DRIVES

Development and Research on Innovative Vocational Education Skills

Predictive Maintenance Engineer

Job Role Skill Set

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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 Predictive Maintenance 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 Fig. 1):

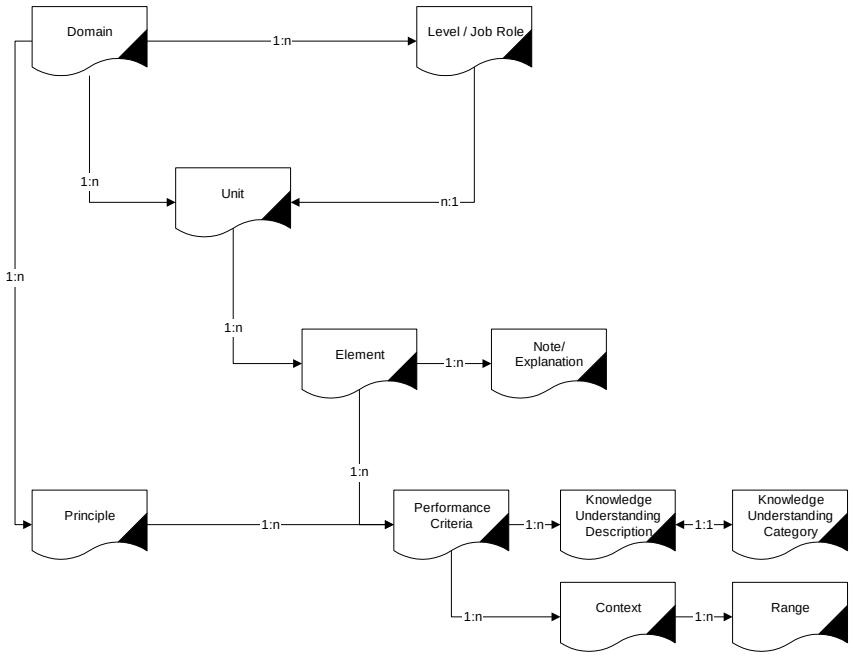

Figure 1 The Skill Definition Model (1:n = one to many relationship)

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 "PREDICTIVE MAINTENANCE 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 "Predictive Maintenance Engineer" has been designed.

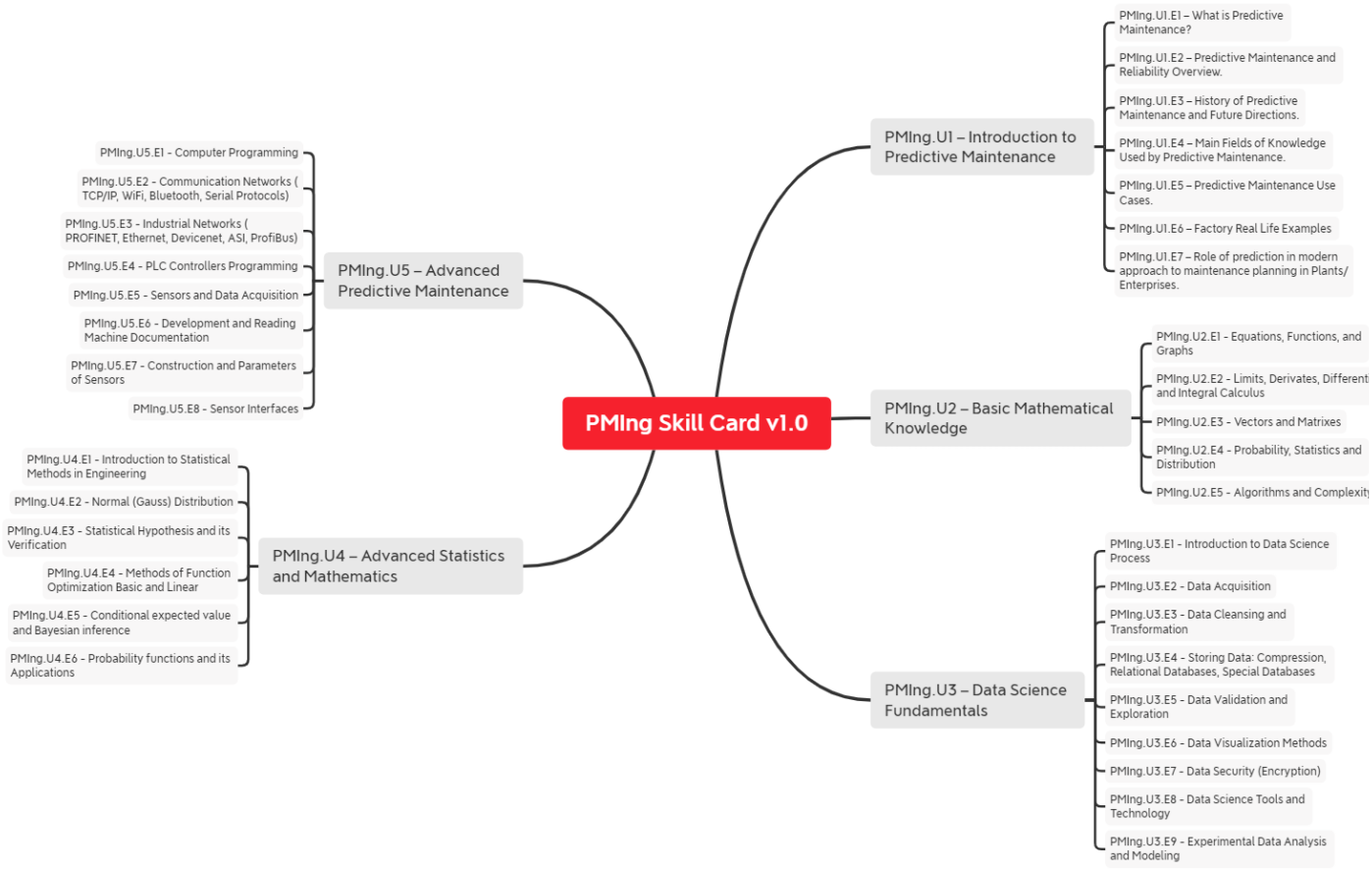

Fig. 2: The Skills Set for ECQA Predictive Maintenance Engineer

3.2 THE SKILLS DESCRIPTIONS – JOB ROLE PREDICTIVE MAINTENANCE ENGINEER

Domain Acronym: Engineering

Domain title: Maintenance

Domain Description:

Prediction, together with Reaction and Prevention is one of the Maintenance process base pillars. It is very important especially in automotive industry, where anticipate of malfunction allows us to be prepared and react immediately.

