FLOATING WIND JOINT INDUSTRY PROGRAMME

Commercial Scale Mooring Integrity Management (CMIM)

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Contents

Authors:

Michael Archer
Associate, Carbon Trust
Michael.Archer@carbontrust.com

Luisa Amorim
Manager, Carbon Trust
luisa.amorim@carbontrust.com

Claire Lazarides
Senior Engineer – Maritime Engineering
claire.lazarides@amog.consulting

Chris Carra
Director – Offshore Energy
chris.carra@amog.consulting

Jon Gumley
Principal Engineer & Team Lead–Maritime Engineering
jon.gumley@amog.consulting

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Introduction

As floating wind moves towards Gigawatt (GW) scale windfarms, there is a clear opportunity for optimisation and cost reduction of mooring system inspection, monitoring and associated management activities. These currently contribute to a significant amount of project operating costs over an asset's lifetime. While cost reduction appears achievable through sampling techniques, current mooring integrity management approaches require adaptation to transfer from an individual unit focus to a multiple unit risk-based approach. There is a need to clearly define mooring system monitoring and inspection methodologies, along with sampling techniques to consider a risk-based approach that is applicable for multiple floating wind units, accepted by classification societies, and deemed insurable.

The Commercial Scale Mooring Integrity Management (CMIM) project was delivered by a consortium led by AMOG, together with ABS, SOFEC and Skowronnek & Bechnak. The project, delivered through the Floating Wind Joint Industry Programme (Floating Wind JIP), investigated how a mooring integrity management (MIM) strategy would be developed for a commercial-scale floating offshore wind farm. The Floating Wind JIP 15MW reference mooring system designs, described and updated as part of the preceding Mooring system redundancy, reliability and integrity (MRR&I) study (delivered in Phase 2 Stage 5) were used as a design basis.

Project objectives

The project aim was to develop and answer the question of what an integrity management strategy for a commercial scale floating wind array would look like. This was undertaken by:

1. Building upon previous Carbon Trust work, in addition to key learnings from marine, Oil and Gas (O&G) industries and fixed bottom turbine inspection regimes/standards, to define key differences for floating wind.
2. Investigating the cost-benefit of strategies based on different risks and mooring line failure implications for different systems.
3. Understanding the implications of mooring line failures, such as predicted loss of production versus occurrence failure rate in floating offshore wind and how they differ from O&G.
4. Evaluating potential methods and technologies for mooring system monitoring, inspection and maintenance aimed at managing the mooring system in a cost effective and safe manner.
5. Understanding requirements for Health, Safety, and Environment (HSE).
6. Proposing key performance indicators (KPIs) to measure mooring integrity, from design to installation and operation.

7. Listing relevant technology development requirements and differences from a Business as Usual (BAU) approach.
8. Investigating different levels of integration between digital twins, physical inspections and remote monitoring.
9. Proposing methodologies for defining the sampling rate for inspections on commercial wind farms, including sensitivities on the selected sampling rate and the impact on the total cost versus expected downtime.
10. Producing a set of suggested documentation to support mooring integrity management (MIM) standardisation to different industry stakeholders including classification societies, insurance companies and equipment suppliers.
11. Identifying how the industry could work together to use data from floating offshore wind farms in the same regional development areas to help inform integrity management of these farms in the wider context, including for example data driven techniques for managing integrity from large data sets.

Methodology

The study investigated how a mooring integrity management (MIM) strategy would be developed for a commercial-scale floating offshore wind farm utilising the mooring systems designed in the previous Floating Wind JIP MRR&I study and how a MIM strategy would vary depending on the type of mooring system used.

