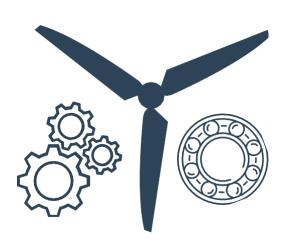


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Module and Scenario Overview



Module:

Gearbox and Bearing
Maintenance
Learning scenario:
Gearbox inspection





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This document has been created as part of the wider T-shore project, co-funded through the European Union's ERASMUS+ programme.



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Document Information

Project Acronym	T-shore
Project Title	Technical Skills for Harmonised Offshore Renewable Energy
Award Number	Project 101055746
Work Package	WP3,4
Document Title	LSO – Learning Module and Scenario Overview
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Co-Author(s)	All partners

Version Control

Version No.	Date	Description	Prepared by	Checked by
0.1	20.11.2024	General modification of document from V01	WP Lead	All partners
0.2	06.05.2024	Modifications from the original input	JdW & Arnt Olav	
0.3	05.2025	Document Update	DH	

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1 Description of module

In a wind turbine where the gearbox is part of the driveline, the gearbox is considered a main component. In the event of a breakdown, it will lead to major financial and operational consequences. It is therefore important to have regular service and maintenance performed by people with expertise in this area.

This module will culminate in a Gearbox Inspection Scenario based on a real gearbox inspection conducted under the operational conditions of a wind turbine. It is a proactive inspection of a gearbox located inside the nacelle of a turbine that has been operational for over 5 years since its start-up.

1.1 Theory

The module consists of a theoretical part where the participant learns about the construction of the gearbox and bearing machines, as well as the functioning of these components. The theoretical part also presents common issues and maintenance procedures, including service and inspections methods.

1.2 Practical

In the practical part, the participant, following the instructor's guidance and documentation, performs practical training doing a visual inspection of the gearbox, inspects the condition of internal parts, and collects an oil sample for laboratory analysis.

1.3 Evaluation

Throughout the entire module, the participant is evaluated by the instructor. The final evaluation is based on a reports review and discussion with conclusions.

2 Instructor pre-qualification

To conduct the learning module theory and practical training, instructors must meet the minimum requirements below:

Knowledge: specialised education or advanced knowledge in the field of gearbox operation and construction, as well as bearing machines.

Skills: manual skills and experience allowing the presentation of the method of conducting gearbox inspections, oil sample collection, and filter replacement. Experience in report creation.

Ability: educational skills related to the ability to conduct classes as an instructor, a reflective approach to teaching, and an instinct related to safe work practices.





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3 Participant pre-qualification

To conduct the module (Theory and practical training), participants must meet the minimum requirements below:

Knowledge: Basic knowledge of wind turbine construction, rotating machinery

Skills: use of manual mechanical tools **Ability:** safe work evaluation of situation

Overview of theoretical content, scenario documents, training equipment and infrastructure

Name	Q/A	Туре	Category	Where to use
PC with projector screen	1	Real-life equipment	Theoretical part equipment	Theoretical part
Gearbox E-learning or Presentation		Digital material	Theoretical part material	Theoretical part
Risk assessment example	1	Printed document	Theoretical part material	Theoretical part
Risk assessment template	6	Printed document	Theoretical part material	Theoretical part
Equipment checklist example	1	Printed document	Practical part material	Preparation for practical exercises part
Equipment checklist template	6	Printed document	Practical part material	Preparation for practical exercises part
Learning scenario manual	6	Printed document	Practical part material	Practical part
Inspection report	6	Printed document	Practical part material	Practical part
Gearbox	1	Real-life equipment	Training infrastructure	Practical part
Gloves with ANSI cut resistant level A1	6	Real-life equipment	Safety equipment	Practical part
Safety shoes	6	Real-life equipment	Safety equipment	Practical part
Safety googles	6	Real-life equipment	Safety equipment	Practical part
Safety helmet	6	Real-life equipment	Safety equipment	Practical part
Suitable working clothing	6	Real-life equipment	Safety equipment	Practical part
Nitrile gloves	12 (2 for each participant)	Real-life equipment	Safety equipment	Practical part





Mechanical tools set (manual torque wrench, screwdriver etc.)	1 set for each participant	Real-life equipment	Tools	Practical part
Borescope	3 (1 for 2 participants)	Real-life equipment	Electronic tools	Practical part
Oil sample container	6	Real-life equipment	Component	Practical part
Gearbox filter	3 (1 for 2 participants)	Real-life equipment	Component	Practical part
Paper towels	-	Real-life equipment	Component	Practical part

Note The list is provided for a group of 6 participants. For smaller or larger groups, the list needs to be adjusted accordingly.

