

Learning from Normal Work: Practical Insights into How Floating Offshore Wind Maintenance Is Performed and Adjusted to Enhance Safety

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Abstract: Norway aims to become a low-emission country by 2050, and offshore wind is one of the focus areas for renewable energy. As competition for new project areas intensifies, stakeholders face pressure to make quick and cost-effective strategic decisions while still maintaining high Health, Safety and Environment (HSE) standards. Norway has solid experience within HSE, still the The Norwegian Labour Inspection Authority has identified a need to clarify the regulations on psychosocial work environment and the effect on occupational health and safety. A dedicated regulatory regime covering HSE in offshore wind is needed but not established. The aim of this paper is to explore and describe how routine maintenance operations in floating wind are performed under real conditions, revealing valuable lessons to support further development of safety knowledge and measures in the industry. The data consist of observations from a one-day ethnographic field study at the Marine Energy Test Centre (METCentre) on the west coast of Norway. Based on Safety II and Learning from Normal Work perspective, the research project sought to identify everyday practices and adaptations made by a maintenance team, to proactively enhance safety at work. Five key safety themes were identified: high adaptive capacity, effective team dynamics and communication, positive organizational responsiveness, proactive management of environmental challenges, and design and ergonomic insights. The observations are further summarized into nine 'Learning Cards' intended for discussions in safety training, education and development. Each card presents real-world scenarios such as proactive safety measures, backup strategies and team communication accompanied by reflective questions, key insights and learning points. With the identified safety themes, the learning cards and the underlying analyses this paper aim to contribute to dialogue and learning to further improve the development of safety measures within the floating offshore wind industry.

Keywords: Norwegian floating offshore wind, Operation and maintenance, Learning from Normal Work, Safety II, Rapid ethnography assessment

1. Introduction

To become a low-emission country by 2050, Norway needs a shift towards products and services with substantially lower climate and environmental impacts than today (Ministry of Energy, 2024). Offshore wind is set to be one of the focus areas for renewable energy, with the ambition of allocating 30,000 MW of offshore wind production areas by 2040. On the Norwegian coast there is so far Hywind Tampen, a floating windfarm built specifically to power offshore oil and gas installations. This wind farm has a capacity of 94,6 MW in 2025. Furthermore, the windfarm Sørlige Nordsjø II was allocated in

2024 and the competition for Utsira Nord was launched in May 2025. Both these windfarms have a total capacity up to 1500 MW (Ministry of Energy, 2025). To achieve the 2040 ambitions there must be a continuous allocation of new projects in the years to come and a total of 20 areas on the Norwegian coast have been identified suitable for wind production (NVE, 2023). In 2020, The Norwegian Ocean Industry Authority was given the responsibility for ensuring that workplaces in offshore wind fulfill their legal obligations as set out in relevant regulatory framework, including health and safety for operators (Norwegian Ocean Industry Authority,

2020). It was stated that offshore wind power has much in common with petroleum activities, but that a dedicated regulatory regime covering HSE in offshore wind needs to be developed for future projects (Norwegian Ocean Industry Authority, 2020). This is so far not established.

Offshore wind is identified as a high risk industry, with an injury rate 3 – 4 times higher than in comparable industries (Rowell et al., 2024). Understanding these safety challenges is important to ensure sustainable growth without negative impact on the workforce. To explore how routine maintenance operations in floating offshore wind turbines is performed, the Western Norway University of Applied Sciences (HVL) conducted a one-day ethnographic study in April 2025 on the floating offshore wind turbine Unitech Zephyros-One. Zephyros is part of the Marin Energy Test Centre (METCentre) located in the same area. The 2,3 MW turbine has been in operation since 2009 and is the world's first floating wind turbine. The turbine supplies power to the onshore grid via a 22 kV/15 MW cable while also serving as a test platform for next-generation components and systems.