Key assumptions

- The A Base Case (3 × 1 mooring system) assumed a non-redundant mooring system and the Alternative Case (3 × 2 mooring system) assumed a redundant mooring system. Redundancy for this project was defined as the mooring system maintaining station and, therefore, preserving the inter-array cable connection in the event of a single mooring line failure. This was linked back to the fundamental performance requirement of a mooring system, which is to maintain station of a floating foundation within tolerable position limits. The consequence of the loss of a mooring line for the Base Case (3 × 1) resulted in the Floating Offshore Wind Turbine (FOWT) unit losing station, exceeding the dynamic cable watch circle offset limits, and resulted in a loss of the inter-array cable; as demonstrated by the MRR&I study.
- The wind farm project was in the FEED stage of the project life cycle. As such, the mooring components were based on early design configurations and not fully defined. The lack of definition of these designs limited the performance assessment in the study as it required the analysis of the performance and characteristic of, for instance, a generic in-line tensioner device instead of a specific manufacturer's product.
- A FEED definition level field layout was proposed, including assumptions for water depth and bathymetry, field topology and number of inter-array cables, farm spread and characteristics of the wind farm location (e.g. seabed conditions, exposure to shipping and fishing traffic, and metocean information). Figure 1 presents the assumed wind farm layout, with 50 FOWT units, arranged in 10 sets of 5 daisy-chained units and spanning water depths from 80 m to 130 m. The definition of this layout supported the development of clustering, sampling, inspection and monitoring strategies based on considerations for farm-wide susceptibility to risk.

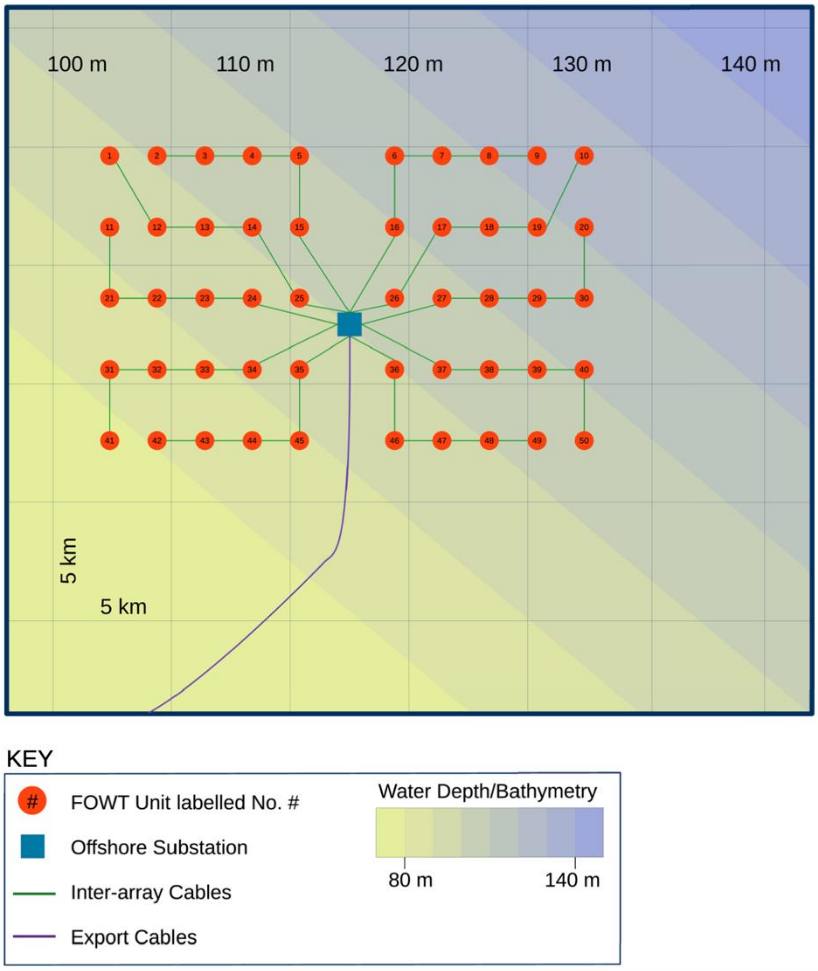

Figure 1. Assumed Floating Offshore Wind Farm Layout

Literature Review

Applicable standards and best practice for mooring integrity management within both offshore wind and O&G sectors were reviewed. Additionally, related research and previous mooring integrity management work in the floating offshore wind sector were also reviewed to identify applicable learnings, products, technology, and sampling techniques.

Stakeholder Engagement

Several workshops between delivery consortium members, industry experts and organisations were conducted. These were used to identify key areas and challenges for effective integrity management at commercial scale.

Failure Modes, Effects and Criticality Analysis (FMECA)

Identification of degradation risks for individual system components, and specific localised site risks across an array relevant to floating offshore wind mooring locations was based on the work undertaken in the MRR&I project. Further assessment regarding criticality of mooring degradation threats was undertaken by qualitatively assessing the likelihood of threat occurrence and the severity of resulting consequences.

