Ref. Ares(2022)8295801 - 30/11/2022

ENGINE

ZERO-DEFECT MANUFACTURING FOR GREEN TRANSITION IN EUROPE

HORIZON-CL4-2021-TWIN-TRANSITION-01-02:

Zero-defect manufacturing for green transition in Europe

Grant Agreement n° 101058179

D7.1: Skills requirements and specifications

Lead Author: Ilze Svalbe, VALTEH

with contributions from:
Dace Careva, VALTEH
Andris Freimanis, VTT
Tero Frondelius, WAR
Filippo Rossetto, ABS
Carlo Menegozzo , SIFR
Juho Könnö, UOULU
Tommi Helander, NOME

Reviewed by
Anssi Laukkanen, VTT

Deliverable nature	Report
Dissemination level	PU
Contractual delivery date	30.11.2022
Actual delivery	30.11.2022
version	1.0

Version History

Version	**Date**	**Editors**	**Description**
0.1	12.10.2022	AF	Initial version
0.2	12.10.2022	IS, DC	Draft version
0.3	21.11.2022	CM, FR, TH, JH	Draft version
0.4	29.11.2022.	IS, DC, JH	Draft version
1.0	30.11.2022	IS, DC, CM, FR, TH, JK, JH	Submitted version

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Abstract

ENGINE developments are split into three parts – data, software, and hardware. This deliverable combines (1) current training practices of SIFR, ABS, WAR, WIT, and institutions outside of the consortium, (2) materials for factory workers - obtained information from WP2, WP3, and WP4 about data, software, and hardware specifications, steps as will lead to curriculum development, (3) skills website, (4) materials for product design engineers, (5) industry-oriented workshops.

Publishable Summary

The green and digital transitions are creating demand for new skills, with over 70% of companies reporting access to talent as an obstacle to new investment. Moreover, the European Commission has estimated that between 37% to 69% of jobs in the EU could be partly automated in the future. People need retraining or upskilling to work with modern technologies, so they would fall out of the labor pool less. Therefore, the development of up-to-date training and upskilling materials is necessary to ensure that manufacturing plant personnel and new trainees have skills for a job.

Additionally, the uptake of new modeling tools in the industry can be slow because engineers may not have the skills to translate industry problems into computational modeling workflows, and modeling results back to industry-ready solutions.

ENGINE tackles this issue with two approaches. First, VALTEH develops training and upskilling to endow manufacturing line workers with skills to work with the ENGINE system. Here, the challenge is to determine the direct training points, or training content, as early as possible during the development of the system, to create high-quality and easy-to-understand training content.

Second, in collaboration with VALTEH, UOULU is developing training materials for engineers currently working in industry and university engineering students to demonstrate how to translate industry problems into computational modeling workflows.

Table of Contents

Deliverable Content

Deliverable 7.1 Skills requirements and specifications understand the current state of development of the ENGINE system and the essential need to define users and usage scenarios, which would further allow us to identify potential training points and tentatively outline more specific types of training materials and training methods. Best training practices in IND partners have been collected, and a plan has been defined for the primary needs of an interactive website (learning management system) and system testing courses. Collected information on Materials for product design engineers.

It is split into four parts: (1) current training practices of SIFR, ABS, WAR, and WIT, (2) Materials for factory workers - information obtained from WP2, WP3, WP4 about data, software, and hardware specifications, steps on how to develop the curriculum, (3) skills website, (4) materials for product design engineers, industry-oriented workshops.

Degree Of Progresses

This document complies with 100% of the expected degree of progress.

Dissemination Level

The following Deliverable in ENGINE has a “PU” Dissemination level.

1. Good Training Practices in Production Plants

In companies, the issues of employee development and training should not be seen as a short-term increase in competencies and employee motivation, but also as a far-reaching strategic tool for ensuring the sustainability of the company in the long term.

When planning ENGINE system training, it is essential to realize that the time and financial resources invested in each employee's training will help companies increase their efficiency. If, for example, training (learning) is an equal part of business processes, it is predominant to define clear criteria for the evaluation of training (learning) and a methodology for measuring the impact of training (learning) benefits and business outcomes.

The ENGINE system is at the early stages of development, which complicates the immediate identification of learning needs and the planning of practical results and subsequent processes.

VALTEH has gathered the experience of training employees of metalworking companies (partners ABS, SIFR), we plan to get a broader picture during a face-to-face visit to ABS and SIFR companies in M8 during the ENGINE GA.

1.1. ABS Training Experience

In 2021, ABS employees received 20,000 hours of training in technical and soft skills. The training process is organized by the HR representative of the company together with the personnel manager or director of the enterprise and is based on the job descriptions and training needs created by the health and safety department. Training is carried out depending on the position of each employee. To provide an evaluation system, ABS use metrics associated with a systematic assessment of the manufacturing enterprise, which compares professional skills and abilities for each job description. Each employee is evaluated on two factors Y (technical skills) and X (ABS core values such as sustainability, innovation, caring for other employees, etc.).

