DRIVES

Development and Research on Innovative Vocational Education Skills

Automotive Mechatronics Developer

Job Role Skill Set

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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 Automotive Mechatronics Developer 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.**):

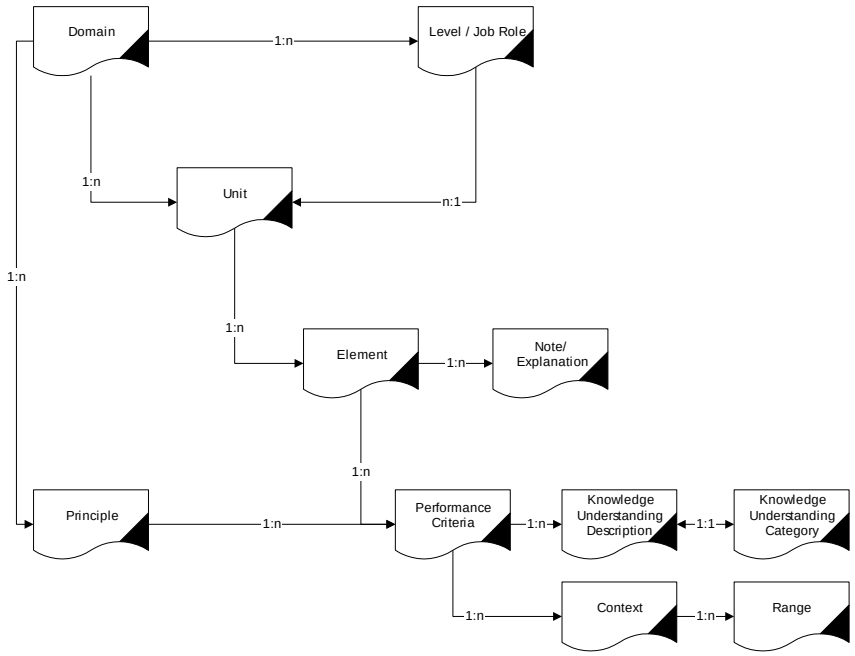


Figure 1: The Skill Definition Model (1:n = one to many relationship)

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 "AUTOMOTIVE MECHATRONICS DEVELOPER"

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 roles of the "**Automotive Mechatronics Training Programme**" has been designed.

Content Unit of the Training Skill Card	Introduction to Automotive Mechatronics	Automotive Mechatronics Manager Basic Level	Automotive Mechatronics Expert	Automotive Mechatronics Developer
Unit 1 - Introduction to Automotive Mechatronics (virtual course)				
U1E1 Introduction to Mechatronics Systems	comprehension			
U1E2 Mechatronics Systems Development & Production	comprehension			
U1E3 Required Skills and Boundary Conditions	comprehension			
Unit 2 - Automotive Mechatronics Systems Development				
U2E1 Boundary Conditions in Automotive Industry		comprehension	comprehension	comprehension
U2E2 Characteristics, Structures and Functions of Mechatronics Systems		comprehension	comprehension	comprehension
U2E3 Mechatronics Systems Development Processes and -Standards		application	application	application
U2E4 Mechatronics System Engineering Basics		application	application	application
Unit 3 - Introduction of Electrical Engineering & Information Technology				
U3E1 Basic Elements of Electric Circuits			comprehension	comprehension
U3E2 DC-Circuits Layout and Calculation, AC-Current Basics			analysis	analysis
U3E3 Basics of Magnetic and Electric Fields			analysis	analysis
U3E4 IT Development Process and Embedded System Integration			comprehension	comprehension
U3E5 Introduction of IT Hardware and Software Engineering			comprehension	comprehension
U3E6 Automotive Communication Systems & Data Interfaces			application	application
Unit 4 - Sensor, Actuator and Electric Motor Technologies				
U4E1 Sensing & Measurement Principles			analysis	analysis
U4E2 Sensor System Data Processing			application	application
U4E3 Sensor & Measurement Technologies			application	application
U4E4 Types and Functions of Electric Motors and Actuators			analysis	analysis
U4E5 Electric Motor / Actuator Design & Control Characteristics			application	application
Unit 5 - Quality Management & Verification of Mechatronics Systems				
U5E1 Mechatronics Development Processes, Standards and Guidelines			comprehension	comprehension
U5E2 Basics of Functional Safety, System Verification and Optimization			comprehension	comprehension
U5E3 Quality Management			application	application
U5E4 ISO 26262, ASPICE, CMMI			application	application
U5E5 Risk Assessment, System Test and Integration			application	application
Unit 6 - Introduction of Matlab-Simulink				
U6E1 Introduction and Overview of Simulation Basics				comprehension
U6E2 Program Introduction and User-Handling				comprehension
U6E3 Constants, Variables, Vectors, Matrices				analysis
U6E4 Modelling of Simple Systems, Solution of Linear Equation Systems				application
U6E5 Data Processing and Programming Structures				application
U6E6 Model-Based Simulation of Mechatronics Systems				application
Unit 7 - Introduction of Control Engineering				
U7E1 Notion of Control				comprehension
U7E2 Feedback Control vs. Feedforward Control				analysis
U7E3 Basic Modelling and Simulation Concepts				analysis
U7E4 Transfer Functions and Stability				application
U7E5 PID controllers				application
U7E6 Simulation of Feedback Loops / Applications				application
Unit 8 - Advanced Systems & Components Design				
U8E1 Mechatronics System Layout and Design				application
U8E2 Mechatronics System Simulation				application
U8E3 Sensor, Actuators and ECU Hardware Simulation and Optimization				application
U8E4 Investigations of Control Strategies				application
U8E5 Application and Discussion based on a Project Work				application

Figure 2: The Skills Set for ECQA Certified Automotive Mechatronics Roles (overview)

3.2 THE SKILLS DESCRIPTIONS – JOB ROLE AUTOMOTIVE MECHATRONICS DEVELOPER

Domain Acronym: Engineering

Domain title: Mechatronics

Domain Description:

With rising degree of electrification and digitalization of automotive systems, an effective integration of the domains mechanics, electrics and information technology plays a significant role in automotive development processes. Besides engineering expertise in each of the domains, vehicle manufacturer and supplier increasingly need human resources for the management, development and administration of mechatronics systems throughout the entire value-creation chain. This includes conception, design, simulation, manufacturing engineering as well as production, logistics, maintenance and quality management of mechatronics systems, which are composed of modules and components of the three mentioned domains. The complexity of mechatronics systems is considered and represented by several standardized development processes, e.g. the V-model according to VDI 2206 or the Functional Safety Standard ISO 26262.