Development of Mitigation Strategies

Degradation controls for each individual degradation mechanism (identified as part of the FMECA) were used to develop key performance indicators. These indicators enabled effective implementation of control measures that address specific degradation risks, mitigating potential degradation threats and preventing emergences such as; a mooring line failure or loss of station. The control measures were considered across all stages of the wind farm (approximately 25-year life cycle), from installation to end-of-life. Examples of mitigation strategies include increasing the frequency of inspection, monitoring, and modelling of high-risk components at specific times in their life cycle, such as installation, close to wear out, or when monitoring and modelling indicate a potential future failure.

Development of MIM Framework Suitable for Commercial Scale Floating Offshore Wind

A risk-based MIM approach was proposed, adapted from the safety case framework (set out in the UK by the UK Health and Safety Executive (HSE)) to provide a greater focus on system and wind farm performance. This approach considered both a single floating FOWT unit's integrity and the overall susceptibility of the farm to risk. The approach for multiple FOWT units and clustering approach used to inform sampling, including unit monitoring approach variation. More details on the MIM framework approach can be found in the Appendix: MIM Framework approach details.

Comparison of Prescriptive and Risk-Based MIM Approaches

The requirements for both extensive prescriptive and risk-based approaches for inspection and monitoring were identified. These requirements were subsequently compared to determine where mooring integrity management planning can benefit the most from the implementation of a risk-based framework, potentially reducing the inspections required.

Development of Class-Accepted MIM Plan Documentation and Templates

MIM plans were developed based on project definition at FEED stage. These comprehensive plans included documentation and templates for:

- MIM philosophies
- Risk assessments
- System controls definition
- Control test and verification record requirements
- Emergency response planning
- Numerical monitoring requirements
- Monitoring and simulation requirements
- In-service inspection and monitoring plans on a prescriptive and risk basis

These plans were developed in collaboration with a classification society and the insurance industry, whereby an approval-in-principle was granted by ABS at the concept verification stage. Skowronnek & Bechnak (S&B) provided guidance on the critical aspects that insurers are expected to look for within a MIM plan to assess potential impacts on coverage and insurability.

Development of Guidance & Recommendations

The challenges expected to arise with the implementation of mooring integrity management at a commercial scale were identified at each life cycle phase, in addition to broader integrity management system challenges. Areas where it would be beneficial to develop additional guidance to support standardised and acceptable implementation of CMIM were also highlighted.

Key findings

1 **The comprehensive mooring integrity management (MIM) strategy developed was capable of addressing challenges specific to floating offshore wind (FOW) and met criteria for ABS approval in principle at the concept verification stage.**

- A comprehensive MIM plan was generated as at the FEED stage of a project comprising of a detailed MIM strategy, risk assessment, controls for key mooring degradation threats, monitoring and simulation strategy, emergency response plans and risk-based in-service inspection and monitoring plans.
- The development of an overall commercial-scale MIM framework and subsequent mooring integrity management array plan required a whole-of-life-cycle approach in accordance with foundational MIM guidance documents (API-RP-2MIM, DNV-RP-E308 and The ABS Guide to Mooring Integrity Management), which were generally aligned on effective MIM recommendations. The magnitude of this task should not be underestimated for floating wind projects. Guidance remains limited for the serialised nature and number of floating wind mooring systems in a single commercial-sized project. These arrays will consist of large numbers of individual floating units affected by localised variations in metocean characteristics across the array e.g. varying water depth, exposure and wake effects depending on turbine location in an array.
- Mooring integrity management is a process that requires continual review throughout the project life cycle. New information from each life cycle phase or inspection is crucial to assure that the mooring system remains reliable and available, whilst being managed in a cost effective and safe manner. As the MIM plan was developed at FEED stage, the documentation will be subjected to continued evolution as the design progressed through subsequent life cycle stages.
- Multi-disciplinary teams should be engaged throughout the lifetime MIM process to review risks, current condition information, and ultimately review and audit the risk-based inspection and monitoring activities during operation.
- An insurer's perspective of the MIM plan was provided to identify critical aspects of the approach that may impact coverage and insurability.

2 **Implementation of CMIM requires the adaption of single-unit risk-based MIM processes to account for the considerations of wind farms containing multiple FOWT units.**

- The development of the MIM process for commercial-scale wind required the adaptation of current conventional practice based on single floating wind turbine units. Although risk-based approaches have been utilised reliably in other industries, foundational MIM literature does not provide detailed guidance on implementation of a risk-based framework for inspection planning.