2. Theory

Offshore wind involves challenging activities with potential for major accidents and incidents involving multiple fatalities (Norwegian Ocean Industry Authority, 2024). To optimize energy production, floating offshore wind turbines are located far from shore, making both safety regulations, procedures and proactive safety behavior crucial. Rough weather conditions, ladder climbing, heat and cold, exposure to noise, vibrations and seasickness are some of the challenges in maintenance operations. The continuous changing and sometimes unpredictable work environment further underscore the use of this approach in promoting worker safety, health and efficiency (Roberts & Flin, 2025; Rowell et al., 2024).

The concept of workplace safety has undergone a profound transformation over the past century. Early industrial approaches, called Safety 1, was rooted in a positivist paradigm, framed accidents as outcomes of mechanical failure or individual error. Safety management emphasized hazard elimination, failure prevention, and procedural compliance (Hale & Hovden, 1998). Later, another perspective has been launched,

highlighting complexity, uncertainty, and the adaptive nature of human work (Rasmussen, 1997). Named Safety-II, it emphasizes safety as the system's ability to succeed under varying conditions rather than merely avoiding failure. It is a complexity-oriented approach to managing risk in socio-technical systems and describes how safety emerges through continuous adaptive capacities and proactive behaviors during normal operations rather than merely by preventing failures or incidents (Hollnagel, 2014). In this research we took the Safety-II perspective and the Learning from Normal work approach (IOGP, 2022) to systematically study routine performance, adaptive practices and successful adjustments done during maintenance work on a floating wind turbine in Norway.

3. Materials and Methods

This research project was funded by MARKOM, a national maritime competence program. The financing included one day of fieldwork at the METCentre, accompanied by a maintenance team. Due to continuously changing and challenging weather conditions, the preparations included the ability to conduct the fieldwork on short notice. Harsh weather conditions were also the cause of multiple delays during the research period. Based on this limited field access window, we choose to use Rapid Ethnography Assessment (REA) to efficiently capture detailed observations and meaningful interactions within limited field access windows. The research team consisted of two researchers with complementary backgrounds (Sangaramoorthy & Kroeger, 2020), one with maritime navigation experience and the other with experience from occupational health service, enabling diverse and comprehensive observational insights. The maintenance crew consisted of three workers, a boat captain and two maintenance operators.

Rapid ethnography has been criticized as a research method based on assumptions that ethnographers require time to generate relationships, to capture changes, richness and complexity in relations to the topics of interest and to capture events or situations that were not originally anticipated (Vindrola-Padros, 2021). But because of both financial and access limitations it was crucial that data collection could be performed rapidly and on short notice. Before entering the turbine, both researchers had Basic

Safety and Emergency Preparedness Course and a pre-visit briefing with the responsible operator. During the visit the researchers had to be accompanied by a qualified turbine operator the entire time.

The project sought to observe how workers' knowledge and experience contributed to proactive adaptations to complete their tasks safely and under varying conditions. Focus areas for the observations were set to be:

- Communication practices
- Adaptations to unexpected conditions
- Use of procedures vs technical workarounds
- Group decision-making
- Situational awareness and anticipation

The observations were primarily non-intrusive with short, informal chats during safe moments (avoid disrupting work). Both researchers separately took notes during the operations, based on the agreed focus areas. This holistic qualitative approach gave the opportunity to rapidly collect safety information by both observing and asking probing questions when needed. The researchers' complementary backgrounds further strengthened the validity of findings aimed at developing practical achievable safety recommendations (Sangaramoorthy & Kroeger, 2020).

Shortly after the fieldwork the notes were compared and sorted thematically based on the areas of interest in order to gain some key insights. The analyses were inspired by the SEPTIGON model, which gives an example of components and interactions in a socio-technical system and how safety performance may evolve from workers' ideas, practices and strategies (Koester, 2007, 2024). Analyzing the data, we performed the following steps: a) each researcher presented all observations to the other, b) the most relevant observations to the projects determined focus areas were selected, c) the findings were sorted and categorized.

4. Results

The observations and analyses resulted in a total of nine findings of positive practice adding safety to the work process. This included small behavioral gestures like nods or hand gestures when waiting for the right moment to perform a challenging task, others were structural

adjustments to safety procedures made by the company after feedback from the crew.

