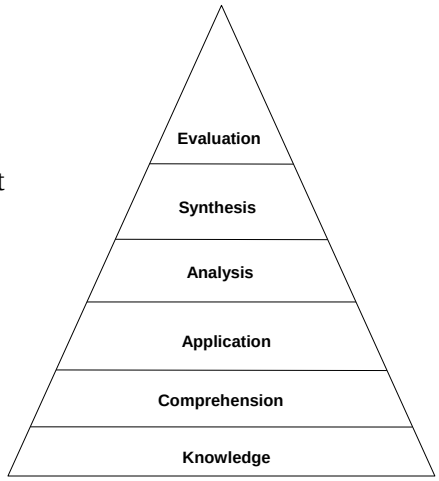
In most cases the same job role can be offered on different levels. e.g. IT Security Manager Basic Level (NVQ level 2), IT Security Manager Advanced level (NVQ Level 3), and IT Security Manager Expert Level (NVQ Levels 4 and 5).

## MAPPING BASED ON EUROPEAN QUALIFICATION FRAMEWORK (EQF) LEARNING LEVELS

- Six level taxonomy:

  Level 0: I never heard of it

  1. Knowledge (I can define it):
  2. Comprehension (I can explain how it works)
  3. Application (I have limited experience using it in simple situations)
  4. Analysis (I have extensive experience using it in complex situations)
  5. Synthesis (I can adapt it to other uses)
  6. Evaluation (I am recognized as an expert by my peers)




Picture 3: Blooms Learning levels

| Level | Knowledge | Example |
|---|---|---|
| Level 1 | Basic general knowledge | |
| Level 2 | Basic factual knowledge of a field of work or study | |
| Level 3 | Knowledge of facts, principles, processes and general concepts, in a field of work or study | Six Sigma Yellow Belt |
| Level 4 | Factual and theoretical knowledge in broad contexts within a field of work or study | |
| Level 5 | Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge | |
| Level 6 | Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles | Six Sigma Green Belt |
| Level 7 | • Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research<br>• Critical awareness of knowledge issues in a field and at the interface between different fields | Six Sigma Black Belt |

| Level | Knowledge | Example |
|---|---|---|
| Level 8 | Knowledge at the most advanced frontier of a field of work or study and at the interface between fields | Six Sigma Master Black Belt |

Picture 4 : EQF Learning levels

## MAPPING BASED ON ECTS AND ECVET SCHEMA

ECQA has established a procedure to map ECQA skills sets onto the ECTS (European Credit Transfer System) and the ECVET framework n the European Union.

A job role is assigned ECTS and ECVET points using a defined framework.

### ECTS Mapping

Each element of the skills set is assigned hours of lecturing and exercises. These hours determine the ECTS points which are then agreed among a cluster on different universities in Europe.

| Level | Knowledge | AQUA | ECTS | Safety Manager | ECTS |
|---|---|---|---|---|---|
| Level 1 | Basic general knowledge | - | | - | |
| Level 2 | Basic factual knowledge of a field of work or study | - | | - | |
| Level 3 | Knowledge of facts, principles, processes and general concepts, in a field of work or study | | | | |
| Level 4 | Factual and theoretical knowledge in broad contexts within a field of work or study | | | | |
| Level 5 | Comprehensive, specialized, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge | | | | |
| Level 6 | Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles | AQUA - Automotive Quality Integrated Skills - presentations / theory | 3 | AQUA - Automotive Quality Integrated Skills - presentations / theory | 3 |
| Level 7 | - Highly specialized knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research<br>- Critical awareness of knowledge issues in a field and at the interface between different fields | AQUA - Automotive Quality Integrated Skills - with exercises to apply on nan example (e.g. ESCL) | 4 | AQUA - Automotive Quality Integrated Skills - with exercises to apply on nan example (e.g. ESCL) | 4 |
| Level 8 | Knowledge at the most advanced frontier of a field of work or study and at the interface between fields | AQUA - Automotive Quality Integrated Skills - implementation in a research at PhD level / with link to a real project | 5 | AQUA - Automotive Quality Integrated Skills - implementation in a research at PhD level / with link to a real project | 5 |

Picture 5 : Example Automotive Quality Engineer and Safety Manager

The 2 job roles illustrated in the picture above have been assigned to ECTS and are taught using the same skills set at industry and also universities.