There is potential for the CMIM project guidance to be integrated into class guidance documents or recommended best practices.

- The key benefits of the risk-based approach are only realised when there is continuous and consistent application of the MIM strategy over the life cycle of a wind farm. The lack of detailed guidance raises a significant challenge for floating offshore wind as it is widely recognised by the industry that for commercial projects to be cost effective, these will have a significant reliance on a risk-based inspection and monitoring framework. Guidance from other recommended practices was therefore adapted to address mooring systems and their degradation threats in the context of a multi-unit wind farm.
- A methodology to adapt existing risk-based single unit MIM processes across commercial-scale wind farms containing multiple FOWT units was developed. This methodology was based on the understanding of the potential degradation threats, locations and timescales throughout the life cycle at which the degradation may occur. An understanding of the dynamic behaviours at a system and component levels is an essential part of the methodology.

3 **Proper consideration of potential risks across multiple units in a FOW farm, or clusters, is critical for development of an effective monitoring and inspection strategy.**

- The susceptibility of a FOWT unit's moorings across the wind farm to specific degradation threats needs to be evaluated early in the MIM process, as a common-cause problem across many units in the farm would likely result in substantial rectification costs. The inspection task methodology in Figure 2 (appendix) addresses threat susceptibility on a stand-alone unit, and on a multiple unit farm basis, where the consequence criticality of units within the farm is reflected in the farm-wide inspection and monitoring plan; units with higher derogation and failure risk require higher levels of monitoring and inspection.
- The clustering approach is expected to have a significant impact on integrity management planning through the application of common inspection and monitoring requirements across a number of units, as further discussed in the Appendix.
- Due to the cost implication of complete instrumentation of all FOWT units in a wind farm and maintaining those instrumentation packages throughout the farm operating life, monitoring strategies will rely more heavily on simulation of system responses derived from minimal, but reliable instrumentation sources, and the selection of representative units from different permutations of clusters.

4 **As the FOW industry is in its infancy, first adopters will be instrumental in driving key learnings and future developments of understanding project cost and risk.**

- Floating offshore wind specific guidance for risk-based implementation of mooring integrity management is limited and thus the first commercial projects will require conservative decisions based on both risk evaluation and engineering judgement derived from offshore O&G related experience and prescriptive inspection practices.

- As the industry's understanding of degradation threats and system performance improves, and advances in inspection techniques occur, the industry will be better equipped to implement whole-of-life-cycle risk-based MIM strategies that utilise evidence of risk to integrity and can appropriately justify decisions to justify adjustments from the initial conservative approaches used on the first wind farms.
- FOWT mooring system design is expected to evolve in order to support larger turbine sizes (exceeding 15 MW), exceeding the current supply chain capacity for both mooring chain and synthetic components. Robust integrity management systems will be essential to ensure additional degradation mechanisms are not introduced through new mooring technologies (e.g. nylon rope or load reduction devices), and do not exceed the current limitations in component sizes. In addition, the deployment of new mooring technologies will require modifications to inspection and more rigorous design and manufacturing controls, such as technology qualification, validation and quality assessment (QA) or quality control (QC). The effort associated with these activities will be linked to the perceived cost-benefit of their adoption. The use of first annual surveys and the extent of subsequent inspections in operation will be determined on an individual project-needs basis and will need to consider the risk profile of both the mooring system and the wind farm.
- Whilst the core inspection tasks may be driven by risk assessments, the final inspection plan may also include other tasks based on opportunity and efficiency considerations, vessel availability and other scheduling optimisations.
- Lessons learned from the implementation of MIM practices on the first commercial-scale wind farms will drive future decisions of floating offshore wind MIM. These learnings should ideally be shared to advance the understanding and implementation of efficient and effective MIM practice.