The job roles of Automotive Mechatronics Manager / Expert / Developer are embedded into the complex development processes in the automotive industry. These roles fit into both system- and vehicle development as well as production engineering. The training is designed as modular course; in this way the trainees can attend units and elements separately and independently, although it is recommended to attend the entire unit structure according to the targeted job role. In general, there are four levels offered:

1. Introduction to Automotive Mechatronics (online training course)
2. Automotive Mechatronics Manager Basic Level
3. Automotive Mechatronics Expert
4. Automotive Mechatronics Developer

This document focusses on the "**Automotive Mechatronics Developer**". The training includes seven units comprising different main elements. The duration of training is seven weeks. After having accomplished the training, the trainees can take an exam and become a certified **Automotive Mechatronics Developer**.

Job Role Acronym: AMMD

Job Role Title: Automotive Mechatronics Developer

Description:

The Skill card comprises the following thematic learning units

In modern cars a main share of the functions is controlled by software, electronics, and mechatronics. **Automotive Mechatronics Developer** – as an enhanced level of the job role "Automotive Mechatronics Expert" - understand the legal background, complexity and behaviour of mechatronics functions and products. In addition, they understand risks and impacts on design and costs and required organisation roles and responsibilities in the development and production of mechatronics systems. **Automotive Mechatronics Developer** have a knowledge about the complex interactions of the development domains mechanics, electrics and IT and can plan and manage the proper methods to be applied in successful development projects. They know the required development standards and guidelines and can manage the involvement of required expertise and resources.

In addition to the Job Role of Automotive Mechatronics Manager Basic Level and Automotive Mechatronics Expert, the **Automotive Mechatronics Developer** have deep technical insights of mechatronics products. This includes knowledge in electrical- and computer engineering, detailed knowledge in sensor systems and electric actuators, as well as fundamental understanding of Quality Management and Verification of Mechatronics Systems. **Automotive Mechatronics Developer** have skills for the development of mechatronics systems, including layout, design, simulation and testing. They have the knowledge to develop control algorithms within comprehensive simulation tools and they understand the complex interaction between the components of embedded systems.

Description:

The skill card comprises the following thematic learning seven units, and several learning elements.

Unit 2 - Automotive Mechatronics Systems Development

U2E1: Motivation & Boundary Conditions in Automotive Industry

U2E2: Characteristics, Structures and Functions of Mechatronics Systems

U2E3: Mechatronics Systems Development Processes and -Standards

U2E4: Mechatronics Systems Engineering Basics

Unit 3 - Introduction of Electrical Engineering & Information Technology

U3E1: Basic Elements of Electric Circuits

U3E2: DC-Circuits Layout and Calculation, AC-Current Basics

U3E3: Basics of Magnetic and Electric Fields

U3E4: IT Development Process and Embedded System Integration

U3E5: Introduction of IT Hardware and Software Engineering

U3E6: Automotive Communication Systems & Data Interfaces

Unit 4 - Sensor, Actuator and Electric Motor Technologies

U4E1: Sensing & Measurement Principles

U4E2: Sensor System Data Processing

U4E3: Sensor & Measurement Technologies

U4E4: Types and Functions of Electric Motors and Actuators

U4E5: Electric Motor / Actuator Design & Control Characteristics

Unit 5 - Quality Management & Verification of Mechatronics Systems

U5E1: Mechatronics Development Processes, Standards and Guidelines

U5E2: Basics of Functional Safety, System Verification and Optimization

U5E3: Quality Management

U5E4: ISO 26262, ASPICE, CMMI

U5E5: Risk Assessment, System Test and Integration

Unit 6 - Introduction of Matlab-Simulink

U6E1: Introduction and Overview of Simulation Basics

U6E2: Program Introduction and User-Handling

U6E3: Constants, Variables, Vectors, Matrices

U6E4: Modelling of Simple Systems, Solution of Linear Equation Systems

U6E5: Data Processing and Programming Structures

U6E6: Model-Based Simulation of Mechatronics Systems

U6E7: Model-Based Simulation of Mechatronics Systems

Unit 7 - Introduction of Control Engineering

U7E1: Notion of Control

U7E2: Feedback Control vs. Feedforward Control

U7E3: Basic Modelling and Simulation Concepts

U7E4: Transfer Functions and Stability

U7E5: PID controllers

U7E6: Simulation of Feedback Loops / Applications

Unit 8 - Advanced Systems & Components Design

U8E1: Mechatronics System Layout and Design

U8E2: Mechatronics System Simulation

U8E3: Sensor, Actuators and ECU Hardware Simulation and Optimization

U8E4: Investigations of Control Strategies

U8E5: Application and Discussion based on a Project Work

3.3 UNIT AMMBL.U2 AUTOMOTIVE MECHATRONICS SYSTEMS DEVELOPMENT

Acronym: AMMBL.U2

Title: Automotive Mechatronics Systems Development

Description:

Die training unit introduces into the field of automotive mechatronics and the boundary conditions of mechatronics product development, addressing:

- Introduction of mechatronics systems in automotive applications
- Overview of mechatronics systems components
- Development processes and standards of mechatronics systems
- Mechatronics systems requirements- and systems engineering

Also the unit discusses

- Challenges in multi-domain development

And the unit finally presents

- the impact on product design, the impact on cost, and
- the roles of Automotive Mechatronics Manager – Basic Level under different viewpoints.

3.3.1 Unit AMMBL.U2 - Element 1: Motivation & Boundary Conditions in Automotive Industry

Acronym: AMMBL.U2.E1

Element Title: Motivation & Boundary Conditions in Automotive Industry

Element Note:

This element gives an introduction and overview about the following aspects:

- You know about historical development, state-of-the-art and trends of mechatronics systems in automotive applications.
- You know about the integration of mechatronics systems into automotive products development.
- You have knowledge about the corresponding legislative boundary conditions in different worldwide markets.