Job Role Acronym: PMIng

Job Role Title: Predictive Maintenance Engineer

Description:

The Skill card comprises the following thematic learning units

Unit 1 – Introduction to Predictive Maintenance

Unit 2 – Basic Mathematical Knowledge

Unit 3 – Data Science Fundamentals

Unit 4 – Advanced Statistics and Mathematics

Unit 5 – Advanced Predictive Maintenance

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3.3 UNIT PMING.U1 INTRODUCTION TO PREDICTIVE MAINTENANCE

Acronym: PMIng.U1

Title: Introduction to Predictive Maintenance

Description:

First Unit is an introduction to predictive maintenance methodology with description of classic and modern techniques. It consists from learning elements:

E1 What is Predictive Maintenance?

E2 Predictive Maintenance and Reliability Overview.

E3 History of Predictive Maintenance and Future Directions.

E4 Main Fields of Knowledge Used by Predictive Maintenance.

E5 Predictive Maintenance Use Cases.

E6 Factory Real Life Examples.

E7 Role of prediction in modern approach to maintenance planning in Plants/Enterprises.

3.3.1 Unit PMIng.U1 - Element 1: What is Predictive Maintenance?

Acronym: PMIng.U1.E1

Element Title: "What is Predictive Maintenance?"

Element Note:

This element describes idea of predictive maintenance based on definition, technologies and industry 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
PMIng.U1.E1.PC1	**Predictive Maintenance definition:** Student is able to define what is predictive Maintenance. Student understands reasons why predictive maintenance is used.
PMIng.U1.E1.PC2	**Maintenance methodology – predictive versus preventive:** Student knows how to recognise differences between predictive and preventive maintenance (also reactive)

Performance Criterion	Evidence Check: The student can demonstrate
	Student is able to classify different maintenance actions to proper group (preventive, reactive, predictive)
PMIng.U1.E1.PC3	**Technologies of prediction maintenance:** Student is able to classify predictive methods (destructive, non destructive tests) Student knows different of test methods. Student understands combination between prediction of failures and process efficiency.
PMIng.U1.E1.PC4	**Commercial software to provide predictive maintenance:** Student knows generally what kind of software can be used for predictive maintenance applications.
PMIng.U1.E1.PC5	**Industry Application:** Student knows in which industry prediction maintenance is applied. Student is able to list few examples of those industries.

Table 1: Performance Criteria for the Element PMIng.U1.E1

3.3.2 Unit PMIng.U1 - Element 2: Predictive Maintenance and Reliability Overview

Acronym: PMIng.U1.E2

Element Title: "Predictive Maintenance and Reliability Overview"

Element Note:

This learning element classify typology of machine failures, describe machine different work conditions and introduce students to theory of reliability with calculation of its base indicators.

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
PMIng.U1.E2.PC1	**Typology of machine failures:** Student is able to classify typology of machine failures Student knows different between them. Student understands character of failure root cause.

PMIng.U1.E2.PC2	**Materials and work conditions:** Student is able to describe different kind of materials (for machine parts) Student knows types of chronic factors with biggest impact for machine parts degradation. Student understands relationship between work condition and machine state.
PMIng.U1.E2.PC3	**Theory of reliability – introduction:** Student knows definition of reliability theory. Student is able to describe mathematic (statistic) elements of reliability theory. Student knows examples of reliability tools and techniques.
PMIng.U1.E2.PC4	**Reliability KPI's[1] in modern maintenance:** Student knows reliability KPI's, Students knows how to calculate reliability KPI's

Table 2: Performance Criteria for the Element PMIng.U1.E2

3.3.3 Unit PMIng.U1 - Element 3: History of Predictive Maintenance and Future Directions

Acronym: PMIng.U1.E3

Element Title: "History of Predictive Maintenance and Future Directions"

Element Note:

This learning element present history of predictive approach in maintenance departments of different industries. Describe actual situation and new trends in this area, especially for machines equipped with IoT interfaces and working in 4.0 factories.

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
PMIng.U1.E3.PC1	**Techniques of Predictive maintenance:** Student is able to list and describe techniques of predictive maintenance.

1 KPI – abbreviation of Key Performance Indicator

	Student knows different between them. Student understands how measured value impact machine failures.
PMIng.U1.E3.PC2	**Classic predictive algorithms and methods:** Student is able to describe classic predictive methods. Student knows how to interpretate data from trend.
PMIng.U1.E3.PC3	**Modern techniques and future directions:** Student is able to describe modern predictive methods. Student knows base of mathematic statistic. Student is able to describe what means industry 4.0 Student is able to describe new trends in data analysis.

Table 3: Performance Criteria for the Element PMIng.U1.E3

3.3.4 Unit PMIng.U1 - Element 4: Main Fields of Knowledge Used by Predictive Maintenance.

Acronym: PMIng.U1.E4

Element Title: "Main Fields of Knowledge Used by Predictive Maintenance."