ABS's standard choice is online training or on-site training in person but the number of places for face-to-face training is limited. During the COVID-19 pandemic, in-person training was not possible, but there were training opportunities outside the production premises. ABS uses the home page of the learning environment system, where an employee can log in and enter the information about the received training, like an archive for data storage. There is no internal learning management system. Information about the planned training is sent to the employee by e-mail or brought to the attention of the employee's shift or direct supervisor. 90% of employees have a work e-mail; if there is none, then the information should be given orally or in written (printed) form. ABS is still collecting data, but in this phase, it is predicted that ENGINE training will be needed only in the areas of Quality, production, and process engineers in ENGINE system training.

1.2. SIFR Training Experience

In SIFR, employee training is planned in two main directions, which are related to the direct work of the employee and the other with additional skills that are needed secondarily, for example, language, and computer skills courses. The SIFR matrix evaluates the employees in both hard (technical knowledge directly related to work tasks) and soft (team building, motivational, behavioral) skills. The skills of the employees are determined according to the matrix, which already defines the skills and knowledge required for the profession. Depending on the direction of training, the HR specialist decides who will conduct the training, whether it will be an employee from the company or an outsourced specialist. An employee can propose the training of the courses he needs, and his direct supervisor evaluates the need and makes the final decision. Partner SIFR plans to dedicate 8,000 hours to the training of all production plant employees in the next year (2023). Covid 19 pandemic affected training plans for the last couple of years (2019-2022).

SIFR does not have a learning environment system, but some courses might have one, depending on the type of the course (the platform is made available by the supplier of the course). Some training is done face-to-face; others are made remotely with a platform.

Only office workers and department managers have work e-mails in SIFR; other employees do not have work e-mails. Employees receive essential information about the planned training from their supervisor.

Currently, ENGINE involves employees who do not directly work on metalworking, but HR, finance and marketing, engineering, and quality office staff. Based on the following stages of the project's development, the operators will be involved and trained in working with the solutions/system created in ENGINE.

1.3. WAR/ WIT Training Experience

WAR People Strategy helps the company and its businesses to achieve their business goals and ambitions by translating our strategy, The Wärtsilä Way, into people priorities. These priorities are aimed at ensuring that HR, together with the Businesses, have the workforce effectiveness capable of developing our organisation and its competences to reach our targets and bring our purpose to life.

At WAR, equal opportunities and opportunities for professional and personal growth are core principles. We empower employees by providing self-paced learning, and by encouraging them to drive their own career paths to stay relevant in a rapidly changing business environment. Learning on the job, self-learning, mentoring, coaching, and job rotation are integral to the development of knowledge and competence within the company. Whilst employees are given formal classroom learning opportunities at all organisational levels, from induction for new employees to learning programmes for the company's top executives, virtual and informal learning opportunities are of growing importance, and are in line with the 70/20/10 learning principles. On average WAR spent 357 euros per employee for traditional training purposes in 2021.

2. Materials for Factory Workers

The training and upskilling materials will focus on usability, interaction, and integration of diagnostics and modeling tools developed in WP3 and WP4. Moreover, they will show how to integrate them into existing workflows on the manufacturing plant floor.

VALTEH is planning 2-3 modules, but currently, that cannot specify the topics or the number of study modules.

To create training materials for factory workers, it is first necessary to see the overall picture of the ENGINE system (Table no. 1) and to understand which of the stages/activities of the system will require the involvement of human resources. Currently, the main ENGINE data flow is defined, which consists of the phases of the metalworking cycle from Continuous casting to Fatigue criterion development, but currently, there is not enough information to realize the real impact of human work on the ENGINE system, which will require training.

Within the work packages of WP2, WP3, and WP4, it is necessary to define potential users and usage scenarios, which can probably be more precisely defined as soon as the metal testing and actual data extraction are completed.

VALTEH from WP2, WP3, and WP4 primarily need to obtain the following information (Table no. 2):

- A specific phase of ENGINE data flow (e.g., Machining);
- WP involvement (e.g., WP2);
- The Concern involved (e.g., WAR);
- Usage scenario (e.g., Machine shop usage scenario);
- User/ Job title (e.g., CNC machining operator or team leader);
- Task/ Action (e.g., A) CNC machining operator or team leader – needs to make green/red decision on a specific part (clear indicator));
- Subtask;
- Other users involved? (Yes (Job title/ Task)/ No);
- What does the employee work with? (e.g., specific hardware, software);
- Need training? (Yes/Possible/No).