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
AMMBL.U2.E1.PC1	The students know mechatronics systems in automotive applications and their historical background and future trends.

Performance Criterion	Evidence Check: The student can demonstrate
AMMBL.U2.E1.PC2	The students know about the integration of mechatronics systems within automotive system architectures.
AMMBL.U2.E1.PC3	The students know the corresponding legislative boundary conditions in different worldwide markets.

Table 1: Performance Criteria for the Element AMMBL.U2.E1

3.3.2 Unit AMMBL.U2 - Element 2: Characteristics, Structures and Functions of Mechatronics Systems

Acronym: AMMBL.U2.E2

Element Title: Characteristics, Structures and Functions of Mechatronics Systems

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the characteristics of mechatronics systems and their control.
- You know the architectural design of different mechatronics systems.
- You know the main components of mechatronics 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
AMMBL.U2.E2.PC1	The students know the characteristics of mechatronics systems and are able to distinguish between different types of control.
AMMBL.U2.E2.PC2	The students know the architectural design of different mechatronics systems.
AMMBL.U2.E2.PC3	The students know the main components of mechatronics systems.

Table 2: Performance Criteria for the Element AMMBL.U2.E2

3.3.3 Unit AMMBL.U2 - Element 3: Mechatronics Systems Development Processes and -Standards

Acronym: AMMBL.U2.E3

Element Title: Mechatronics Systems Development Processes and -Standards

Element Note:

This element gives an introduction and overview about the following aspects:

- You know automotive development processes and the integration of mechatronics systems development.
- You know the development processes for mechatronics products.
- You know the development standards and guidelines.

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
AMMBL.U2.E3.PC1	The students know automotive development processes and understand the integration of mechatronics systems development.
AMMBL.U2.E3.PC1	The students the development processes for mechatronics products.
AMMBL.U2.E3.PC1	The students know the development standards and guidelines.

Table 3: Performance Criteria for the Element AMMBL.U2.E3

3.3.4 Unit AMMBL.U2 - Element 4: Mechatronics Systems Engineering Basics

Acronym: AMMBL.U2.E4

Element Title: Mechatronics Systems Engineering Basics

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the basics of requirements engineering of mechatronics systems development.
- You know the main aspects of systems engineering in multi-domain development.
- You know about simulation-based systems engineering tools for mechatronics development.

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
AMMBL.U2.E4.PC1	The students know the basics of requirements engineering of mechatronics systems development.
AMMBL.U2.E4.PC2	The students understand the main aspects of systems engineering in multi-domain development.

Performance Criterion	Evidence Check: The student can demonstrate
AMMBL.U2.E4.PC3	The students know about simulation-based systems engineering tools for mechatronics development.

Table 4: Performance Criteria for the Element AMMBL.U2.E4

3.4 UNIT AMME.U3 INTRODUCTION OF ELECTRICAL ENGINEERING & INFORMATION TECHNOLOGY

Acronym: AMME.U3

Title: Introduction of Electrical Engineering & Information Technology

Description:

Die training unit introduces into the field of electrical engineering and information technology, addressing:

- Basic Elements of Electric Circuits
- DC-Circuits Layout and Calculation, AC-Current Basics
- Basics of Magnetic and Electric Fields
- IT Development Process and Embedded System Integration
- Introduction of IT Hardware and Software Engineering
- Automotive Communication Systems & Data Interfaces

Also the unit discusses

- the integration of electrical and information technology development into the comprehensive systems engineering approach of mechatronics products.

And the unit finally presents knowledge

- of electrical circuits layout and design by use of different examples and exercises and
- introduces into the basics of controller programming and software application.

3.4.1 Unit AMME.U3 - Element 1: Basic Elements of Electric Circuits

Acronym: AMME.U3.E1

Element Title: Basic Elements of Electric Circuits

Element Note:

This element gives an introduction and overview about the following aspects:

- You know about the basic elements of electrical circuits and their electrical and physical behaviour.

- You know the different technological mechanisms of the electrical components and the available variations.
- You have knowledge about the mathematical description of the components behaviour and you are aware of the basic knowledge for selection and layout of basic elements of electrical circuits.

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
AMME.U3.E1.PC1	The students know about the basic elements of electrical circuits and their electrical and physical behaviour.
AMME.U3.E1.PC2	The students know the different technological mechanisms of the electrical components and the available variations.
AMME.U3.E1.PC3	The students have knowledge about the mathematical description of the components behaviour and you are aware of the basic knowledge for selection and layout of basic elements of electrical circuits.

Table 5: Performance Criteria for the Element AMME.U3.E1

3.4.2 Unit AMME.U3 - Element 2: DC-Circuits Layout and Calculation, AC-Current Basics

Acronym: AMME.U3.E2

Element Title: DC-Circuits Layout and Calculation, AC-Current Basics

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the methods and tools for electrical DC circuits layout and development.
- You have knowledge and can apply the required calculations for DC circuits layout.
- You understand the basics of alternating current and their application in automotive mechatronics 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
AMME.U3.E2.PC1	The students know the methods and tools for electrical DC circuits layout and development.
AMME.U3.E2.PC2	The students have knowledge and can apply the required calculations for DC circuits layout.
AMME.U3.E2.PC3	The students understand the basics of alternating current and their application in automotive mechatronics systems.

Table 6: Performance Criteria for the Element AMME.U3.E2

3.4.3 Unit AMME.U3 - Element 3: Basics of Magnetic and Electric Fields

Acronym: AMME.U3.E3

Element Title: Basics of Magnetic and Electric Fields

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the basic physical behaviour and mathematical descriptions of magnetic and electric fields.
- You can relate the knowledge in selected examples of automotive mechatronics applications.
- You know the integration of electric components to accomplish the required magnetic and electric fields in automotive applications.

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
AMME.U3.E3.PC1	The students know the basic physical behaviour and mathematical descriptions of magnetic and electric fields.
AMME.U3.E3.PC2	The students can relate the knowledge in selected examples of automotive mechatronics applications.
AMME.U3.E3.PC3	The students know the integration of electric components to accomplish the required magnetic and electric fields in automotive applications.