4 Timeframe

Time	Part
7 hours	Theory
7 hours	Practice in workshop (include evaluation)
Total: 14 hours	

Note Timeframe may vary depending on number of participants, level of initial knowledge, skill and ability of participants and need to meet learning objectives.

5 Learning methods

Part	Learning method
Theory part	E-learning on Moodle T-Shore, power-points, lectures and group work
Practical part	Practical skill training and scenario participation in workshop, VR trainings

Note Learning methods depends on accessibility of infrastructure and equipment.

6 Main learning outcomes for the module

Main learning outcome	Competency	No.
Demonstrates a good understanding of gearbox technology and function in wind turbines	Mechanical	2.3 Understand the basic build and function of main mechanical wind turbine components.
Has knowledge about scheduled and unscheduled maintenance of Gearbox	Mechanical	2.2 Understand the basic manufacturing, installation and operation & maintenance (O&M)





		processes of main mechanical wind turbine components.
Can identify and troubleshoot common issues, and demonstrate the ability to inspect a gearbox, including the use of relevant tools	Mechanical	2.6 Diagnose and resolve mechanical issues and breakdowns.
Can perform a borescope inspection and perform basic maintenance	Mechanical	2.5 Operate machinery and tools commonly used in the wind industry.
Can plan and conduct safe work in accordance with general HSE requirements	Health, Safety, and Environment	4.2 Implement safety procedures and protocols for wind energy work environments
Has knowledge about hazardous environment, can plan risk assessment and execute work in accordance with risk assessment	Health, Safety, and Environment	4.6 Perform risk assessments and have the proper safety mindset / risk awareness
Can recognise the importance of, and demonstrate, proper teamwork and communication	Teamwork & communication	5.1 Communicate effectively using verbal skills, industry-specific terminology, and active listening.5.2 Interpret and apply industry-standard hand signals for crane operations and equipment movement.
Can supply written and verbal report	Teamwork & communication	5.3 Document technical information accurately, including maintenance records and reports, using written and digital tools.

7 Theory part

7.1 Learning theory

The part of the training dedicated to theory - involves classroom-based teaching of theory or the assessment of knowledge for students who have completed e-learning before commencing the learning scenario. This can be implemented as a hybrid of both methods.

Note Some modules / practical learning parts may require a back-and-forth between theory and practice.

Instructor must:

- Present introduction / opening presentation specific for site
- Inform about and explain feedback questionnaire.
- Present the theory material or verify if participants complete e-learning on their own
- Collect feedback after theory introduction.

Each course participants must:





- Learn theory part
- Ask questions related to learning materials and module
- Conduct feedback questionnaire

Learning outcomes:

Detailed learning outcome	Main learning outcome
The participants can describe the main components of gearbox	Demonstrates a good understanding of gearbox technology and function in wind turbines
The participants can explain how gearbox work	Demonstrates a good understanding of gearbox technology and function in wind turbines
The participants can explain how to conduct gearbox inspection	Has knowledge about scheduled and unscheduled maintenance of Gearbox

7.2 Risk Assessment

The part of the training focused on risk assessment and its planning involves the instructor guiding students through an exercise on planning a risk assessment for a specific learning scenario and location.

Instructor must:

- Explain what risk assessment is and how it is being created
- Show template of risk assessment (Gearbox Inspection_Risk assesment_Template_V01)
 and filled example (Gearbox Inspection_Risk assesment_example_V01)
- Conduct risk assessment exercise with students
- Answer questions and give feedback

Each course participants must:

- Ask questions related to learning materials
- Conduct risk assessment exercise

Learning outcomes:

Detailed learning outcome	Main learning outcome
Participants can identify and list specific hazards associated with executing the planned learning scenario.	Has knowledge about hazardous environment, can plan risk assessment and execute work in accordance with risk assessment
Participants can create a corresponding risk assessment addressing the hazards identified in the planned learning scenario.	Has knowledge about hazardous environment, can plan risk assessment and execute work in accordance with risk assessment





8 Practical part - introduction

8.1 General Introduction

This part of the document describes how the practical part of the module should be organised. This template is a guideline which may need local adaptation. Modules may require that the students undergo practical skill training before they do scenario training. This may include how to operate tools, equipment and how a component function. After the skill training, the students will test their skills and knowledge in a practical learning scenario. Both the practical skill training and the scenario training can be adapted to be a practical examination.

Instructor must provide constructive feedback to participants on relevant practice activities. It includes feedback concerning the correctness of the exercise performed by the training participant, suggestions for improving the execution of the exercise by the training participant, and general remarks about participant safety at a given moment during performing of exercises.