5 **Establishing a Mooring Integrity Management (MIM) philosophy early in the project will enable the evaluation of the true cost impact of operational decisions before final investment decision.**

- The definition of the MIM philosophy and strategy are critical for ensuring an effective approach to MIM. Whilst the immediate focus of system designers may be on the sizing and configuration of a mooring system from a mooring performance viewpoint, neglecting integrity management considerations from early stages of a project can lead to suboptimal outcomes in terms of project cost and schedule arising from the implementation of changes needed to satisfy Class society, regulator or insurer requirements later in the project life cycle.
- Developers should ensure that implementation of a MIM program occurs at an early enough stage to ensure all aspects of MIM program are accounted for in the design process, including technology risk considerations, installation considerations, potential for major overhaul and mooring replacement and emergency response.
- Developers need to understand the cost impact of MIM-related decisions, including factors such as mooring system redundancy, production interruption, inter-array cable loss, shutdown duration and mitigation against escalation of consequences. Redundant mooring systems are

expected to provide some advantages by requiring less extensive mooring integrity management approaches.

- The selected MIM strategies will have a significant impact on the insurability and premium level during operations. Engagement with insurers will be crucial and should be considered in the early phases of the project life cycle.
- Many challenges identified in this project are not only related to mooring system design but also broader industry concerns and overall integrity management. For example, managing information is crucial for commercial-scale wind farms. Significant information can be lost between the design, manufacturing, installation, and operational phases. Using risk-based inspection practices that rely on operational measurements and tuned numerical models, instead of or alongside extensive physical inspections, will increase pressure on effective management systems.

Industry needs/innovations

1 **There are opportunities to develop alternative approaches to CMIM framework implementation, building on the risk-based MIM approach developed during this project.**

- The MIM literature review on the wider offshore O&G industry highlighted that risk-based planning has been widely accepted in other industries and that there are several solutions and strategies for its implementation. While this project focused on developing a single approach for implementing risk-based mooring integrity management for commercial-scale wind farms, many alternative approaches may merit exploration by developers, given that the industry is still in its pre-commercial stages.
- Large-scale floating wind turbines (15MW+) present unique design and load challenges, with unique floater and array locations requiring specific mooring system design makeup. Further work is recommended to understand the level of uncertainty and risk-tolerance given the likelihood of the underlying mooring degradation threat emerging. This analysis should be done on the statistical basis for the work selection matrices (inspection intervals and sampling approaches) and include a benchmark against periodic 100% inspection and monitoring requirements.
- The proposed framework includes adjustment factors for risk-based inspection planning that are applied to sample size or inspection interval, based on current condition and degradation progression rate. There is an opportunity to further investigate and compare approaches for adjusting sample size and inspection frequency, either from a scientific basis (such as a cost impact study) or exercising engineering judgement on a test case.
- The monitoring strategy proposed depends on the assumed MIM philosophy and project requirements, focusing on reliable instrumentation and numerical model validation to reduce the need for full instrumentation of FOWT units or extensive inspection regimes. Considering the heavy reliance on monitoring, there is an opportunity to evaluate the practicality, track record and

cost of implementation of various monitoring, modelling and instrumentation approaches for broader application across multiple floating offshore wind projects.

2 **There is significant need for standardisation and agreement of MIM practices between Class, insurers, developers and operators to support effective MIM strategy implementation.**

- As more commercial floating wind projects progress through their life cycle, the industry will gain experience and insights into effective mooring integrity management strategies and failure rates. However, these learnings will likely be delayed without industry collaboration to establish consistent best practices. There is a significant need to learn from previous industry failures to improve mooring system integrity, as it reduces the likelihood of repeating mistakes through collaborative knowledge sharing. This is especially important for an emerging industry like floating offshore wind, which needs to quickly turn commercial to be impactful. As such, sharing knowledge from smaller-scale, pre-commercial projects is a crucial step to inform how reliance on prescriptive approaches may be reduced and replaced with a focus on risk for commercial scale wind farms, which would support future standardisation and agreement within the industry.
- Each organisation has their own internal management procedures, which influence their approach to integrity management based on factors such as design preferences and risk considerations. Standardising MIM practice within the industry would support project outcomes applicable for any floating offshore wind project, rather than developing many varied procedures based on differing approaches taken by individual projects.
- Standardising inspections and record-keeping would improve information and data management. While the data management requirements have been identified in this project, further assessment of the methodologies and practical considerations is needed to propose a strategy suitable for commercial-scale MIM.
- There is an opportunity to standardise, inspection, monitoring planning, and data management, by developing software or an industry tool. This would standardise how the outcomes of risk assessments translate into inspection and monitoring plans, including baseline and condition information required to effectively monitor risks during operations.