Table 7: Performance Criteria for the Element AMME.U3.E3

3.4.4 Unit AMME.U3 - Element 4: IT Development Process and Embedded System Integration

Acronym: AMME.U3.E4

Element Title: IT Development Process and Embedded System Integration

Element Note:

This element gives an introduction and overview about the following aspects:

- You know about information technology development processes.
- You know procedures and methods for the integration of embedded systems in automotive applications.
- You know about controller design and testing on hardware and software level.

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
AMME.U3.E4.PC1	The students know about information technology development processes.
AMME.U3.E4.PC2	The students know procedures and methods for the integration of embedded systems in automotive applications.
AMME.U3.E4.PC3	The students know about controller design and testing on hardware and software level.

Table 8: Performance Criteria for the Element AMME.U3.E4

3.4.5 Unit AMME.U3 - Element 5: Introduction of IT Hardware and Software Engineering

Acronym: AMME.U3.E5

Element Title: Introduction of IT Hardware and Software Engineering

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the basics of IT hardware design, development and optimization.
- You understand the main aspects of software development for embedded systems.
- You know about the basics of controller programming, testing and software integration by conduction of selected examples out of automotive applications.

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
AMME.U3.E5.PC1	The students know the basics of IT hardware design, development and optimization.
AMME.U3.E5.PC2	The students understand the main aspects of software development for embedded systems.
AMME.U3.E5.PC3	The students know about the basics of controller programming, testing and software integration by conduction of selected examples out of automotive applications.

Table 9: Performance Criteria for the Element AMME.U3.E5

3.4.6 Unit AMME.U3 - Element 6: Automotive Communication Systems & Data Interfaces

Acronym: AMME.U3.E6

Element Title: Automotive Communication Systems & Data Interfaces

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the different types of communication systems (bus systems) in automotive applications.
- You know the different types of data interfaces for communication between embedded systems.
- You know automotive network architectures, gateways, standardized interfaces and requirements on data security.

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
AMME.U3.E6.PC1	The students know the different types of communication systems (bus systems) in automotive applications.

Performance Criterion	Evidence Check: The student can demonstrate
AMME.U3.E6.PC2	The students know the different types of data interfaces for communication between embedded systems.
AMME.U3.E6.PC3	The students know automotive network architectures, gateways, standardized interfaces and requirements on data security.

Table 20: Performance Criteria for the Element AMME.U3.E6

3.5 UNIT AMME.U4 SENSOR, ACTUATOR AND ELECTRIC MOTOR TECHNOLOGIES

Acronym: AMME.U4

Title: Sensor, Actuator and Electric Motor Technologies

Description:

The training unit introduces into the field of electric sensor and actuator systems goes specifically into detail of electric motors for automotive applications. In particular, the unit addresses:

- Sensing & Measurement Principles
- Sensor System Data Processing
- Sensor & Measurement Technologies
- Types and Functions of Electric Motors and Actuators
- Electric Motor / Actuator Design & Control Characteristics

Also the unit introduces procedures and tools for layout, design and optimization of measurement systems with a focus on automotive applications.

Subsequently, basics and enhances knowledge of electric actuator and motor design are introduced and applied by different examples from automotive use-cases.

3.5.1 Unit AMME.U4 - Element 1: Sensing & Measurement Principles

Acronym: AMMBL.U4.E1

Element Title: Sensing & Measurement Principles

Element Note:

This element gives an introduction and overview about the following aspects:

- You know about the physical and electrical basics of measurement principles.
- You have knowledge about different types of measurement of physical, chemical and biological characteristics in automotive applications.
- You know different sensor systems and their application in automotive industry.

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
AMME.U4.E1.PC1	The students know about the physical and electrical basics of measurement principles.
AMME.U4.E1.PC2	The students have knowledge about different types of measurement of physical, chemical and biological characteristics in automotive applications.
AMME.U4.E1.PC3	The students know different sensor systems and their application in automotive industry.

Table 11: Performance Criteria for the Element AMME.U4.E1

3.5.2 Unit AMME.U4 - Element 2: Sensor System Data Processing

Acronym: AMME.U4.E2

Element Title: Sensor System Data Processing

Element Note:

This element gives an introduction and overview about the following aspects:

- You know methods and tools applied for sensor data processing.
- You know the different data structures, formats and interfaces in automotive sensor systems.
- You can develop and apply sensor data processing in automotive applications.

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
AMME.U4.E2.PC1	The students know methods and tools applied for sensor data processing.
AMME.U4.E2.PC2	The students know the different data structures, formats and interfaces in automotive sensor systems.
AMME.U4.E2.PC3	The students can develop and apply sensor data processing in automotive applications.

Table 32: Performance Criteria for the Element AMME.U4.E2

3.5.3 Unit AMME.U4 - Element 3: Sensor & Measurement Technologies

Acronym: AMME.U4.E3

Element Title: Sensor & Measurement Technologies

Element Note:

This element gives an introduction and overview about the following aspects:

- You have knowledge about sensor system design and the application of different measurement technologies.
- You can apply the knowledge of measurement principles on automotive use-cases and develop layouts of the corresponding sensor system solutions.
- You know about the integration and verification of sensor systems in automotive environments.

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
AMME.U4.E3.PC1	The students have knowledge about sensor system design and the application of different measurement technologies.
AMME.U4.E3.PC1	The students can apply the knowledge of measurement principles on automotive use-cases and develop layouts of the corresponding sensor system solutions.
AMME.U4.E3.PC1	The students know about the integration and verification of sensor systems in automotive environments.

Table 43: Performance Criteria for the Element AMME.U4.E3

3.5.4 Unit AMME.U4 - Element 4: Types and Functions of Electric Motors and Actuators

Acronym: AMME.U4.E4

Element Title: Types and Functions of Electric Motors and Actuators

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the working principles of electric actuators and their physical and mathematical descriptions.
- You know types and functions of electric motors and actuators.

- You know about the layout of electric propulsion systems and their integration in automotive use-cases.

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
AMME.U4.E4.PC1	The students know the working principles of electric actuators and their physical and mathematical descriptions.
AMME.U4.E4.PC2	The students know types and functions of electric motors and actuators.
AMME.U4.E4.PC3	The students know about the layout of electric propulsion systems and their integration in automotive use-cases.