At all the time during training participant can ask questions and expect feedback from the instructor.

8.2 Workshop introduction

Before start of practical exercises:

Participants may be divided into more groups. Max ratio: 6 participants per instructor for practical session.

All participants and instructors shall use appropriate PPE in accordance with local laws and regulations.

The minimum requirement is:

- Overalls/work clothes long sleeves
- Safety shoes
- Safety helmet
- Safety glasses
- Gloves with ANSI cut resistant level A1

The participants must be instructed about the followings:

- All the equipment to be used and their correct use.
- The instructor must be informed immediately if anyone feels ill, in pain, or exhausted about any condition that may affect health and safety.
- If anybody feels uncomfortable during the training, e.g. uncomfortable working position, dizziness, etc., the instructor must be notified immediately.





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 If anyone gets injured or causes harm to others, the instructor must be notified immediately.

Exclusion zones must be set up and maintained around the practical training area.

9 Preparation for practical exercises

9.1 HSE brief & PPE dressing

The HSE brief includes information specific to the components and equipment used during the practical portion. It also involves verifying all safety aspects related to the practical exercises and ensuring that participants use PPE correctly.

Instructor must:

- Present and explain the hazards and risks in workshop zones.
- check if each participant has correct PPE and wear it correctly.

Each course participants must:

- Demonstrate the ability during practical exercises to keep themselves out of hazard and risk in the workshop zone during scenario exercises.
- Inspect PPE before use and wear correct PPE equipment for training.

Learning outcomes:

Detailed learning outcome	Main learning outcome
Participants can select the appropriate PPE based on the hazard analysis related to planning activities	Can plan and conduct safe work in accordance with general HSE requirements
Participants can wear correctly PPE equipment for planning activities	Can plan and conduct safe work in accordance with general HSE requirements

9.2 Manual handling

Manual handling is a part of the training dedicated to preparing participants for physical tasks such as lifting heavy objects, bending, or assuming unnatural positions during exercises.

Instructor must:

 Facilitate warming up exercise, and manual handling exercises with group and discussions on to handle equipment manually according to the equipment characteristics and potential hazards and risks.





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Correct positioning under manual tasks

Each course participants must:

 Warm up, and practice correct manual lifting techniques. Focus on correct work positioning.

Learning outcomes:

Detailed learning outcome	Main learning outcome
Participants understand the rules for proper manual handling techniques.	Can plan and conduct safe work in accordance with general HSE requirements
Participants can perform practical tasks in compliance with manual handling requirements.	Can plan and conduct safe work in accordance with general HSE requirements

9.3 Equipment checks

This part of the training focuses on presenting the verification and inspection process for equipment needed during the practical part, as well as identifying when equipment require quarantine. It also emphasises proper storage conditions and procedures.

Instructor must:

- Show where the gearbox service accessories, tools, and equipment are stored. Explain how to store it correctly and describe potential consequences of failing to do so.
- Explain the different indicators that must be checked during pre-use and post-use checks
- Explain the reasons for quarantining accessories and equipment.
- Explain how to fill equipment checklist

Each course participants must:

- Practice the ability to correctly store accessories and tools executing also during later practical exercises.
- Practice how to conduct pre-use and post-use check of equipment and accessories.
- Practice the ability to identify accessories requiring quarantine.
- Practice the completion of equipment checklist

Learning outcomes:





Detailed learning outcome	Main learning outcome
Participants understand the importance of correct equipment storage	Can plan and conduct safe work in accordance with general HSE requirements
Participants can perform equipment inspection	Can plan and conduct safe work in accordance with general HSE requirements
Participants can correctly fill out equipment checklist	Can supply written and verbal report

10 Practical skill training

Practical skill training is a part of highly dependent on participants' pre-qualifications. Based on an assessment of participants' skills, the instructor should determine the amount of skill training required to allow participants to engage in exercises from the learning scenario. In cases where participants possess varying skill levels identified through a gap analysis, skill training should be planned according to the lowest skill level identified. This approach ensures learning opportunities for less experienced participants, while for more advanced participants, it serves as a review and practice of their skills.

Examples of skill training exercises related to the Gearbox Inspection learning scenario:

- Use of mechanical tools
- Use of a borescope

Implement practical skill training on equipment that can simulate the environment.

10.1 Use of mechanical tools

The skill training on the use of mechanical tools focuses on familiarising participants with the tools required for the learning scenario. In the case of gearbox inspection, the primary tool is a manual torque wrench, which is used for opening the gearbox hatch and subsequently correctly close it and secure by the end of exercises.