Element Note:

This learning element shows students main areas of knowledge which is used to provide all activities according to predictive maintenance actions. It is essence of knowledge for students to achieve competencies of predictive maintenance expert. This learning element shows what kind of knowledge students will learn in next elements.

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**

PMIng.U1.E4.PC1	**Math theory for Predictive maintenance:** Student knows base mathematical functions and their trends analysis. Student knows base of probability theory. Student knows base of statistic theory.
PMIng.U1.E4.PC2	**Data analysis theory:** Student is able to list and describe base of statistic tools for data analysis. Student knows what is FFT[2].
PMIng.U1.E4.PC3	**Computer software and configuration:** Student is able to list and describe, what kind of software is needed to provide predictive maintenance. Student knows operating system and their network configuration tools.

Table 4: Performance Criteria for the Element PMIng.U1.E4

3.3.5 Unit PMIng.U1 - Element 5: Predictive Maintenance Use Cases

Acronym: PMIng.U1.E5

Element Title: "Predictive Maintenance Use Cases"

Element Note:

This learning element describe machine elements and components applied in automotive industry. Shows students classification of those elements and methods of their technical condition assessment.

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**

2 FFT – abbreviation of Fast Fourierr Transformation.

PMIng.U1.E5.PC1	**Automotive industry machine elements and components:** Student knows base type of machine components applied in automotive industry. Student is able to classify those elements.
PMIng.U1.E5.PC2	**Advance assessment of machine technical condition:** Student is able to list and describe methods of assessment. Student knows what statistical machine modelling is. Student is able to describe machine communication interfaces

Table 5: Performance Criteria for the Element PMIng.U1.E5

3.3.6 Unit PMIng.U1 - Element 6: Factory real life examples

Acronym: PMIng.U1.E6

Element Title: "Factory real life examples"

Element Note:

This learning element shows real life examples of predictive maintenance applications and tools. Production plant (factory) visit should be planned under this module.

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
PMIng.U1.E6.PC1	**Critical machine parameters monitoring examples** Student is able to describe example of prediction system, from gathering data to visualisation and analysiss. Student knows what is RCA[3] and can explain it.

3 RCA – abbreviation of Root Cause Analysis

	Student is able to describe example of ERP system and what kind of data it collect.

Table 6: Performance Criteria for the Element PMIng.U1.E6

3.3.7 Unit PMIng.U1 - Element 7: Role of prediction in modern approach to maintenance planning in Plants/Enterprises.

Acronym: PMIng.U1.E7

Element Title: "Role of prediction in modern approach to maintenance planning in Plants/Enterprises."

Element Note:

This learning element will show students aspect, what kind of benefits organisations can have using predictive maintenance approach. Describe the change from static to dynamic maintenance strategy based not only on scheduled prevention but rather on predictive analysis of machine actual condition.

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
PMIng.U1.E7.PC1	**Dynamic maintenance management:** Student knows about methods of planning in maintenance department. Student knows what kind of computer system are used in maintenance – ERP[4], CMMS[5].
PMIng.U1.E7.PC2	**Cost optimisation:** Student is able to describe kind of maintenance strategies. Student is able to describe methods of spare parts management.

4 ERP – abbreviation of Enterprise Resource Planning
5 CMMS – abbreviation of Computerised Maintenance Management System

PMIng.U1.E7.PC3	**Employees development:** Student is able to list and describe, what kind of competencies must have maintenance crew, to use predictive maintenance tools.

Table 7: Performance Criteria for the Element PMIng.U1.E7

3.4 UNIT PMING.U2 BASIC MATHEMATICAL KNOWLEDGE

Acronym: PMIng.U2

Title: Basic Mathematical Knowledge.

Description:

Second Unit is an introduction to basic mathematical knowledge which is important to provide predictive analysis.

E1 Equations, Functions, and Graphs.

E2 Limits, Derivatives, Differential and Integral Calculus.

E3 Vectors and Matrixes.

E4 Probability, Statistics and Distribution.

E5 Algorithms and Complexity.

3.4.1 Unit PMIng.U2 - Element 1: Equations, Functions and Graphs.

Acronym: PMIng.U2.E1

Element Title: "Equations, Functions and Graphs"

Element Note:

This element describes basic mathematical concepts such as equations, functions and graphs.

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
PMIng.U2.E1.PC1	**Equations:** Student is able to solve linear, simple polynomial, trigonometric, exponential and logarithmic equations.
PMIng.U2.E1.PC2	**Functions:**

Performance Criterion	Evidence Check: The student can demonstrate
	Student knows the formal function definition and is familiar with elementary functions such as polynomials, rational, trigonometric, exponential and logarithmic functions. Student is able to define multi-variable functions.
PMIng.U2.E1.PC3	**Graphs:** Student knows what is graph of the function and can draw it.

Table 8: Performance Criteria for the Element PMIng.U2.E1

3.4.2 Unit PMIng.U2 - Element 2: Limits, Derivatives, Differential and Integral Calculus

Acronym: PMIng.U2.E2

Element Title: "Limits, Derivatives, Differential and Integral Calculus"

Element Note:

This learning element explains the basic concepts of differential and integral calculus.

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
PMIng.U2.E2.PC1	**Limits:** Student knows the formal definition of limit and is able to calculate sequence limits.
PMIng.U2.E2.PC2	**Differential calculus:** Student knows the formal definition of derivative and is able to compute derivatives of elementary functions with single variable. Student can compute partial derivatives and directional derivatives.
PMIng.U2.E2.PC3	**Integral calculus:** Student knows the Riemman definition of integral and is able to compute integrals of elementary functions.

Table 9: Performance Criteria for the Element PMIng.U2.E2

3.4.3 Unit PMIng.U2 - Element 3: Vectors and Matrixes.

Acronym: PMIng.U2.E3

Element Title: "Vectors and Matrixes."