And further steps can be taken to reach the planning and creation of training content, where the already involved partners (e.g., NOME, ADV, VTT, and other partners) will define the Content type, Training content, Content Format, etc. Below, Figure 1 shows the process of defining and creating materials for factory workers

Nome will provide UI for factory workers to use a vibration / sound measurement system and short instructions on use.

At the first phase test materials are machined in the UOULU machining center and instructions. UOULU works have to be trained to guarantee 100% traceability of fatigue rods, the time of machining, etc. A template has to be created with WP4 partners (UOULU, GBW, WAR, and Nome). A template is used for material tracking purposes.

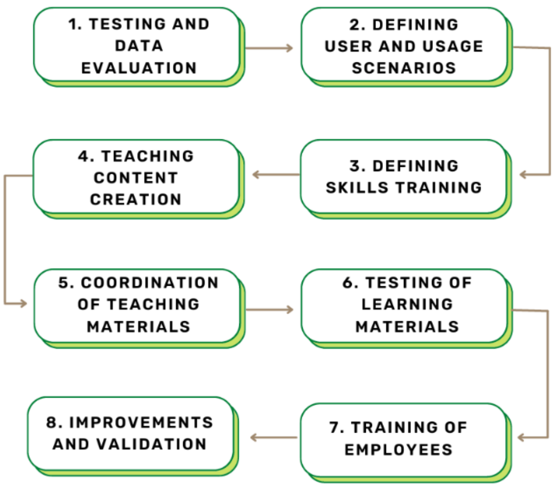

Figure 1. The process of defining and creating materials for factory workers.

2.1. WP2 Progress and Results

Within the framework of WP2, the "ENGINE exchange" software (cloud platform) will be developed, in which all data from various devices will be collected and delivered to the end-user companies (ABS, SIFR, WAR/WIT) and their employees. Potential users and usage scenarios have been defined to provide a preliminary understanding of ENGINE exchange data flow from various production processes. Defined users and usage scenarios are currently not usable for planning training content for employees, as they do not reflect the involvement of end users but form an initial understanding of the structure of the system and its use. Users and usage scenarios should be clarified by all project partners to find out more precisely what will be the direct or indirect involvement of each employee in working with the ENGINE system. The leader of WP2 mentions that currently there is a clear path as to how the data reaches the system, but it is not known how many end consumers of the data will be and how this data will be presented to the user/s in the production plant in the working environment according to their role (machine operator, maintenance manager, technical manager, etc.). M6, among all working groups, needs to define what data will be obtained and used in the optimization of metalworking production processes, but this will most likely be possible when the initial testing of metal bars with sensors within WP3 and WP4 starts. Knowing this final data can define more precise users and usage scenarios, going through all stages of the data flow of the ENGINE system. A potential deadline for defining such scenarios is M7, after the visits to the ABS and SIFR factories, because then it would be possible to see the factories in operation.

Talking about the process of work with ENGINE exchange, it is not yet clear how it will directly interact with end users, reporting the obtained data reports, after which the employee will decide on how to proceed. Expect that there will be training, but its volumes and types cannot be predicted. Provisionally, it could be based on online training in webinars and video format, explaining how the system works, how to access it, and how to download the necessary data from the dashboard. Users of the software will have multiple roles here to access the ENGINE exchange platform directly. It is important for the user to receive the ENGINE exchange software with real or factory test environment data before the platform training to have a better idea.

ADV's partner mentions from experience that the user prefers online sessions with the possibility to ask questions, even though contextual help is integrated into the software. The advantages of the cloud platform are that the employee does not have to perform the installation, and the links between the sensors and the ENGINE system will be provided by the entrepreneurs, which means that the use of the system will be more accessible to employees of production plants without prior IT education.

2.2. WP3 Progress and Results

The activities of the work package contribute to the materials for factory workers only indirectly, i.e., the tools and toolsets of WP3 are for research and development type activities, and in terms of the ENGINE system they are used to provide the ENGINE capabilities via user interfaces provided by WP2, but are not to be used by the end users themselves directly.

2.3. WP4 Progress and Results

Within WP4 (ENGINE hardware), the main activities will be focused on sensor development and measurement data gathering. Data will be collected from sensors, production machinery, and factory automation and used for recognizing material defects or manufacturing processes causing defective products. AI (ARTIFICIAL intelligence) will be used for recognizing abnormalities and analyzing root causes. WP4 will utilize both existing measurements such as ultrasonic inspections at Wärtsilä production, and data from sensors developed during the project (vibration and sound measurements of the machining center). The obtained data from the sensors, machining centers, and factory automation will be collected by the cloud system; this information will be used for AI.