Instructor must:

- Present and explain the correct usage of tools, including how to properly set and adjust the torque wrench to the correct value.
- Observe participants use of the tools, assess their technique, and provide constructive feedback on their actions.

Each course participants must:

 Demonstrate the skills and ability to correctly use mechanical tools during practical exercises

Learning outcomes:





Detailed learning outcome	Main learning outcome
Participants can effectively and correctly use mechanical tools	Can identify and troubleshoot common issues, and demonstrate the ability to inspect a gearbox, including the use of relevant tools

10.2 Use of a borescope

The skill training on the use of a borescope focuses on familiarising participants with how borescope is built and how it works. The exercises should involve correctly setting up the borescope and capturing trial images.

Instructor must:

- Present and explain the correct set up and use of borescope
- Take trial pictures and discuss it with participants

Each course participants must:

Demonstrate the skills and ability to correctly use borescope during practical exercises

Learning outcomes:

Detailed learning outcome	Main learning outcome
Participants can effectively and correctly use borescope	Can perform a borescope inspection and perform basic maintenance

11 Learning scenario

11.1 Scenario Introduction

Participants will learn to perform a proactive inspection with required documentation, of a gearbox located inside the nacelle of a turbine that has been operational for over 5 years since its start-up.

If the workshop does not have realistic wind turbine components that supports all the practical steps described below: Implement practical skill training on equipment that can simulate the environment.

11.2 Exercise 1 – Exterior gearbox inspection

Exterior inspection is the first step in performing a proper inspection. It allows the identification of initial irregularities, such as mechanical damage, leaks, or ruptured housings. The exercise should focus on accurate reporting and developing the ability to conduct an objective assessment.

Instructor must:





- Explain and discuss the steps in Exercise 1 from the learning scenario manual,
 emphasising the details of each action while maintaining safety protocols.
- During the exercise, provide feedback and reflections to the participants, engaging them in discussions.
- Explain and demonstrate how to complete the visual inspection checklist.
- Review and discuss the results of the participants reports with them.

Each course participants must:

- Familiarise yourself thoroughly with the exercise manual and clarify any unclear points.
- Perform each step from the manual.
- Complete the visual inspection checklist.

Learning outcomes:

Detailed learning outcome	Main learning outcome
The participants can explain how to conduct gearbox inspection	Has knowledge about scheduled and unscheduled maintenance of Gearbox
The participants can perform visual inspection on gearbox	Can identify and troubleshoot common issues, and demonstrate the ability to inspect a gearbox, including the use of relevant tools
The participants are able to collaborate effectively to successfully complete the task.	Can recognise the importance of, and demonstrate, proper teamwork and communication
The participants can fill out check documentation in correct and reflective way	Can supply written and verbal report

11.3 Exercise 2 – Interior gearbox inspection

Interior gearbox inspection is a comprehensive procedure for assessing the condition of a gearbox. It involves a visual evaluation of the state of individual gearbox components using specialised borescope equipment. The exercise focuses on the ability to conduct a valuable inspection, capture images illustrating the condition of specific gearbox components, and report their status effectively.

Instructor must:

- Explain and discuss the steps in Exercise 2 from the learning scenario manual,
 emphasising the details of each action while maintaining safety protocols.
- During the exercise, provide feedback and reflections to the participants, engaging them in discussions.





- Explain and demonstrate how to complete the visual inspection checklist.
- Review and discuss the results of the participants reports with them.

Each course participants must:

- Familiarise yourself thoroughly with the exercise manual and clarify any unclear points.
- Perform each step from the manual.
- Complete the visual inspection checklist.

Learning outcomes:

Detailed learning outcome	Main learning outcome
The participants can explain how to conduct gearbox inspection	Has knowledge about scheduled and unscheduled maintenance of Gearbox
The participants can perform internal visual inspection on gearbox	Can identify and troubleshoot common issues, and demonstrate the ability to inspect a gearbox, including the use of relevant tools
Participants can effectively and correctly use borescope	Can perform a borescope inspection and perform basic maintenance
The participants are able to collaborate effectively to successfully complete the task.	Can recognise the importance of, and demonstrate, proper teamwork and communication
The participants can fill out check documentation in correct and reflective way	Can supply written and verbal report

11.4 Exercise 3 – Lubrication system inspection

The exercise involves correctly conducting a lubrication system inspection, including check the oil level, taking an oil sample and filter inspection & replacement (if applicable). The focus of the exercise is on the ability to follow correct procedures and correct reporting.