Element Note:

This learning element describes basic mathematical concepts of linear algebra.

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
PMIng.U2.E3.PC1	**Vectors and linear spaces:** Student knows the formal definition of vector, linear space and its base. Student is able to operate on vectors.
PMIng.U2.E3.PC2	**Matrixes and linear transformation:** Student knows the formal definition of linear transformation and is able to represent it as a transformation matrix.
PMIng.U2.E3.PC3	**Operations on vectors and matrixes:** Student is able to transform vectors using matrixes and change linear space base from one to another.
PMIng.U2.E3.PC4	**Eigenvalues and eigenvectors of linear transformations:** Student knows the formal definition of eigenvector and is able to bring the matrix to the diagonal form.

Table 10: Performance Criteria for the Element PMIng.U2.E3

3.4.4 Unit PMIng.U2 - Element 4: Probability, Statistics and Distribution.

Acronym: PMIng.U2.E4

Element Title: "Probability, Statistics and Distribution."

Element Note:

This learning element explains basic mathematical concepts of probability and statistics.

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
PMIng.U2.E4.PC1	**Probability:** Student knows the formal definition of probability for both finite and infinite elementary event space. Student is able to compute probability function for both discrete and continuous cases.
PMIng.U2.E4.PC2	**Distribution:** Student knows the formal definition of distribution, expected value, variance and cumulative distribution function. Student is able to compute expected values and variances both for discrete and continuous distributions.
PMIng.U2.E4.PC3	**Statistics:** Student knows the formal definition of statistics, significance level and statistical test. Student is able to test statistical hypothesis.

Table 11: Performance Criteria for the Element PMIng.U2.E4

3.4.5 Unit PMIng.U2 - Element 5: Algorithms and Complexity

Acronym: PMIng.U2.E5

Element Title: "Algorithms and Complexity"

Element Note:

This learning element describes mathematical concepts related to algorithms and complexity.

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
PMIng.U2.E5.PC1	**Algorithms:**

	Student is able to create block diagrams of algorithms.
PMIng.U2.E5.PC2	**Complexity:** Student knows the formal definition of asymptotic notation and its properties. Student is able to find asymptotic complexity function to given algorithm for both sequential and recurrence form.

Table 12: Performance Criteria for the Element PMIng.U2.E5

3.5 UNIT PMING.U3 DATA SCIENCE FUNDAMENTALS

Acronym: PMIng.U3

Title: Data Science Fundamentals.

Description:

Third Unit is dedicated to fundamentals of data science which are used in predictive maintenance.

E1 Introduction to Data Science Process

E2 Data Acquisition

E3 Data Cleansing and Transformation

E4 Storing Data: Compression, Relational Databases, Special Databases

E5 Data Validation and Exploration

E6 Data Visualization Methods

E7 Data Security (Encryption)

E8 Data Science Tools and Technology

E9 Experimental Data Analysis and Modelling

3.5.1 Unit PMIng.U3 - Element 1: Introduction to Data Science Process.

Acronym: PMIng.U3.E1

Element Title: “Introduction to Data Science Process”

Element Note:

This element describes information flow between sensors, applications and databases.

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
PMIng.U3.E1.PC1	**Databases:** Student knows different types of data and know how they are stored in database. Student has basic knowledge of compression methods and its application in databases.
PMIng.U3.E1.PC2	**Information flow process:** Student knows the formal definition of information and is able to describe information flow between different applications.

Table 13: Performance Criteria for the Element PMIng.U3.E1

3.5.2 Unit PMIng.U3 - Element 2: Data Acquisition

Acronym: PMIng.U3.E2

Element Title: "Data Acquisition"

Element Note:

This learning element describes methods of data acquisition.

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
PMIng.U3.E2.PC1	**Data formats:** Student knows how integers, floating numbers, binary strings, images, video and audio data are collected.
PMIng.U3.E2.PC2	**Acquisition process:** Student is able to insert collected data into database using SQL commands (case of relational databases). Student is able to insert collected data into special database (directories, files, indexes).

Table 14: Performance Criteria for the Element PMIng.U3.E2

3.5.3 Unit PMIng.U3 - Element 3: Data Cleansing and Transformation.

Acronym: PMIng.U3.E3

Element Title: "Data Cleansing and Transformation."

Element Note:

This learning element describes methods for digital data processing.

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
PMIng.U3.E3.PC1	**Data filtering:** Student is able to use methods of Digital Signal Processing to filter the data to get data without noise.
PMIng.U3.E3.PC2	**Signal recognition:** Student is able to search patterns in images and sound signals.

Table 15: Performance Criteria for the Element PMIng.U3.E3

3.5.4 Unit PMIng.U3 - Element 4: Storing Data: Compression, Relational Databases, Special Databases.

Acronym: PMIng.U3.E4

Element Title: "Storing Data: Compression, Relational Databases, Special Databases."

Element Note:

This learning element describes methods of data storing.

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
PMIng.U3.E4.PC1	**Compression:** Student knows methods for data compression and is familiar with their properties. Student is able to choose and apply the appropriate compression method to a given data set.

PMIng.U3.E4.PC2	**Relational databases:** Student knows the structure of relational database and is familiar with most popular implementations. Student is able to create database and its structure using SQL commands. Student is able to create basic SQL queries and perform database operations.
PMIng.U3.E4.PC3	**Special databases:** Student knows other types of databases (different than relational). Student is able to indicate in which cases it is worth using special purpose database.

Table 16: Performance Criteria for the Element PMIng.U3.E4

3.5.5 Unit PMIng.U3 - Element 5: Data Validation and Exploration.

Acronym: PMIng.U3.E5

Element Title: "Data Validation and Exploration"

Element Note:

This learning element explains how to explore and validate data stored in database.