NOME will carry out two phases of test measurements. In phase 1. The vibration and sound measurement system and sensors are used in the test environment at the University of Oulu CNC lathe. A local measuring system is used to get vibration and sound data during the machining of test bars. Some information is collected directly from the lathe using the MTConnect interface, and some information is gathered by hand. Measured data is later used to find correlations between vibration/sound data to surface roughness and fatigue test results of test bars. This phase requires some instructions and skills development for the machining center operator (UOULU) and engineers at GBW:

- Instructions to operate measuring system in error conditions (machining center operator, UOULU);
- Instructions on which information should be collected before, during, and after machining (sheets or UI where data is collected);
- Instructions on which information/test results to be delivered and how from fatigue and surface roughness tests (test engineer GBW).

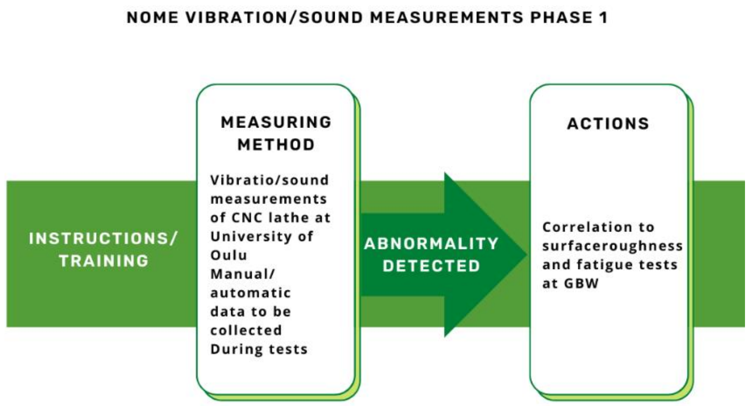

Figure 2. Nome vibration and sound measurements phase 1.

In phase 2. the vibration and sound measurement system will be tested at the Wärtsilä Vaasa production environment. Machining center operators should have basic knowledge of how to act if the measurement system indicates failure. Also, depending on how automated the measuring process is there might be a need to collect some parameters by hand.

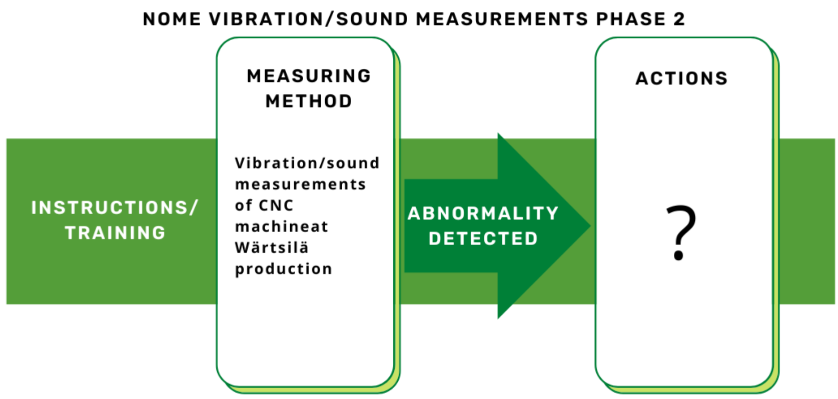

Figure 3. Nome vibration and sound measurements phase 2.

For Nome's engineer's basic knowledge/instructions on how to remotely operate the monitoring unit and what to do if the measuring unit fails to operate:

- Instructions to operate measuring system in error conditions (machining center operator WAR).
- Instructions on which information should be collected before, during, and after machining (sheets or UI where data is collected).
- Instructions on which information/test results to be delivered and how from fatigue and surface roughness tests (test engineer GBW).

Finally, after the project, if it is seen that phenomena causing deviations in machining are possible to be identified by using measuring methods, it should be thought how this information is used. AI-recognizing tools might be in a key role in making the identification and sometimes corrective actions might be automated but probably it involves human work as well.

In a later phase, the pilot system will be installed and implemented in WAR and ABS production, we envisage instructions that will be useful for machine operators, the current plan can be seen in Figure 4 and Figure 5.

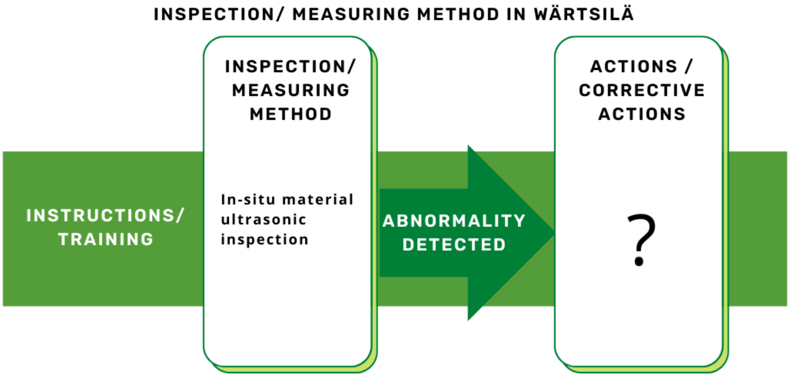

Figure 4. Inspection/ measuring method in Wärtsilä.