3 **Focused studies on optimisation of MIM would provide greater clarity on key considerations, improve guidance and help plan CMIM implementation.**

- Developing a set of industry-agreed requirements should be considered at the early stages of the project life cycle, when a MIM philosophy is first developed. This would improve the consistency of the approach and aid the interaction between developers, technology providers, Class, insurers and regulators.
- Guidance on the minimum number and location of reference units within a wind farm should consider the associated numerical model simulation and validation approaches. Additionally, as risk-based commercial-scale MIM will be reliant on monitoring and simulation of all units in the farm, minimum requirements for validating numerical models relied upon for system condition

assessment should be developed. This includes signals to be generated synthetically by the numerical models for both high-order models, where measured signals would be used to validate the synthetically produced signals, and for low-order models, which generate synthetic signals based on a limited set of input signals.

- Development of industry consensus on the process for capturing and translating the risk assessment outcomes within the sampling approach and inspection interval setting activities to ensure risk-based implementation of inspection planning is consistent and applicable to commercial-scale wind farms. Reviewing consequence categorisation and likelihood ranges for industry acceptability may be advantageous and could be extended to the risk-based approaches to sampling and inspection interval setting.

- Developing a minimum set of as-installed survey requirements and guidance on the baseline documentation to be retained at the end of each life cycle phase would improve the definition of the inspection scope and findings. This would include design documentation, fabrication documentation and installation documentation, minimising the uncertainty around the baseline condition for ongoing condition assessment, potential life extension, as well as allowing for a better definition of areas to be targeted during first annual inspections.

- The objectives and requirements for the first annual inspection should be better defined and linked to the overall MIM strategy and the risk-based inspection and monitoring program. Existing prescriptive guidance for inspection of all mooring legs is inefficient. The first annual inspection scope should consider applying risk-based approaches to the extent of inspection in terms of:
    - Inspection task and sample size and coverage within the farm
    - Addressing gaps in baseline data
    - Accounting for the wind farm installation schedule

- Since commercial-scale MIM relies on monitoring and simulation, in conjunction with inspection surveying, the scope of the annual review process needs to be modified to reflect those additional review requirements. Current guidance is based on the inspection of typical floating production units, where mooring leg terminations are above water or on deck, and does not adequately address the combined requirements for commercial-scale MIM where reliance on monitoring and simulation will be greater.

Appendix: MIM Framework approach details

This risk-based MIM approach considered both a single floating FOWT unit's integrity and the susceptibility of the overall wind farm to risk. The approach was then expanded for multiple FOWT units and a clustering approach was used to inform sampling. More details on this approach framework can be found below.

Inspection and monitoring requirements of a single unit could be developed once the manifestation and progression of applicable mooring degradation threats, and their risk level was understood. These requirements could then be developed in two ways:

- Prescriptive basis using typical class inspection tasks;
- Or risk-based approach.

Following the proposed inspection and monitoring task methodology shown in Figure 2, this required an understanding of:

- The objective evidence requirements to verify condition;
- The applicable inspection methods across the operating life of system components and the probability of detection using different inspection methods.

The effectiveness and performance of the chosen inspection technique and the quality of the data provided need to be carefully evaluated in developing an efficient strategy for inspection and monitoring, and utilising sampling techniques and simulation to complement the strategy.

The inspection task methodology was then expanded to consider multiple units in a floating offshore wind farm. This included considerations for:

- Clustering units in the field based on design, operation and condition;
- Monitoring whereby simulation and digital twins can be relied on;
- Selection of inspection sample sizes of FOWT units, mooring lines or individual components, along with a series of adjustment factors should the underlying mechanisms be inspectable and monitorable.

Monitoring allows an operator to verify, validate and predict future performance of a mooring system, subsystem or component if current condition can be tracked or inferred. Considering the cost implication of complete instrumentation of all FOWT units in a wind farm and maintaining those instrumentation packages throughout the farm operating life, the monitoring strategy was developed to rely more heavily on simulation of system responses derived from minimal, but reliable instrumentation sources.

This monitoring approach required all the FOWT units being instrumented with a suitable means of determining integrity of the mooring system and identifying that all mooring legs are intact, through monitoring platform position and motions, defined as Minimally Instrumented Units (MIUs). A small subset of FOWT units were additionally instrumented with direct tension monitoring to be utilised primarily for validation, these units defined as Highly Instrumented Units (HIUs). Consequently, direct tension sensors (such as load cells or strain gauges), that currently have a poor reliability record in the offshore industry, did not need to be replaced after failure in operation, on the basis that numerical models had been validated by this time. Data management (baseline, inspection, monitoring and simulation data sets), accuracy of numerical models and selection of reference units (or HIUs) that were instrumented with tension monitoring to enable validation, was therefore crucial for implementing an effective monitoring strategy.