The workers demonstrated behaviors indicative of mutual trust and articulated the significance of trust in their interactions. Both among the crew members and between the crew and the company. The one-day field observation gave multiple examples of how the harsh environment affected both the crew and the equipment, making work processes unpredictable. Even within acceptable weather conditions, safety-enhancing adjustments were necessary to get the work done efficiently. The nine identified situations showing successful everyday practices and adaptations were further used to develop "Learning Cards" (Koester, 2024), aimed at fostering proactive safety discussions within industry training sessions or in maritime courses. The observations and learning cards show "work as done" not "work as imagined". The adaptations or workarounds may not be the right solutions, changes and adaptations may also lead to creation of new hazards (IOGP, 2022). But the findings may serve as conversation starter and give valuable insight into the continuous systematic health and safety work in organizations.

Each learning card has two sides; a front side with a short story of something that worked well, two open-ended reflective questions to spark discussion and a "Try this" suggestion to apply the insight in practice. The back side is for the facilitator with "Why this matters", explaining the deeper significance and key learning points to help guide or summarize the conversation. The nine situations identified in the analyses are as follows:

4.1. Proactive Adjustment of Fall Protection Procedures

When entering the wind turbine from the boat, there was no use of fall protection when climbing the first ladder. The crew explained that they were not comfortable using the fall protection equipment at this first ladder, as it created a potential crushing hazard between the vessel and the wind turbine. Instead, they had proactively suggested to the company management to modify the procedure to delay connecting to fall protection until safely reaching the first platform. According to the workers, the management had considered, approved and implemented this

change in the safety procedures. Workers performing daily tasks often have the clearest insights into what works safely and effectively, and what could be improved. When management actively listens and swiftly responds to frontline suggestions, it may strengthen both operational safety and organizational trust.

Learning Card #01

Proactive Adjustment of Fall Protection Procedures

What happened?

Workers identified that using fall protection on the first ladder created a potential crushing hazard between the boat and the wind turbine. They proactively suggested modifying the procedure to chain connecting to fall protection until safety reaching the first platform. Management quickly considered, approved, and implemented this change in the safety procedures.

Reflective questions:

- Can you recall a situation in your own team where direct feedback from you or your colleagues led to safer or improved work practices?
- In your view, how should management respond when workers suggest improvements to enhance safety?

Try this:

Next time you notice a task could be done more safely or successfully, bring it up with your team—our suggested it in a daily meeting. Small improvements add up.



Figure 1. Example Learning Card

4.2. Flexible Weather-based Scheduling

The maintenance team frequently adjusted their schedules based on real-time weather forecasts. Rather than sticking rigidly to pre-planned dates, they actively monitored conditions, which significantly reduced risks associated with poor weather. Recognizing and proactively responding to environmental conditions is crucial for offshore safety and organizational flexibility reduces unnecessary risk exposure. Adjustments may be necessary both before leaving the dock and during maintenance operations. While working in the nacelle, the enclosed structure at the top of the wind turbine that houses the main mechanical and electrical components, the operators relied on the boat captain to monitor weather changes and determine whether the work needed to be stopped or paused.

4.3. Effective Backup During Seasickness Incident

When the boat captain became seasick during the operation, the maintenance lead calmly took control of the vessel without hesitation or confusion. The team seamlessly adjusted roles, demonstrating clear role clarity and effective backup behavior. Teams that have clearly defined roles and trust each other's skills can adapt

effectively during unexpected incidents. Good teamwork and clear communication maintain safety even when unforeseen events occur.

4.4. Proactive Handling of Equipment Issues

Before using the lift inside the turbine, the maintenance leader routinely checked all visible equipment related to safe use of the lift. While doing this he explained that this was part of their safety routine so they would notice changes or damage from the last visit. This visual strategy continued during the use of the elevator, which resulted in the discovery of a lift cable at risk of becoming stuck due to movement of the floating turbine. By proactively stopping and adjusting the cable, the crew prevented a potentially serious equipment issue. Human vigilance and proactive action are essential complements to technological safety measures. Early recognition and intervention significantly reduce operational downtime and risk.