## ECVET Mapping

Also ECQA provides a framework to assign ECVET points onto elements of the skills set. The ECQA guidance recommends to offer the ECQA course (which is offered as a lecture at university) as a short course (2 weeks with exercises) in industry to retrain for a job role in industry. The recommended size is 30 ECVET points in total. The lecturing time and exercise per element determine how many ECVET points ae assigned to an element of the skills set.

| Automotive Quality Engineer | | | |
|---|---|---|---|
| | | | ECVET L7&8 |
| U1 | 4 | U1.E1: Introduction | 2 |
| | | U1.E2: Organisational Readiness | 2 |
| U2 | 32 | U2.E1 Life Cycle | 8 |
| | | U2.E2 Requirements | 8 |
| | | U2.E3 Design | 8 |
| | | U2.E4 Test and Integration | 8 |
| U3 | 12 | U3.E1: Capability | 2 |
| | | U3.E2: Hazard and Risk Management | 8 |
| | | U3.E3 Assessment and Audit | 2 |
| U4 | 12 | U4.E1: Measurement | 6 |
| | | U4.E2: Reliability | 6 |
| | | ECVET Points Total | 60 |

Picture 6 : ECVET Mapping example - Automotive Quality Engineer

| Functional Safety Manager / Engineer | | | |
|---|---|---|---|
| | | | ECVET L7&8 |
| U1 | 2 | U1.E1 International Standards | 1 |
| | | U1.E2 Product Life Cycle | 1 |
| | | U1.E3 Terminology | |
| U2 | 4 | Safety management on organisational | 1 |
| | | Safety Case Definition | 1 |
| | | Overview of Required Engineering an | 1 |
| | | Establish and Maintain Safety Plannin | 1 |
| U3 | 16 | System Hazard Analysis and Safety Co | 4 |
| | | Integrating Safety in System Design & | 4 |
| | | Integrating Safety in Hardware Design | 4 |
| | | Integrating Safety in Software Design | 4 |
| U4 | 4 | Integration of Reliability in Design to I | 2 |
| | | Safety in the Production,Operation an | 2 |
| U5 | 4 | Legal aspects and Liabilities | 2 |
| | | Regulatory & Qualification Requireme | 2 |
| | | | |
| | | ECVET Points Total | 30 |

Picture 7 : ECVET Mapping example – Functional Safety Manager / Engineer

# ANNEX C ECQA LEGAL BACKGROUND FOR CERTIFICATION

## ISO/IEC 17024 STANDARD FOR PERSONNEL CERTIFICATION PROGRAMMES

The ISO/IEC 17024 standard describes standard processes for the examination and certification of people. Some of the basic principles described include:

- Standard exam procedure
- Standard certification procedure
- Identification of persons receiving the certificate
- Independence of examiner and trainer
- Certification system that allows to log the exam to keep a record/proof that the examinee passed the exam
- Mapping of processes towards ISO 17024

## ECQA AND ISO/IEC 17024 STANDARD

- ECQA defined standard exam processes
- ECQA defined standard certification processes
- ECQA developed an exam system that generates random exams and corrects exams.
- ECQA developed a certification database to identify persons and map them to exam results
- ECQA established a mapping onto the ISO 17024 norm and published that in form of a self declaration.

## LIASION WITH NATIONAL UNIVERSITIES

ECQA established cooperation with national universities who teach job roles with ECTS. The same job roles are offered with ECVET on the market by training bodies.

# ANNEX D REFERENCES

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