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
PMIng.U3.E5.PC1	**Relational database exploration:** Student knows advanced syntax of SQL queries. Student is able to obtain very specific information from the database. Student knows the fundamentals of database indexing and is able to index some types of data.
PMIng.U3.E5.PC2	**Special database exploration:**

	Student knows how searching methods in special database works and what kind of algorithms can be used to find the right patterns.
PMIng.U3.E5.PC3	**Data validation:** Student is able to perform data validation process.

Table 17: Performance Criteria for the Element PMIng.U3.E5

3.5.6 Unit PMIng.U3 - Element 6: Data Visualization Methods.

Acronym: PMIng.U3.E6

Element Title: "Data Visualization Methods"

Element Note:

This learning element describes methods for data visualization and presentation.

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
PMIng.U3.E6.PC1	**Bases of vector and raster graphics:** Student knows what is the main difference in presentation data in the format of vector or raster graphics. Student is able to use proper applications to create vector and raster graphics in given quality.
PMIng.U3.E6.PC2	**Data readability:** Student knows how data should be presented to give right level of readability.
PMIng.U3.E6.PC3	**Data presentation formats:** Student knows different file formats to store graphics both in vector and raster format.

	Students knows technical requirements for the presentation of data on various types of media. Student is able to use proper informatics tools to present different types of graphic files.

Table 18: Performance Criteria for the Element PMIng.U3.E6

3.5.7 Unit PMIng.U3 - Element 7: Data Security (Encryption).

Acronym: PMIng.U3.E7

Element Title: "Data Security (Encryption)"

Element Note:

This learning element describes basic concepts of 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
PMIng.U3.E7.PC1	**Symmetric data encryption:** Student knows what is symmetric data encryption and is able to choose the right algorithms to encrypt data. Student is able to encrypt/decrypt data using application and development library.
PMIng.U3.E7.PC2	**Asymmetric data encryption:** Student knows the concept of cryptography with public key and is able to use application to generate key pair and encrypt/decrypt data.
PMIng.U3.E7.PC3	**Digital signatures:**

	Student knows the concept of digital signatures and hash functions. Student is able to use application to sign/verify digital signature.

Table 19: Performance Criteria for the Element PMIng.U3.E7

3.5.8 Unit PMIng.U3 - Element 8: Data Science Tools and Technology

Acronym: PMIng.U3.E8

Element Title: "Data Science Tools and Technology"

Element Note:

This learning element presents typical tools used in data science.

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
PMIng.U3.E8.PC1	**Spreadsheet:** Student is able to use advanced functions (including pivot tables) of spreadsheet for presentation and analysis of data.
PMIng.U3.E8.PC2	**Advanced applications:** Student is able to use advanced statistical software to verify hypothesis, analysis and data presentation.

Table 20: Performance Criteria for the Element PMIng.U3.E8

3.5.9 Unit PMIng.U3 - Experimental Data Analysis and Modeling

Acronym: PMIng.U3.E9

Element Title: "Experimental Data Analysis and Modeling"

Element Note:

This learning element describes methods of creating mathematical and digital models to carry out data analysis.

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
PMIng.U3.E9.PC1	**Mathematical modelling:** Student knows how convert real processes into mathematical formulas and relations. Student knows algorithms used in process modelling. Student is able to generate a system of functional dependencies that represent the modelled process.
PMIng.U3.E9.PC2	**Tools for modelling and analysis:** Student is able to use tools that support process of data modelling and analysis. Student is able to create simple tools and scripts to data modelling.

Table 21: Performance Criteria's for the Element PMIng.U3.E9

3.6 UNIT PMING.U4 ADVANCED STATISTICS AND MATHEMATICS

Acronym: PMIng.U4

Title: Advanced Statistics and Mathematics.

Description:

Fourth Unit is a part of learning material which introduce mathematic statistic into preventive maintenance process. In this unit, students will know some advanced statistical tools, which they will use to analyse historical machine data and predict their future behaviour.

Whole Unit consist of following elements:

E1 Introduction to Statistical Methods in Engineering

E2 Normal (Gauss) Distribution

E3 Statistical Hypothesis and its Verification

E4 Methods of Function Optimization Basic and Linear

E5 Conditional expected value and Bayesian inference

E6 Probability functions and its Applications

3.6.1 Unit PMIng.U4 - Element 1: Introduction to Statistical Methods in Engineering.

Acronym: PMIng.U4.E1

Element Title: "Introduction to Statistical Methods in Engineering"

Element Note:

This element describes, what kind of statistic methods and tools can be useful for engineering application. Especially those elements, which can be used for prediction data analysis.

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
PMIng.U4.E1.PC1	**Basic statistic parameters:** Student knows and is able to calculate simple statistic parameters for data set, like: mean, median, standard deviation.
PMIng.U4.E1.PC2	**Statistical Distributions:** Student knows different kinds of statistical distributions, and their graphic visualisations.
PMIng.U4.E1.PC3	**Software for statistical calculations:** Students can list different types of statistical software.
PMIng.U4.E1.PC4	**Basic data presentation:** Students are able how to present data and simple analyse it using tables and different kinds of graphs (like: histogram, bar chart, box plot etc.).

Table 22: Performance Criteria for the Element PMIng.U4.E1

3.6.2 Unit PMIng.U4 - Element 2: Normal (Gauss) Distribution

Acronym: PMIng.U4.E2

Element Title: "Normal (Gauss) Distribution"

Element Note:

This learning element will show the students what is a normal (Gauss) data distribution.

It shows how to build distribution graph and assess data according to their variation (if they fit the pattern or no). In this module student will know how to recognise data normality.