Figure 2. Lift inside turbine

4.5. Adapting Equipment Use to Fit the Task

The maintenance crew actively adjusted how and when they used safety equipment depending on the situation. For example, some of the climbing equipment and the safety suit were only used on outdoor climbing. These outdoor climbing hooks and the warm bulky safety suit were left behind when they safely arrived at the last outside platform and entered the inside of the turbine. At this first inside platform they also added some new lighter climbing equipment and checked that everybody had what they needed for the task ahead. This reduced unnecessary strain and made the work easier without compromising safety. Adapting equipment to the real demands of the task helps reduce physical and cognitive load and may prevent negative workarounds resulting in unsafe operations. Practical flexibility in how equipment is used may support both safety and efficiency.

4.6. Active Waiting Across Critical Operations

Throughout various parts of the maintenance operation, boarding and disembarking the turbine, climbing ladders, using the lift, and during equipment work in the nacelle, crew members who were not directly involved in the task remained observant and ready to assist. They followed each other's movements closely, anticipated needs, and avoided distraction. This created a calm, safe atmosphere with high mutual awareness. This collective focus seemed to reduce the chance of miscommunication or missed signals during transitions or high-risk moments.



Figure 3. Situation awareness

4.7. Calm, Clear and Contextual Communication

During operations, whether climbing, troubleshooting in the nacelle, or managing vessel transfers, the crew communicated with short, focused messages. Instructions were clear, delivered without raising voices or adding stress, and adjusted to match the situation (e.g., hand signals, short verbal cues, checking understanding). Calm, situation-specific communication helps keep operations safe and coordinated, especially in dynamic or noisy environments. Consistent tone and clarity reduce cognitive load and increase confidence within the team.

4.8. No-Rush Environment Despite Efficiency

Although the maintenance tasks at Zephyros were carried out efficiently and professionally, there was never a sense of being rushed. Crew members moved with purpose but maintained a calm pace. There were no reminders to “hurry up,” and transitions like gearing up, using the lift, or reboarding the vessel were done with focus and time to think. The atmosphere allowed for

deliberate, safe action without unnecessary pressure. Rushing increases risk, especially in high-stakes or physically demanding environments. A calm working tempo supports better decision-making, fewer mistakes, and higher situational awareness.

4.9. Proactive Communication and Environmental Awareness – With Room to Improve

While the team was working inside the turbine, the boat captain actively checked in by phone to monitor progress. He also mentioned that he kept an eye on the weather, ready to alert the team if conditions changed. Since the crew inside the turbine couldn't easily detect changes in sea state or wind, this external awareness gave an important safety buffer. However, the team relied on regular mobile phones without hands-free or integrated communication systems, limiting their ability to stay connected during critical operations. Proactive cross-role communication enhances team situational awareness, even when working in different physical locations. Monitoring external conditions while others are focused on their task is an excellent example of shared safety responsibility. Good communication behavior can be limited by suboptimal tools and sometimes improvement means upgrading systems, not people.

5. Discussions

In Norway, the Working Environment Act is the fundamental law regulating working life. Employers are responsible for ensuring a safe and compliant working environment. They are required to conduct and maintain all operations in accordance with regulatory requirements and internal policies to prevent harm to individuals, the environment, and property. Employees, in turn, are obligated to actively participate in efforts to uphold these standards (Arbeids-og sosialdepartementet, 2006). Work shall be organized and adapted to ensure employees a fully satisfactory working environment, safeguarded from physical and psychological harm (Lovdata, 2011).