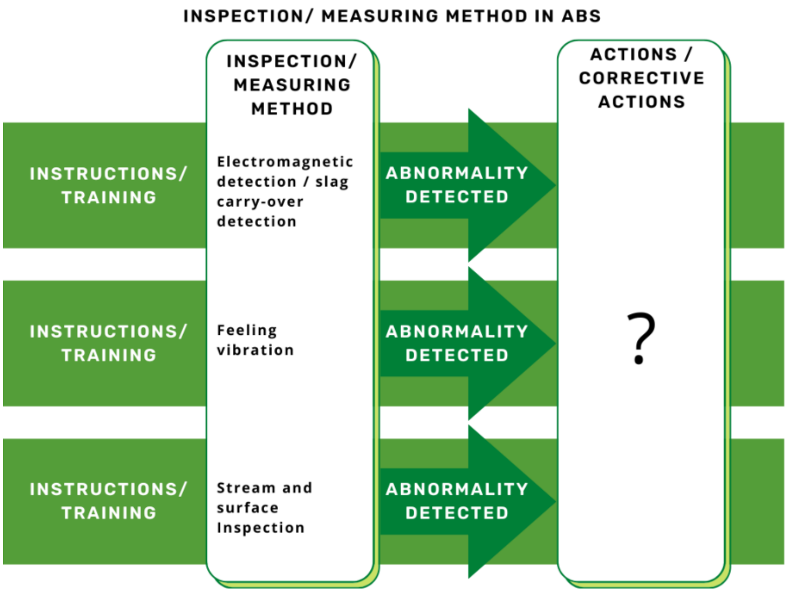

Figure 5. Inspection/ measuring method in ABS.

During M5, within the framework of WP4, it is not possible to name all potential training users and scenarios because it is not clear what measurement methods will be used by SIFR partners.

Currently (M5), WP4 can specify material and machining inspection methods, hardware/software, and potential testing time, see Appendix Table 6 Planned times for metal inspection/measurement.

	Inspection/ measuring method	Equipment	Scheduled dates for testing	Provider	The factory where this will be implemented
1.	**In-situ material ultrasonic inspection**	Olympus material ultrasonic inspection machinery	TBA	WAR	WAR
2.	**Machine center vibration measurements**	Nome nmas vibration measurement system	The first phase at UOULU M6-10, the second phase at Wärtsilä production after month 24	Nome	UOulu/WAR
3.	**Feeling vibration**	Made by operators	Currently, M5, done in ABS	ABS	ABS
4.	**Stream and Surface Inspection**	Made by operators	Currently, M5, done in ABS	ABS	ABS
5.	**Immersion UT tests**		ABS laboratory	ABS	ABS

2.4. Steps To Get to the Learning Content

1. **Define WP2-WP4 ENGINE system users and usage scenarios. I**n this step, can determine the actual involvement of people in working with the ENGINE system, understanding whether it is one or more operations with a specific device/program, and whether and to what extent prior training or a simple manual is required.

This stage will clarify (Table no. 3):

1.1. Which production facilities (SIFR, ABS, WAR, WIT) will be involved, in the testing equipment and processes used within the ENGINE system. **WAR, ABS, and UOULU will be involved in testing equipment. The SIFR part is not clear.**

1.2. Target audience/ positions of employees who will work directly or indirectly with the ENGINE exchange system; **WAR workers, UOULU machine shop workers, and ABS workers (GBW / Nome staff will need some instructions).**

1.3. Define the main topics on which the ENGINE training course or instruction will be created;

Train the staff of the workshop of the University of Oulu in the production of fatigue rods, to guarantee 100% traceability. The rods must be marked, the time of machining must be marked, etc. In the later phase workers of WAR (maybe ABS / SIFR) need to have instructions on how the new inspection tools and devices are used.

1.4. Defined knowledge and skills that will be acquired with the help of training on ENGINE;

How to collect needed data and operate with measurement devices and what is done if the system indicates deviations (actions).

1.5. Define knowledge and skills - which can be improved or renewed through a general training course, if applicable.

How to operate with measuring devices, how to collect relevant data how to react if the system detects deviation.