Instructor must:

- Explain and discuss the steps in Exercise 3 from the learning scenario manual,
 emphasising the details of each action while maintaining safety protocols.
- During the exercise, provide feedback and reflections to the participants, engaging them in discussions.
- Explain and demonstrate how to complete the visual inspection checklist.
- Review and discuss the results of the participants reports with them.





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Each course participants must:

- Familiarise yourself thoroughly with the exercise manual and clarify any unclear points.
- Perform each step from the manual.
- Complete the visual inspection checklist.

Learning outcomes:

Detailed learning outcome	Main learning outcome
The participants can explain how to conduct lubrication system inspection. how to take oil sample and replace the filter	Has knowledge about scheduled and unscheduled maintenance of Gearbox
The participants can perform lubrication system inspection with correct reflective actions according to gearbox parts conditions	Can identify and troubleshoot common issues, and demonstrate the ability to inspect a gearbox, including the use of relevant tools
The participants are able to collaborate effectively to successfully complete the task.	Can recognise the importance of, and demonstrate, proper teamwork and communication
The participants can fill out check documentation in correct and reflective way	Can supply written and verbal report

11.5 Exercise 4 – Final reporting

The final exercise, Final Reporting, focuses on practicing reporting skills, including clear and accurate communication of content, as well as reflections on the previously performed exercises. In this part, the instructor evaluates how well the participants understood the tasks they carried out and whether they drew correct conclusions and reflections.

Instructor must:

- Discuss with participants each of the exercises and summarise results of them
- Review with participants their filled-out documentation
- Discuss final report outcome

Each course participants must:

- Engage in discussion about exercises.
- Finalise all required documentation and verify if all documentation is completed.
- Prepare final report section in Inspection report with next step service action proposition.
- Listen to feedback from the instructor and peers to improve your assessment skills.





Learning outcomes:

Detailed learning outcome	Main learning outcome
The participants can fill out check documentation in correct and reflective way	Can supply written and verbal report
The participants can reflect on inspection outcomes and recommend the next step actions	Can supply written and verbal report

12 Completion of training practical part

13 Safe dismounting and tools storage

This exercise involves safely cleaning up the workshop after completing the practical sessions. It aims to demonstrate the correct sequence for safely dismantling equipment, returning it to the storage space, and preparing it for future use.

Instructor must:

 Inform participants how safely and in what order unmount tools & accessories and return it to the storage.

Each course participants must:

- Safely unmount tools & accessories.
- Correctly return tools and accessories to the storage

Learning outcomes:

Detailed learning outcome	Main learning outcome
Participants understand the importance of correct equipment storage	Can plan and conduct safe work in accordance with general HSE requirements
Participants can perform equipment inspection	Can plan and conduct safe work in accordance with general HSE requirements

14 Learning module & scenario evaluation

Module part	Exercise name	Evaluation method
Theory	learning theory	Test assignment.





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Theory	Risk assessment	Instructor evaluation based on the risk assessment document created by the participant.
Preparation for practical exercises	HSE brief & PPE dressing	Instructor evaluation based on the participant's correct preparation procedure.
Preparation for practical exercises	Manual handling	Instructor evaluation based on the participant's demonstration of proper manual handling techniques.
Preparation for practical exercises	Equipment check	Instructor evaluation based on the equipment check report completed by the participant.
Practical skill training	Use of mechanical tools	Instructor evaluation based on the practical skills demonstrated by the participant.
Practical skill training	Use of a borescope	Instructor evaluation based on both practical and digital skills demonstrated by the participant.
Learning scenario	Exterior Gearbox inspection	Instructor evaluation based on the participant's practical skills demonstrated and the completed section of the inspection report .
Learning scenario	Interior Gearbox inspection	Instructor evaluation based on the participant's practical skills demonstrated and the completed section of the inspection report .
Learning scenario	Lubrication system inspection	Instructor evaluation based on the participant's practical skills demonstrated and the completed section of the inspection report .
Learning scenario	Final reporting	Role-play exercise between a site manager and a wind technician regarding the inspection reporting. Instructor evaluation based on the participant's reflections, reporting quality, and the completed inspection report document.





Co-funded by the European Union

The T-shore project is funded through the the Erasmus+ Centres of Vocational Excellence (CoVEs) call 2021

Acknowledgements

We would like to extend our sincere thanks to all the project partners for their invaluable contributions to this report and their dedicated work on the T-shore project.

Our deepest appreciation also goes to all T-shore stakeholders, particularly the members of the regional Centres of Vocational Excellence (CoVEs), whose ongoing efforts are instrumental in driving the success of this initiative.

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