Recent years, the Norwegian Labour Inspection Authority has identified a need to clarify the regulations on psychosocial work environment and the effect on occupational health and safety, both on- and offshore (Arbeidstilsynet, 2024). Examples of identified

risks are demands for efficiency, the complexity of the work, role-conflicts (collaboration, disagreements, decision-making) and work management. Top and middle managers must be sufficiently familiar with organizational and psychosocial risks and their consequences. A lack of understanding may lead to low priority of assessment and measures to avoid these risks (Derdowski & Mathiesen, 2022; Gravdal et al., 2024). Worker’s experience and competence must be highlighted and actively used to enhance safety performance. In such a complex and unpredictable environment, their view on how to safely perform, make adjustments or stop their work is of great value. The way the problem was solved yesterday may not be the best way the next day. Weather may change, equipment may be broken since last visit, or a member of the crew may get sick. This was all incidents appearing in just one day of field observations. But to safely make work adaptations or workarounds requires trust and agreement. In this field study, positive social support was revealed both within the team and between the team and the organization. They were in control of the situation during the maintenance operation, with the opportunity to adjust procedures when needed.

Creating work environments that balance demands with adequate control and support is vital to workplace safety. Workers faced to intense demands with little autonomy and minimal support are more prone to burnout, emotional exhaustion and disengagement, which may lead to decreased attention, higher error rates, and reduced adherence to safety protocols (Bakker & Demerouti, 2024; Karasek & Theorell, 1990; Narhgang et al., 2010). In this study we aimed to learn from what goes well, taking the Safety-II perspective. We did not search for incidents going wrong, but successful behavior and decisions made, that can be of value in further safety discussions within offshore floating wind. Risk mapping is a well-known tool within risk management, but it is important to understand why and how it is used (Jørgensen & Jordan, 2016). Real life experiences and workers’ knowledge must be included in risk management, and management must be included if workers discover the need for changes or improvements of established safety procedures.

The results of this study have two outcomes: nine Learning Cards to be used as

conversations starters in safety training or other safety discussions and five key safety themes for further research and development:

Table 1. Overview of key safety themes

Thematic findings	Key observations and insights
High Adaptive Capacity	Workers consistently anticipated potential risks, particularly around climbing safety and equipment interactions, proactively adjusting practices to manage these effectively
Effective Team Dynamics and Communication	Clear, concise communication characterized interactions, supported by mutual trust and psychological safety within the team, especially during unexpected situations such as equipment malfunctions or health-related incidents like seasickness.
Positive Organizational Responsiveness	The maintenance team successfully influenced safety practices through direct and positive communication with management, leading to rapid procedural improvements based on practical frontline experiences
Proactive Management of Environmental Challenges	The Maintenance operations were consistently adapted in real-time to environmental conditions, demonstrating both individual and organizational flexibility, which is critical for offshore operational safety
Design and Ergonomic Insights	Practical observations highlighted ergonomic challenges due to excessive safety gear and identified potential technological design improvements, specifically concerning the management of equipment within dynamic floating environments.

6. Limitations

This fieldwork was conducted at a test center, which naturally has some limitations. The study was also limited to a single-day REA, meaning that we did not have the opportunity to compare multiple crews, tasks, or other weather conditions. Nevertheless, the work observed involved real-world maintenance under authentic technological and environmental conditions. The observations and analyses are not intended to be judged as

“right” or “wrong” but are examples of successful everyday practices and how we can Learn about Safety from Normal Work. This study is also the first part of a PhD project looking at interorganizational cooperation in offshore wind maintenance, with particular focus on how organizational and psychosocial factors influence occupational health and safety in offshore wind maintenance.

7. Conclusions

Offshore wind maintenance is situated far from shore in a rough and unpredictable work environment. Due to the working conditions, proactive and safe adjustments may be necessary to solve the different tasks of the day with minimal downtime. The dynamics and communication both within the maintenance team and between the team and the management are crucial for effective and safe decision making in the industry. This paper aims to raise awareness and discussions to be used in further research and in the development of safe work environments for the operators in the industry. There are some parallels between offshore wind and petroleum activities with regard to risk conditions and safety challenges, but there are also some important differences. And so far there is a lack of industry specific HSE regulations for offshore wind in Norway.

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