2. **Work on learning content acquisition.** VALTEH needs basic information from software or equipment developers (ADV, NOME, VTT, and other partners), and this content will be a source for a training course or instruction. This stage is divided into two small-scale stages:

2.1. **Defining content topics, format, and achievable result -** 1. Defining subtopics of the topics defined in step 1 (if applicable), defining the most successful formats of topic and subtopic materials (Supporting material Table 5). Define the learning objectives for the main topics and the results to be achieved for the sub-topics. Good practice in the creation of e-courses and pedagogy, in general, is to first define the essential topics and the results to be achieved, so that only the essential information is placed in the course content or instruction, without burdening the user of the course content with unnecessary content. The content presentation format will depend on the specifics of the topic. It is essential to evaluate different ways of presenting content in the creation of course content, to maximally cover a larger scope of the students' teaching habits, which is the perception of content visually, audibly, and less kinaesthetically (but this could be compensated with VR).

2.2. **Creation of course content and learning materials** - According to the defined topics and the feedback, the partners prepare the textual content and corresponding supporting material draft content. According to the type of consumables (instructions, images, video, VR, ppt, pdf), VALTEH plans and implements drafts of materials with partners and jointly develops them to the end. A uniform visual identity is planned for the auxiliary materials, which will adapt from the existing visual identity of the project website. At this stage, cooperation between VALTEH and partners ADV, NOME, GBW, WAR, SIFR, and ABS is important. VALTEH made sure that the content is easy to read and understand, and from the content submitted by the partners, visually and user-friendly.

At this stage, the E-learning course will be designed and adapted to the learning management system. the experience will be useful, it will be gained by visiting ABS and SIFR production plants, and seeing employees in action in a suitable environment, will give VALTEH and partners an idea of a real process. It is essential to gain experience and information by visiting ABS and SIFR production facilities M8 and seeing employees in action in a real work environment, this will give VALTEH and partners a real idea of the work process of work floor employees.

3. **Preparation and approval of the knowledge test of the study course.** At this stage, VALTEH uses the existing teaching content and, in consultation with cooperation partners, prepares a self-test, and drafts of the final tests are first approved (direct consultation with partners) and then make improvements and clarifying details.

4. **Testing the learning environment and course content**. At this stage, repeated content and usability testing are carried out by the initially involved partners in the learning environment system, and then by the HR specialists of the manufacturing plants. Potentially, I see an opportunity to test 1-2 employees from each company (ABS, SIFR, WAR, WIT). At the end of this stage, the noticed shortcomings are recorded, and improvements are made, then they are coordinated with partners and representatives of production plants.

5. **Feedback from users.** At this stage, a usability test is performed with end users (1-2 from each production plant). If significant ambiguities or deficiencies with the learning environment system or the content of the learning course recur, VALTEH is responsible for improvements (if applicable).
6. **Translation and harmonization of teaching content.** Ultimate coordination of study courses with partners in the study content and translation of materials into Latvian. Translation of teaching content and auxiliary materials into other languages is provided by partners, VALTEH offers to place the training course in other languages in the learning environment system.

3. Skills Website

The goal of the interactive skills website is to provide access to training and upskilling materials to the public; therefore, it will be made as part of the existing VALTEH website. It will be built on the commonly used Moodle framework.
Currently, the potential learning environment system needs and the main usage scenario to be considered for content creation are identified - User of training courses ENGINE system the user creates a profile with a work or personal e-mail and has access to free ENGINE training courses (the number of course modules will be clarified, at least 2-3), which are learned in a period of 6 months, after which the profile is automatically deleted, if knowledge needs to be renewed, then a new profile is created again. We plan to consider the possibility of the user authenticating with a global authentication tool.

Now (M5), VALTEH has the possibility of placing a link in the navigation on the project website https://theengineproject.eu/ as one of the paths to training; the other path will be through the VALTEH website.

The first version will be available on M16-M18. It will have full functionality, but we expect that not all content will be available by that date. The missing content will be added by the end of ENGINE.

4. Training Courses for Testing the Learning Environment System

VALTEH plans to implement adult education courses on the basic level of knowledge of labor protection, and acquisition of special knowledge in the field of labor protection, metalworking, and fire safety, the content of the courses is universal and applicable in all companies; VALTEH plans to test the content of these courses in the learning environment system and activate the process of creating the content placed in them. In each course, there will be, video or VR simulations (if applicable), self-tests, and a final test. Acquisition of basic knowledge of labor protection, and specialized knowledge in the field of labor protection, metalworking, and fire safety. The exact content of the planned modules and the list of supporting materials developed within the modules will be prepared in M7-M9.

5. Materials for Product Design Engineers

The most relevant work packages for product design engineers are WP1, WP3, and WP6. The target of the product engineer design training is (1) to get the engineers acquainted with the integrated design process including the manufacturing chain and lifecycle assessment; (2) to understand how the basic concepts of model-based systems engineering can be applied in the whole product development chain to assure first time right results and (3) to get a basic knowledge of utilizing the ENGINE system and ENGINE toolbox for product design. UOULU will define the roles of the needed participants in the engineering training.