Table 54: Performance Criteria for the Element AMME.U4.E4

3.5.5 Unit AMME.U4 - Element 5: Electric Motor / Actuator Design & Control Characteristics

Acronym: AMME.U4.E5

Element Title: Electric Motor / Actuator Design & Control Characteristics

Element Note:

This element gives an introduction and overview about the following aspects:

- You know different types of electric actuators and motors and their design characteristics.
- You understand the tools and methods for development of electric actuators and motors.
- You have knowledge about electric propulsion control systems layout, design and optimization.

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
AMME.U4.E5.PC1	The students know different types of electric actuators and motors and their design characteristics.

Performance Criterion	Evidence Check: The student can demonstrate
AMME.U4.E5.PC2	The students understand the tools and methods for development of electric actuators and motors.
AMME.U4.E5.PC3	The students have knowledge about electric propulsion control systems layout, design and optimization.

Table 65: Performance Criteria for the Element AMME.U4.E5

3.6 UNIT AMME.U5 QUALITY MANAGEMENT & VERIFICATION OF MECHATRONICS SYSTEMS

Acronym: AMME.U5

Title: Quality Management & Verification of Mechatronics Systems

Description:

Die training unit introduces into quality management and verification of mechatronics systems, addressing:

- Mechatronics Development Processes, Standards and Guidelines
- Basics of Functional Safety, System Verification and Optimization
- Quality Management
- ISO 26262, ASPICE, CMMI
- Risk Assessment, System Test and Integration

Also the unit discusses

- the integration of established automotive quality standards and functional-safety guidelines in the development processes of mechatronics products.

And the unit provides

- a number of use-cases and exercises to relate the gathered knowledge on typical automotive applications.
- a number of examples of applications to point out the importance of quality management in automotive mechatronics systems development.

3.6.1 Unit AMME.U5 - Element 1: Mechatronics Development Processes, Standards and Guidelines

Acronym: AMME.U5.E1

Element Title: Mechatronics Development Processes, Standards and Guidelines

Element Note:

This element gives an introduction and overview about the following aspects:

- You know about mechatronics system development processes and the integration of quality management.
- You know about the motivation of quality management in automotive product development.
- You have knowledge about different types of development standards and quality-related guidelines in automotive industry.

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
AMME.U5.E1.PC1	The students know about mechatronics system development processes and the integration of quality management.
AMME.U5.E1.PC2	The students know about the motivation of quality management in automotive product development.
AMME.U5.E1.PC3	The students have knowledge about different types of development standards and quality-related guidelines in automotive industry.

Table 76: Performance Criteria for the Element AMME.U5.E1

3.6.2 Unit AMME.U5 - Element 2: Basics of Functional Safety, System Verification and Optimization

Acronym: AMME.U5.E2

Element Title: Basics of Functional Safety, System Verification and Optimization

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the purpose, procedures and guidelines for functional safety development.
- You have knowledge about the different methods of mechatronics system verification and optimization in automotive industry.
- You are able to apply the knowledge on different types of use-cases in automotive development processes.

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
AMME.U5.E2.PC1	The students know the purpose, procedures and guidelines for functional safety development.
AMME.U5.E2.PC2	The students have knowledge about the different methods of mechatronics system verification and optimization in automotive industry.
AMME.U5.E2.PC3	The students are able to apply the knowledge on different types of use-cases in automotive development processes.

Table 87: Performance Criteria for the Element AMME.U5.E2

3.6.3 Unit AMME.U5 - Element 3: Quality Management

Acronym: AMME.U5.E3

Element Title: Quality Management

Element Note:

This element gives an introduction and overview about the following aspects:

- You have knowledge and a broad overview of the different quality management – related activities in automotive mechatronics systems development.
- You know the tools and methods of quality management.
- You can apply the quality management tools and methods in automotive development projects.

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
AMME.U5.E3.PC1	The students have knowledge and a broad overview of the different quality management – related activities in automotive mechatronics systems development.
AMME.U5.E3.PC2	The students know the tools and methods of quality management.

Performance Criterion	Evidence Check: The student can demonstrate
AMME.U5.E3.PC3	The students can apply the quality management tools and methods in automotive development projects.

Table 98: Performance Criteria for the Element AMME.U5.E3

3.6.4 Unit AMME.U5 - Element 4: ISO 26262, ASPICE, CMMI

Acronym: AMME.U5.E4

Element Title: ISO 26262, ASPICE, CMMI

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the standards ISO 26262, ASPICE, CMMI.
- You know how these standards are integrated into automotive development processes.
- You have knowledge about the application and verification procedures demanded by the standards.
- You have knowledge about the required resources and skills for a successful implementation of the standards in the enterprises, respectively process landscape.

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
AMME.U5.E4.PC1	The students know the standards ISO 26262, ASPICE, CMMI.
AMME.U5.E4.PC2	The students know how these standards are integrated into automotive development processes.
AMME.U5.E4.PC3	The students have knowledge about the application and verification procedures demanded by the standards.
AMME.U5.E4.PC4	The students have knowledge about the required resources and skills for a successful implementation of the standards in the enterprises, respectively process landscape.

Table 109: Performance Criteria for the Element AMME.U5.E4

3.6.5 Unit AMME.U5 - Element 5: Risk Assessment, System Test and Integration

Acronym: AMME.U5.E5

Element Title: Risk Assessment, System Test and Integration

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the tools for risk assessment in automotive mechatronics systems development.
- You can apply the tools in automotive development processes.
- You know about mechatronics systems testing and integration.
- You can develop comprehensive mechatronics systems verification plans and define the corresponding tools and methods.

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
AMME.U5.E5.PC1	The students know the tools for risk assessment in automotive mechatronics systems development.
AMME.U5.E5.PC2	The students can apply the tools in automotive development processes.
AMME.U5.E5.PC3	The students know about mechatronics systems testing and integration.
AMME.U5.E5.PC4	The students can develop comprehensive mechatronics systems verification plans and define the corresponding tools and methods.