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
PMIng.U4.E2.PC1	**Data collecting:** Student is able to gather measured data and prepare it to present as normal distribution graph.
PMIng.U4.E2.PC2	**Different kinds of distributions:** Student know patterns of another data distribution examples (Chi-squared, Binomial, Exponential)
PMIng.U4.E2.PC3	**Normal distribution parameters:** Student is able to calculate and recognize, where on graph, are located values of median, mode and mean.
PMIng.U4.E2.PC4	**Data normalization:** Student understand data variation and how to quantify it to the normal data.
PMIng.U4.E2.PC5	**Advanced parameters of normal distribution:** Student understand and know concepts like: spread, probability area and 3sigma, according to normal distribution.

Table 23: Performance Criteria for the Element PMIng.U4.E2

3.6.3 Unit PMIng.U4 - Element 3: Statistical Hypothesis and its Verification

Acronym: PMIng.U4.E3

Element Title: "Statistical Hypothesis and its Verification."

Element Note:

This learning element will learn students, how to verify measured (gathered) data, analyse its variation and create hypothesis, based on this data distribution. Second part of this element is learning how to test this hypothesis and prove it, using statistical 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
PMIng.U4.E3.PC1	**Measured data variation:** Student knows how to represent measured data on diagram and understand variation of this data.
PMIng.U4.E3.PC2	**Special and common causes of variation:** Student is able to identify potential sources of data variation and quantify causes of them.
PMIng.U4.E3.PC3	**Identification of variation sources:** Student knows RCA tools helpful to identify, screening and verify causes of data variation.
PMIng.U4.E3.PC4	**Null Hypothesis:** Student know what is Null Hypothesis and is able to calculate probability p-value for normalized data, and decide of hypothesis result based on them.
PMIng.U4.E3.PC5	**Hypothesis testing trust level:** Student knows and understand what means 95% confidence boundaries, according to distribution of sample means.

Table 24: Performance Criteria for the Element PMIng.U4.E3

3.6.4 Unit PMIng.U4 - Element 4: Methods of Function Optimization Basic and Linear.

Acronym: PMIng.U4.E4

Element Title: “Methods of Function Optimization Basic and Linear”

Element Note:

This learning element will present students methods of mathematical function optimization. For predictive maintenance data analysis, student must know about two methods: basic and linear. This learning element must present equations and graphic representation of those two methods and explain difference between them.

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
PMIng.U4.E4.PC1	**Optimization definition:** Student can define what means Mathematical function optimization and where it can be applied according to industrial environment.
PMIng.U4.E4.PC2	**Extremum and trends:** Student knows and can calculate local function minimum or maximum and can define function trend based on it. Student understand how trend of function represent data variation and is able to explain machine/part behave based on this data.
PMIng.U4.E4.PC3	**Linear optimization:** Student understand how to define linear function for problem and can calculate minimum of waste or maximum of profit based on defined function example.
PMIng.U4.E4.PC4	**Optimization examples:** Student can list areas of decision-making process where linear programming can be applied, f.e.: finance, production, operating management, human resource etc.
PMIng.U4.E4.PC5	**Graphical method of linear optimization:**

	Student knows how to use graphical solution method for linear optimization.

Table 24: Performance Criteria for the Element PMIng.U4.E4

3.6.5 Unit PMIng.U4 - Element 5: Conditional expected value and Bayesian inference.

Acronym: PMIng.U4.E5

Element Title: "Conditional expected value and Bayesian inference"

Element Note:

This learning element allows students to know how to calculate probability of some problem occurrence, based on statistical data expectation and inference using Bayesian theory.

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
PMIng.U4.E5.PC1	**Expected value definition:** Student knows how to calculate expected value based on statistical data (historical) under defined condition.
PMIng.U4.E5.PC2	**Conditional probability:** Student understand and is able to explain difference between normal and conditional probability
PMIng.U4.E5.PC3	**Bayes probability calculation:** Student know how to calculate "a posteriori" probability according to Bayes equation.
PMIng.U4.E5.PC4	**Probability forecasting:** Student can explain difference between prior and posterior probability.

PMIng.U4.E5.PC5	**Bayesian prediction function calculation:** Student can calculate function of prior and posterior data distribution for Bayesian prediction.

Table 25: Performance Criteria for the Element PMIng.U4.E5

3.6.6 Unit PMIng.U4 - Element 6: Probability functions and its Applications

Acronym: PMIng.U4.E6

Element Title: "Probability functions and its Applications"

Element Note:

This learning element will show the Students few types of probability function, which can be used to work with statistical machine data. In this element student will now a difference, between probability distribution and probability density function. Also, in this module student will find explanation of discrete and continuous variables.

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
PMIng.U4.E6.PC1	**Basic probability functions:** Student knows and is able to explain basic terms of probability function, like: mode, support, head, tail, expected value, median, variance, standard deviation, skewness, symmetry and kurtosis.
PMIng.U4.E6.PC2	**Discrete functions:** Student knows and is able to list probability functions for discrete variables. F.e.: PMF (Probability Mass Function) or Frequency Distribution.
PMIng.U4.E6.PC3	**Continuous functions:**

	Student knows and is able to list probability functions for continuous variables. F.e.: PDF (Probability Density Function) or Cumulative Distribution Function.
PMIng.U4.E6.PC4	**Probability functions applications examples:** Student understand and can give some examples which kind of function are or can be used in Predictive Maintenance.

Table 26: Performance Criteria for the Element PMIng.U4.E6

3.7 UNIT PMING.U5 ADVANCED PREDICTIVE MAINTENANCE

Acronym: PMIng.U5

Title: Advanced Predictive Maintenance.