Part A: The first part of the engineering training will cover the main principles of the ENGINE project from the viewpoint of an engineering team. First, the main principles of Model-Based Systems Engineering are covered. Second, the manufacturing process will be presented as a system model and the trainees will get acquainted with the interface definition for the different parts of the process. Finally, the whole engineering process covering the ENGINE system will be clarified with the help of these concepts. UOULU will organize the training in the form of a special course that will be available to all the project participants as well as a course for M.Sc. and doctoral students. UOULU will be responsible for organizing the training environment and coordinating and engaging the relevant people from other consortium members and work packages to contribute to their area of expertise. Part A of the training is targeted for M19 of the project as part of the planned workshop.

Topic	Partner	Training time
LCA principles	GD	2 hr
Connecting rod manufacturing process	WAR/WIT	2 hr
MBSE principles	UOULU	2 hr
Ultrasonic immersion testing	WAR/WIT	1 hr
ENGINE system overview	UOULU	2 hr
Manufacturing modeling	ABS / WAR/WIT	2 hr
Micromechanical fatigue overview	VTT	1 hr

Part B: The second part of the training will cover the practical implementation of the methodology for the case study of the connecting rod in the ENGINE project. The aim of the training is to look at the engineering process instead of only the tool. This will be organized as a two-day workshop. The training will provide insight into applying the zero-defect manufacturing tools in the correct phase of the product development process. Applying the ENGINE system to a product development project will be the topic of the first part of the training, and addresses changes in the engineering process and the way of working in a company engaged in zero-defect manufacturing. This will be demonstrated utilizing an industry-typical project gate model as a case study. The second day of the training focuses on utilizing the tools developed in the project as an integral part of the engineering process. Special focus will be given to handling the different data interfaces between the different parties. UOULU will collect and develop material for the hands-on training with VTT (simulation tools) and ADV (data management and IT). Each of the project work package leaders will be contacted to define a suitable case material for an end-to-end demonstration of the toolchain. The final specification for training materials for engineers will be defined when the first version of the ENGINE toolbox is available (expected at M15). UOULU will prepare the first version of the material by M24 and have the first training session for university students and staff for collected feedback for adjusting the final training material. The training is to be held in the last 6 months of the project to ensure a high enough readiness level for the underlying ENGINE system and toolbox.

Training material will be provided in the form of short video clips on the utilization of the ENGINE tools, along with interactive tools, such as Jupyter notebooks as a user interface for the underlying ENGINE toolbox. This material will be developed to be utilized in Part A and B of the training session, and subsequently made available as project results. In all cases, materials will be distributed along the ENGINE system in an online repository e.g., GitHub.

6. Industry Oriented Workshops

Four industry-oriented workshops are planned in ENGINE. Their target audience is people with a materials engineering background. Namely, master/Ph.D. level engineering students and engineers working in the industry. The goal of the workshops is to demonstrate and train them in developing computational mechanics workflows that solve practical materials engineering problems.

The first workshop has been scheduled on 31 January 2023 – 2 February 2023 in Oulu, Finland. Its topic will be “Micromechanics modeling”. A detailed agenda will follow closer to the event.

The other three WS are planned on M19, M27, and M34. On exact dates will decide closer to the events. However, we don’t expect a great deviation from the specified months.

Appendices

Table no. 1 - ENGINE system overview (Data flow). The purpose of the table is to see the overall picture, in which stages of the ENGINE system, which WP2-WP4 and production plants are directly involved, and which technologies (software/hardware) will be used. LCA/LCC tools cover the data flow in its entirety. The contents will be defined in more detail in the months M6-M12

DATA FLOW		WP3 SOFTWARE	WP4 HARDWARE
1.	**Continuous casting**	proprietary (Thercast))and WP3 developed toolsets	Melt monitoring tools
2.	**Rolling simulation**	proprietary (Forge) and WP3 developed toolsets	-
3.	**Rolling**	proprietary (Forge) and WP3 developed toolsets	-
4.	**Bar inspection**	-	UT fatigue testing machinery
5.	**Die forging**	proprietary (Forge) and WP3 developed toolsets	-
6.	**Forging simulation**	proprietary (Forge) and WP3 developed toolsets	-
7.	**Heat treatment**	proprietary (Thermo-Calc) and CALPHAD tools	-
8.	**Machining**	-	Vibration measurements, sound measurements
9.	**Ultrasonic Testing (UT) inspection**	AI and physics-driven tools	In-situ UT test system
10.	**UT data prefiltering**	Specific developed AI tools	-
11.	**Decision making**	User interface as in ENGINE system	-
12.	**Component simulation**	MBS toolsets (MSC)	-
13.	**Assembly to engine**	-	-
14.	**Engine operating conditions analysis**	MBS toolsets (MSC)	-
15.	**Full engine simulation**	MBS toolsets (MSC)	-
16.	**Engine usage**	-	-
17.	**Engine maintenance**	-	-
18.	**Engine end of life**	-	-
19.	**As-manufactured fatigue testing**	-	-
20.	**Fatigue criterion development**	Developed micromechanical modeling tools of WP3 and proprietary tools (Z-set)	-

Table no. 2 - **Full User and usages scenario with basic information for skills training** (an example of a table idea).