Table 20: Performance Criteria for the Element AMME.U5.E5

3.7 UNIT AMMD.U6 INTRODUCTION OF MATLAB-SIMULINK

Acronym: AMMD.U6

Title: Introduction of Matlab-Simulink

Description:

Die training unit introduces into the field of automotive mechatronics and the boundary conditions of mechatronics product development, addressing:

- Introduction and Overview of Simulation Basics
- Program Introduction and User-Handling
- Constants, Variables, Vectors, Matrices
- Modelling of Simple Systems, Solution of Linear Equation Systems

Also the unit discusses

- Data Processing and Programming Structures

And the unit finally presents

- Model-Based Simulation of Mechatronics Systems based on several examples and use-cases from mechatronics systems development.

3.7.1 Unit AMMD.U6 - Element 1: Introduction and Overview of Simulation Basics

Acronym: AMMD.U6.E1

Element Title: Introduction and Overview of Simulation Basics

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the basic principles of computational simulation.
- You have knowledge about simulation procedures, tools and methods.
- You have knowledge about the mathematical background required for mechatronics system 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
AMMD.U6.E1.PC1	The students know the basic principles of computational simulation.
AMMD.U6.E1.PC2	The students have knowledge about simulation procedures, tools and methods.
AMMD.U6.E1.PC3	The students have knowledge about the mathematical background required for mechatronics system simulation.

Table 211: Performance Criteria for the Element AMMD.U6.E1

3.7.2 Unit AMMD.U6 - Element 2: Program Introduction and User-Handling

Acronym: AMMBL.U6.E2

Element Title: Program Introduction and User-Handling

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the simulation programme structure and main functionalities.
- You are able to work within the simulation software by user interaction.
- You understand the software user interfaces and can perform input- and output operations.

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
AMMD.U6.E2.PC1	The students know the simulation programme structure and main functionalities.
AMMD.U6.E2.PC2	The students are able to work within the simulation software by user interaction.
AMMD.U6.E2.PC3	The students understand the software user interfaces and can perform input- and output operations.

Table 22: Performance Criteria for the Element AMMD.U6.E2

3.7.3 Unit AMMD.U6 - Element 3: Constants, Variables, Vectors, Matrices

Acronym: AMMD.U6.E3

Element Title: Constants, Variables, Vectors, Matrices

Element Note:

This element gives an introduction and overview about the following aspects:

- You have knowledge about the application of constants, variables, vectors and matrices in computational simulation.
- You know to define, proceed and read out constants, variables, vectors and matrices in the simulation environment.
- You are able to perform calculations by use of constants, variables, vectors and matrices in the simulation environment.

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
AMMD.U6.E3.PC1	The students have knowledge about the application of constants, variables, vectors and matrices in computational simulation.
AMMD.U6.E3.PC1	The students know to define, proceed and read out constants, variables, vectors and matrices in the simulation environment.
AMMD.U6.E3.PC1	The students are able to perform calculations by use of constants, variables, vectors and matrices in the simulation environment.

Table 23: Performance Criteria for the Element AMMD.U6.E3

3.7.4 Unit AMMD.U6 - Element 4: Modelling of Simple Systems, Solution of Linear Equation Systems

Acronym: AMMD.U6.E4

Element Title: Modelling of Simple Systems, Solution of Linear Equation Systems

Element Note:

This element gives an introduction and overview about the following aspects:

- You are able to develop simulation models of simple systems in the simulation software.
- You know the solution procedures of linear equation systems.
- You understand to define simulation processes for linear equations within the simulation environment and to perform variant studies and basic optimizations.

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
AMMD.U6.E4.PC1	The students are able to develop simulation models of simple systems in the simulation software.
AMMD.U6.E4.PC2	The students know the solution procedures of linear equation systems.
AMMD.U6.E4.PC3	The students understand to define simulation processes for linear equations within the simulation environment and to perform variant studies and basic optimizations.

Table 24: Performance Criteria for the Element AMMD.U6.E4

3.7.5 Unit AMMD.U6 - Element 5: Data Processing and Programming Structures

Acronym: AMMD.U6.E5

Element Title: Data Processing and Programming Structures

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the sequences of data processing in the simulation software.
- You can perform the required data processing steps in computational simulation.
- You understand the programming structures for the definition of tailored simulation models.

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
AMMD.U6.E5.PC1	The students a know the sequences of data processing in the simulation software.
AMMD.U6.E5.PC2	The students can perform the required data processing steps in computational simulation.
AMMD.U6.E5.PC3	The students understand the programming structures for the definition of tailored simulation models.

Table 25: Performance Criteria for the Element AMMD.U6.E5

3.7.6 Unit AMMD.U6 - Element 6: Model-Based Simulation of Mechatronics Systems

Acronym: AMMD.U6.E6

Element Title: Model-Based Simulation of Mechatronics Systems

Element Note:

This element gives an introduction and overview about the following aspects:

- You know how to operate with simulation models of mechatronics systems.
- You are able to define the required input- and output sequences.
- You are able to setup the corresponding simulation models and to perform the simulation tasks of different use-cases and examples.

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
AMMD.U6.E6.PC1	The students know how to operate with simulation models of mechatronics systems.
AMMD.U6.E6.PC2	The students are able to define the required input- and output sequences.
AMMD.U6.E6.PC3	The students are able to setup the corresponding simulation models and to perform the simulation tasks of different use-cases and examples.

Table 26: Performance Criteria for the Element AMMD.U6.E6

3.8 UNIT AMMD.U7 INTRODUCTION OF CONTROL ENGINEERING

Acronym: AMMD.U7

Title: Introduction of Control Engineering

Description:

Die training unit introduces into the field of automotive mechatronics and the boundary conditions of mechatronics product development, addressing:

- Notion of Control
- Feedback Control vs. Feedforward Control
- Basic Modelling and Simulation Concepts

Also the unit introduces and discussed the definition of PID-controllers and their application in different use-cases of automotive mechatronics systems.

And the unit finally treats the definition of simulation of feedback loops and their applications, as well as the set-up of simulation-based development of control systems.

3.8.1 Unit AMMD.U7 - Element 1: Notion of Control

Acronym: AMMD.U7.E1

Element Title: Notion of Control

Element Note:

This element gives an introduction and overview about the following aspects:

- You know about the basic definitions of control engineering.