Description:

Fifth Unit is advanced part of whole module, where students learn how to: integrate physical measuring circuit with PC (data application), setup communication channel, and gather data from sensors. Last two elements describes actual trends in data calculation and analysis using modern devices and methods. Whole Unit consist of following elements:

E1 Computer Programming

E2 Communication Networks (TCP/IP, WiFi, Bluetooth, Serial Protocols)

E3 Industrial Networks (PROFINET, Ethernet, Devicenet, ASI, ProfiBus)

E4 PLC Controllers Programming

E5 Sensors and Data Acquisition

E6 Development and Reading Machine Documentation

E7 Construction and Parameters of Sensors

E8 Sensor Interfaces

3.7.1 Unit PMIng.U5 - Element 1: Computer Programming.

Acronym: PMIng.U5.E1

Element Title: “Computer Programming”

Element Note:

This element describes basic of computer programming, which allows student to create simple algorithms for data gathering and processing. In this element, student learns basic programming in C++, VBApp and also base of microcontrollers programming.

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
PMIng.U5.E1.PC1	**C++ basic of programming:** Student knows C++ language data types, Student is able to create procedures & functions, Student can create data arrays, store data in them and provide operations on data tables.
PMIng.U5.E1.PC2	**Operating systems:** Student knows operating systems like: Windows Xp, 7, 10 and server editions, Student is able to work under Linux distributions in X-Window environment, Student can create and work with virtual machines (Vmware), Student knows basic rules of computer systems Maintenance,
PMIng.U5.E1.PC3	**Visual Basic for Application in MS Office (Excel and Access):** Student is able to present gathered data in tables and graphs, Student knows how to create database queries and macros.
PMIng.U5.E1.PC4	**Microcontrollers programming examples – (Arduino):** Student is able to connect controller to PC, via RS232 and setup transmission, Student knows how to connect sensors to microcontroller and read signals from them.
PMIng.U5.E1.PC5	**Programming in GUI[6] environment:** Student is able to create simple widget application with data logging, processing and trend presentation,

Table 27: Performance Criteria for the Element PMIng.U5.E1

6 GUI – abbreviation of Graphic User Interface.

3.7.2 Unit PMIng.U5 - Element 2: Communication Networks (TCP/IP, WiFi, Bluetooth, Serial Protocols)

Acronym: PMIng.U5.E2

Element Title: "Communication Networks (TCP/IP, WiFi, Bluetooth, Serial Protocols)"

Element Note:

This learning element shows students which kind of communication standards and protocols are used for data exchange between electronic devices.

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
PMIng.U5.E2.PC1	**Communication networks basic information:** Student can classify different networks like LAN and WAN and describe their topologies. Student can describe Ethernet standard, especially: - IP adressing, - TCP port configuration, - Cables, sockets and plugs,
PMIng.U5.E2.PC2	**Wireless networks:** Student can classify and describe different of radio network standards and their applications.
PMIng.U5.E2.PC3	**Internet infrastructure examples:** Student is able to describe examples of network infrastructure devices like PC servers, data hubs and Switches,

Table 28: Performance Criteria for the Element PMIng.U5.E2

3.7.3 Unit PMIng.U5 - Element 3: Industrial Networks (PROFINET, Ethernet, Devicenet, ASI, ProfiBus).

Acronym: PMIng.U5.E3

Element Title: "Industrial Networks (PROFINET, Ethernet, Devicenet, ASI, ProfiBus)."

Element Note:

This learning element describe few most popular standards of industry networks, with examples and explaining differences between them.

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
PMIng.U5.E3.PC1	**Industrial communication most popular standards:** Student is able to name several types of industrial networks and describe their topology and configuration.
PMIng.U5.E3.PC2	**Physical layer equipment:** Student is able to recognize physical elements like cables, sockets and plugs from different types of network.

Table 29: Performance Criteria for the Element PMIng.U5.E3

3.7.4 Unit PMIng.U5 - Element 4: PLC Controllers Programming

Acronym: PMIng.U5.E4

Element Title: "PLC Controllers Programming."

Element Note:

This learning element shows basic information about PLC programming. Classify most popular PLC families and other cooperative devices, like HMI panels or remote I/O modules.

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
PMIng.U5.E4.PC1	**Most popular PLC families:** Student is able to classify most popular families of PLC and name software for these devices.

PMIng.U5.E4.PC2	**Hardware PLC in details:** Student is able to recognize physical plc elements, name them and describe functions. Especially according to I/O modules, their signals and communication methods. Student knows how to create simple PLC (ladder) program to read data from sensor and execute some calculation on this data.
PMIng.U5.E4.PC3	**HMI devices:** Student is able to classify devices and describe them, based on acronyms HMI, MMI and SCADA
PMIng.U5.E4.PC4	**OPC software:** Student knows what kind of software is necessary to gather data from PLC via communication channel. For different PLC families. Student is able to connect and read data, from PLC to MS Excel or created widget application.

Table 30: Performance Criteria for the Element PMIng.U5.E4

3.7.5 Unit PMIng.U5 - Element 5: Sensors and Data Acquisition.

Acronym: PMIng.U4.E5

Element Title: "Sensors and Data Acquisition"

Element Note:

This learning element classify different types of sensors and data acquisition/detection devices. After this module student should know what type of sensor can be applied to detect objects or measure physical values.

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**

PMIng.U5.E5.PC1	**Types of sensors in industrial applications:** Student can classify and recognizes types of sensors like digital (safety, object presence, impulse) and analog (value of temperature, humidity, vibration, speed, frequency, current, voltage etc.)
PMIng.U5.E5.PC2	**Physical values measure sensors:** Student is able to recognize and classify different types of sensor according to physical value and data character, which can be applied on machine. Student understand differences between sensor signal levels and its nature.
PMIng.U5.E5.PC3	**Vision systems and sensors:** Student knows modern types of smart sensor, based on shape recognition and graphic processing.