ENGINE system		User and usage scenario							Skills training				
Data flow	**WP**	**Concern**	**Usage scenario**	**User/ Job title**	**Task/ Action**	**Subtasks**	**Other users involved?**	**Note** (Provider name)	**What does the employee work with?**	**Need training?**	**Content type**	**Training content**	**Content Format**
Machining	*WP2*	*WAR*	*Machine shop usage scenario*	*CNC machining operator or team leader*	*A) CNC machining operator or team leader – needs to make green/red decisions on a specific part (clear indicator)*		*Not defined jet*		*Hardware (sensor, ultrasonic microphone, e.c.,) or Software*	*Yes/ Possible/ No*	*Training course/ Instruction/ Other.*		*Video/ PDF/ VR/ Text/ Audio/ PTT/ Other*
					B) Red -> next level expert comes to re-evaluate the part. The user (specialist) wants to compare the diagnostic results to simulation results (address potential for repair, reuse, etc.)								

Table no. 3 – Basic module information template/ Responsibility

Task	Description	Example	Responsible
1. Target group/ Concern	For which factory personnel is this training content intended.	*This training course is aimed at personnel operating and managing installation with an ENGINE system.*	Provider
2. Prerequisites	What basic knowledge should employees know before learning this training content?	*The trainees should have a basic knowledge and operational experience of the installation's mechanical and/or electrical systems.*	Provider
3. Objective	What knowledge or skills will the employees acquire by studying this training course/part?	*Participants will understand the structure and operation of the ENGINE system. They will understand data flow security aspects and control, enter content, and manage application philosophy.*	Provider
4. Content	A list of topics and subtopics that will be covered in this course of study.		Provider
5. Detailed learning objectives	Brief, clear, specific statements of what trainees will be able to do at the end of training as a result of the activities and learning that has taken place.		Provider/ VALTEH
6. Headings and Subheadings Learning Content	Textual information by topics and subtopics.		Provider
7. Additional study materials	Explanatory materials for the learning content - images, diagrams, schematics, audio, video, VR.		Provider/ VALTEH
8. Online tests and self-tests	Self-tests and a final exam		VALTEH/ Provider
9. Recommended Duration	The potential learning time of the learning content by parts of the main content	*The potential learning time of the learning content by parts of the main content.*	VALTEH

Table no. 5 - Pros and cons of content formats

Format	+	-
Video	Engaging, multi-sensory, build the strongest relationship between the student and teacher.	Can be more time-consuming to create.
Audio	Students can take the content "on the go" and listen anywhere.	Easier to get distracted while listening to can be harder for non-native speakers to understand.
PDF Checklists, Worksheets, Tools/Products, Recommendations, "How to" Guides, Flowcharts, Templates, Scripts	PDF guides are easier to go back to and reference than audio/video and PDF worksheets help walk students through doing the work.	Typically, lower engagement than audio/video.
Text	This is the "easiest" to produce for creators that are comfortable with writing. Requires no additional tools or skills.	Writing well can be difficult (but anyone can learn!).
VR	Engaging, multi-sensory, let's explore different realities and alternate our experiences.	Can be much more time-consuming to create (cost of money and time). With programmed software, things can often go wrong.

A note on accessibility: When publishing video and audio content, make sure that everyone can benefit from your content by including transcripts of any video/audio files.

Table no. 6 – Planned times for metal inspection/measurement table (An example of a table where the overall picture is planned with metal testing methods within WP3 and WP4).

WP	Inspection/ measuring method	Equipment	Scheduled dates for testing	Provider	The factory where this will be implemented
WP4	**In-situ material ultrasonic inspection**	Olympus material ultrasonic inspection machinery	TBA	WAR	WAR
WP4	**Machine center vibration measurements**	Nome nmas vibration measurement system	The first phase at UOULU M6-10, the second phase at WAR production after month 24	Nome	UOULU/WAR
WP4	**Feeling vibration**	Made by operators	Currently, M5, is done in ABS	ABS	ABS
WP4	**Stream and Surface Inspection**	Made by operators	Currently, M5, is done in ABS	ABS	ABS
WP4	**Immersion UT tests**		ABS laboratory	ABS	ABS