- You have knowledge about the notations and the procedures applied in the development of control 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
AMMD.U7.E1.PC1	The students know about the basic definitions of control engineering.
AMMD.U7.E1.PC2	The students have knowledge about the notations and the procedures applied in the development of control systems.

Table 27: Performance Criteria for the Element AMMD.U7.E1

3.8.2 Unit AMMD.U7 - Element 2: Feedback Control vs. Feedforward Control

Acronym: AMMD.U7.E2

Element Title: Feedback Control vs. Feedforward Control

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the characteristics feedback control.
- You know the characteristics of feedforward control.
- You can apply and evaluate both approaches according to the actual requirements of a control system.

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
AMMD.U7.E2.PC1	The students know the characteristics feedback control.
AMMD.U7.E2.PC2	The students know the characteristics of feedforward control.
AMMD.U7.E2.PC3	The students can apply and evaluate both approaches according to the actual requirements of a control system.

Table 28: Performance Criteria for the Element AMMD.U7.E2

3.8.3 Unit AMMD.U7 - Element 3: Basic Modelling and Simulation Concepts

Acronym: AMMD.U7.E3

Element Title: Basic Modelling and Simulation Concepts

Element Note:

This element gives an introduction and overview about the following aspects:

- You understand the procedures of modelling control cycles in mechatronics systems.
- You know the simulation concepts of control systems.
- You are able to develop simulation models and to apply the proper algorithms for the simulation of control cycles of mechatronics 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
AMMD.U7.E3.PC1	The students understand the procedures of modelling control cycles in mechatronics systems.
AMMD.U7.E3.PC1	The students know the simulation concepts of control systems.
AMMD.U7.E3.PC1	The students are able to develop simulation models and to apply the proper algorithms for the simulation of control cycles of mechatronics systems.

Table 29: Performance Criteria for the Element AMMD.U7.E3

3.8.4 Unit AMMD.U7 - Element 4: Transfer Functions and Stability

Acronym: AMMD.U7.E4

Element Title: Transfer Functions and Stability

Element Note:

This element gives an introduction and overview about the following aspects:

- You understand the role of transfer functions in control systems simulation.
- You know stability criteria and how to define and process them.
- You are able to define suitable transfer functions and stability criteria in different use-cases of mechatronics systems control.

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
AMMD.U7.E4.PC1	The students understand the role of transfer functions in control systems simulation.
AMMD.U7.E4.PC2	The students know stability criteria and how to define and process them.
AMMD.U7.E4.PC3	The students are able to define suitable transfer functions and stability criteria in different use-cases of mechatronics systems control.

Table 30: Performance Criteria for the Element AMMD.U7.E4

3.8.5 Unit AMMD.U7 - Element 5: PID controllers

Acronym: AMMD.U7.E5

Element Title: PID controllers

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the requirements on and the different types of controllers in closed-loop control systems.
- You know the single elements of a PID controller and their behaviour and mathematical descriptions.
- You are able to define suitable PID controller for different use-cases in mechatronics systems and to perform simulation and optimization based on computational models.

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
AMMD.U7.E5.PC1	The students know the requirements on and the different types of controllers in closed-loop control systems.
AMMD.U7.E5.PC2	The students know the single elements of a PID controller and their behaviour and mathematical descriptions.

Performance Criterion	Evidence Check: The student can demonstrate
AMMD.U7.E5.PC3	The students are able to define suitable PID controller for different use-cases in mechatronics systems and to perform simulation and optimization based on computational models.

Table 31: Performance Criteria for the Element AMMD.U7.E5

3.8.6 Unit AMMD.U7 - Element 6: Simulation of Feedback Loops / Applications

Acronym: AMMD.U7.E6

Element Title: Simulation of Feedback Loops / Applications

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the methods and tools for definition of feedback loops in control systems.
- You are able to define feedback loops and to perform target-oriented simulations.
- You are able to design and perform complex simulations of mechatronics systems including feedback loops for different use-cases.

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
AMMD.U7.E6.PC1	The students know the methods and tools for definition of feedback loops in control systems.
AMMD.U7.E6.PC2	The students are able to define feedback loops and to perform target-oriented simulations.
AMMD.U7.E6.PC3	The students are able to design and perform complex simulations of mechatronics systems including feedback loops for different use-cases.

Table 32: Performance Criteria for the Element AMMD.U7.E6

3.9 UNIT AMMD.U8 ADVANCED SYSTEMS & COMPONENTS DESIGN

Acronym: AMMD.U8

Title: Advanced Systems & Components Design

Description:

Die training unit introduces into the field of automotive mechatronics and the boundary conditions of mechatronics product development, addressing:

- Mechatronics System Layout and Design
- Mechatronics System Simulation
- Sensor, Actuators and ECU Hardware Simulation and Optimization
- Application and Discussion based on a Project Work

Also the unit discusses investigations of control strategies in mechatronics systems.

And the unit finally applies the gathered knowledge of the training programme in selected use-cases based on a group-project work that includes all components of a typical automotive application.

3.9.1 Unit AMMD.U8 - Element 1: Mechatronics System Layout and Design

Acronym: AMMD.U8.E1

Element Title: Mechatronics System Layout and Design

Element Note:

This element gives an introduction and overview about the following aspects:

- You know the procedures, tools and methods of mechatronics system layout.
- You know about requirements definition of mechatronics system layout and the derivation of specifications for system design.
- You are able to apply the knowledge on an actual example of an automotive controller / embedded system development.

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
AMMD.U8.E1.PC1	The students know the procedures, tools and methods of mechatronics system layout.
AMMD.U8.E1.PC2	The students know about requirements definition of mechatronics system layout and the derivation of specifications for system design.

Performance Criterion	Evidence Check: The student can demonstrate
AMMD.U8.E1.PC3	The students are able to apply the knowledge on an actual example of an automotive controller / embedded system development.

Table 33: Performance Criteria for the Element AMMD.U8.E1

3.9.2 Unit AMMD.U8 - Element 2: Mechatronics System Simulation

Acronym: AMMD.U8.E2

Element Title: Mechatronics System Simulation

Element Note:

This element gives an introduction and overview about the following aspects:

- You are able to develop a simulation model for the target use-case.
- You are able define a simulation plan under consideration of the system specifications.
- You are able to perform functional simulation according to the specifications.