Table 31: Performance Criteria for the Element PMIng.U5.E5

3.7.6 Unit PMIng.U5 - Element 6: Development and Reading Machine Documentation.

Acronym: PMIng.U5.E6

Element Title: "Development and Reading Machine Documentation"

Element Note:

During this module students will learn how work with machine documentation. What is a standard for different types of documents and how to proceed with changes according to standards and law regulations.

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
PMIng.U5.E6.PC1	**Types and standard of machine documentation:** Student must know how to classify machine documentation and where looks for requested element.
PMIng.U5.E6.PC2	**Mechanical documentation:**

	Student understand from which part (elements) consist mechanical documentation and is able to recognize its completeness.
PMIng.U5.E6.PC3	**Electrical documentation:** Student understand from which part (elements) consist electrical documentation and is able to recognize its completeness.
PMIng.U5.E6.PC4	**Pneumatic documentation:** Student understand from which part (elements) consist pneumatic documentation and is able to recognize its completeness.
PMIng.U5.E6.PC5	**Documentation procedures:** Student understand how to proceed changes in machine documentation. Student knows international symbols. Student knows rules how operate with documentation according to CE rules and local registrations.

Table 32: Performance Criteria for the Element PMIng.U5.E6

3.7.7 Unit PMIng.U5 - Element 7: Construction and Parameters of Sensors

Acronym: PMIng.U5.E7

Element Title: "Construction and Parameters of Sensors"

Element Note:

This learning element shows students construction of different types of machine sensors. During this module student will also know how different sensors looks on schematic and how to connect it to input interface.

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
PMIng.U5.E7.PC1	**Digital sensor construction:** Student is able to recognize different types of digital sensors and describe methods of object detection.

PMIng.U5.E7.PC2	**Analog sensor construction:** Student is able to recognize different types of analog sensors and describe methods of signal measure. (f.e. vibration, humidity etc.)
PMIng.U5.E7.PC3	**Sensor communication standards:** Student knows how to connect different sensors for proper type of input module.

Table 33: Performance Criteria for the Element PMIng.U5.E7

3.7.8 Unit PMIng.U5 - Element 8: Sensor Interfaces

Acronym: PMIng.U5.E8

Element Title: "Sensor Interfaces"

Element Note:

This learning element describe standards of sensor interfaces and measuring channels types. It also shows different examples of connection sensors to data logging device.

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
PMIng.U5.E8.PC1	**Sensor signal types:** Student is able to classify different sensor signal types and characters according to kind of sensor.
PMIng.U5.E8.PC2	**Sensor wires, plugs and sockets:** Student is able to recognise sensor connection wires.
PMIng.U5.E8.PC3	**Connection examples:** Student knows how to connect different types of sensor to proper input module.

PMIng.U5.E8.PC4	Sensors measuring channel: Student understand signal scaling in data collection system. Student is able to explain how work signal transducer and what way analog, or current signal is transferred to digital form.

Table 34: Performance Criteria for the Element PMIng.U5.E8

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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.

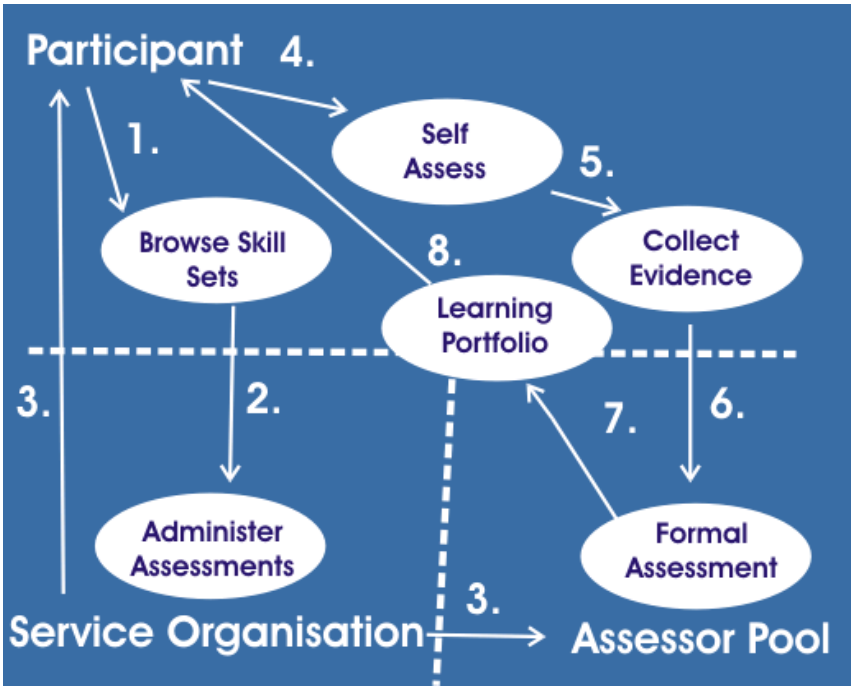
ECQA SKILLS ASSESSMENT MODEL

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

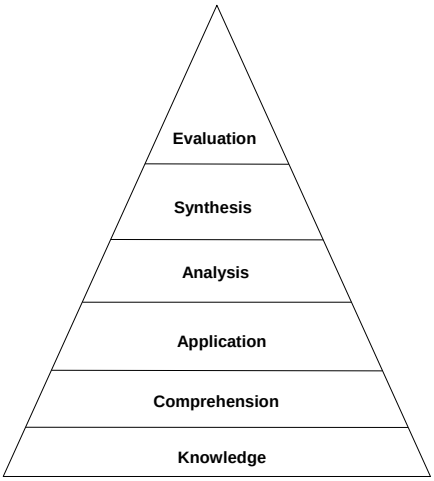
In most cases the same job role can be offered on different levels. e.g. IT Security Manager Basic Level (NVQ level 2), IT Security Manager Advanced level (NVQ Level 3), and IT Security Manager Expert Level (NVQ Levels 4 and 5).

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.

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