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
AMMD.U8.E2.PC1	The students are able to develop a simulation model for the target use-case.
AMMD.U8.E2.PC2	The students are able define a simulation plan under consideration of the system specifications.
AMMD.U8.E2.PC3	The students are able to perform functional simulation according to the specifications.

Table 34: Performance Criteria for the Element AMMD.U8.E2

3.9.3 Unit AMMD.U8 - Element 3: Sensor, Actuators and ECU Hardware Simulation and Optimization

Acronym: AMMD.U8.E3

Element Title: Sensor, Actuators and ECU Hardware Simulation and Optimization

Element Note:

This element gives an introduction and overview about the following aspects:

- You are able to select the proper sensors, actuators according to the systems simulation results and the target specifications.

- You are able to perform hardware simulation and optimization.
- You know how to apply the knowledge in a project example of an automotive use case.

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
AMMD.U8.E3.PC1	The students are able to select the proper sensors, actuators according to the systems simulation results and the target specifications.
AMMD.U8.E3.PC1	The students are able to perform hardware simulation and optimization.
AMMD.U8.E3.PC1	The students know how to apply the knowledge in a project example of an automotive use case.

Table 35: Performance Criteria for the Element AMMD.U8.E3

3.9.4 Unit AMMD.U8 - Element 4: Investigations of Control Strategies

Acronym: AMMD.U8.E4

Element Title: Investigations of Control Strategies

Element Note:

This element gives an introduction and overview about the following aspects:

- You how to set up a controller model for a selected use-case and mechatronics system design.
- You know to perform simulation for controller optimization.
- You know to programme a target microcontroller and how to perform tests for verification of the simulation results.

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
AMMD.U8.E4.PC1	The students know how to set up a controller model for a selected use-case and mechatronics system design.

Performance Criterion	Evidence Check: The student can demonstrate
AMMD.U8.E4.PC2	The students know how to perform simulation for controller optimization.
AMMD.U8.E4.PC3	The students know to programme a target microcontroller and how to perform tests for verification of the simulation results.

Table 36: Performance Criteria for the Element AMMD.U8.E4

3.9.5 Unit AMMD.U8 - Element 5: Application and Discussion based on a Project Work

Acronym: AMMD.U8.E5

Element Title: Application and Discussion based on a Project Work

Element Note:

This element gives an introduction and overview about the following aspects:

- You have learned about the complete procedure of automotive controller development, including requirements definition, derivation of specifications, HW and SW development, simulation-based controller optimization and system testing.
- You have knowledge about the different procedures in mechatronics systems development and you are able to define the proper processes, tools and methods.
- You know about functional testing and verification of mechatronics 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
AMMD.U8.E5.PC1	The students have learned about the complete procedure of automotive controller development, including requirements definition, derivation of specifications, HW and SW development, simulation-based controller optimization and system testing.
AMMD.U8.E5.PC2	The students have knowledge about the different procedures in mechatronics systems development and you are able to define the proper processes, tools and methods.
AMMD.U8.E5.PC3	The students know about functional testing an verification of mechatronics systems.

Table 37: Performance Criteria for the Element AMMD.U8.E5

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.

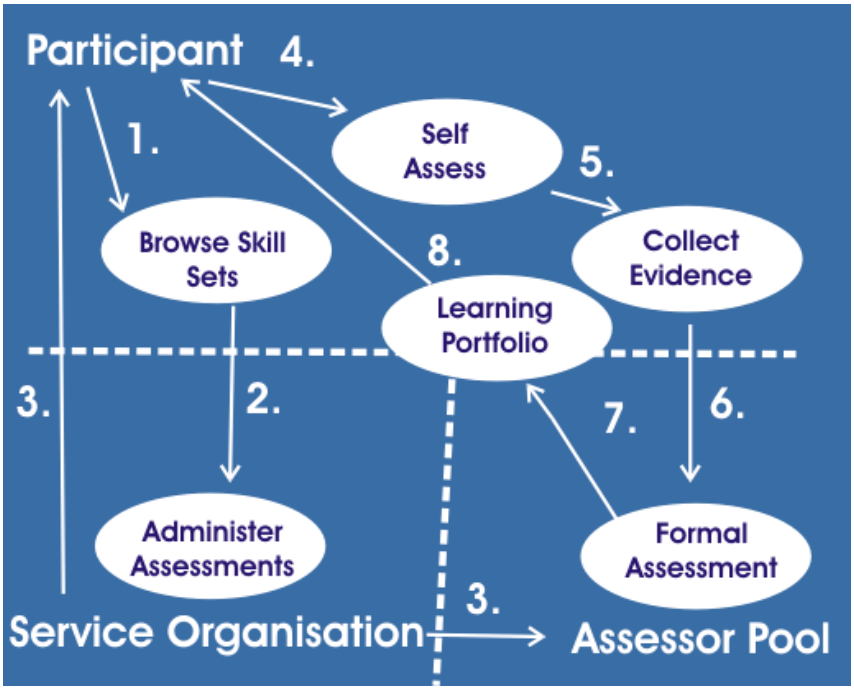
ECQA SKILLS ASSESSMENT MODEL

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

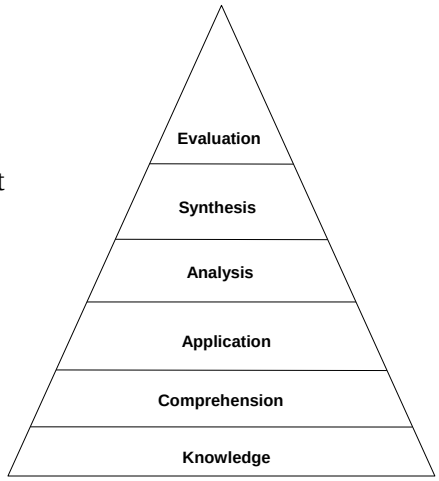
In most cases the same job role can be offered on different levels. e.g. IT Security Manager Basic Level (NVQ level 2), IT Security Manager Advanced level (NVQ Level 3), and IT Security Manager Expert Level (NVQ Levels 4 and 5).

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 • 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 - 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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