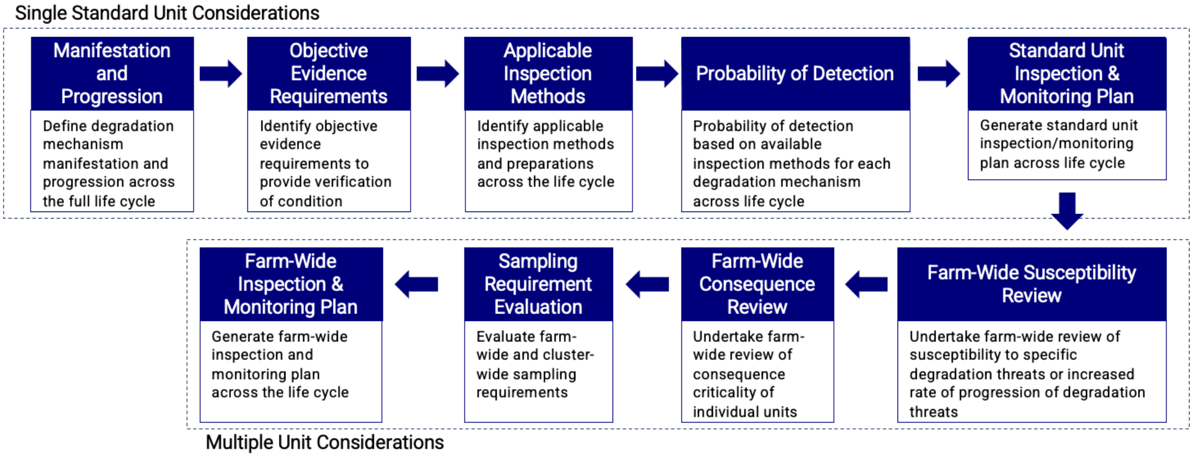

Figure 2. Inspection Task Definition Methodology

Clusters may be applied at different levels considering:

- Risk exposure
- A single threat
- Performance or operating characteristics that affect unit performance compared to those outside the cluster

Figure 3 presents the clustering layers derived for the assumed field development layout, whereby each cluster groups units based on performance or behaviour characteristics, risk exposures or consequence outcomes. As these clusters overlap, individual units are able to be assigned to two or more clusters.

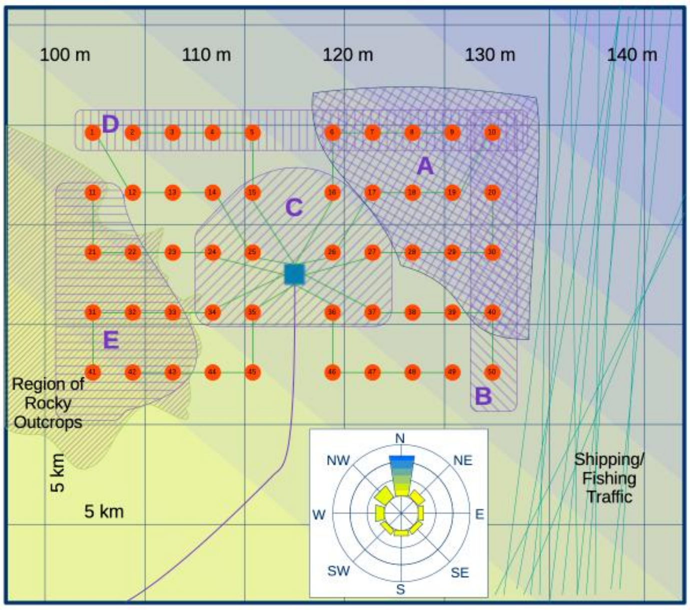

Figure 3. Wind Farm Clustering Layers

The clustering approach outlined above enables varying treatments of each unit in terms of inspection tasks, sampling and frequency. This cluster approach also extends to monitoring and simulation as different models that represent the range of behaviours across the field will need to be adequately validated. Whilst clustering should be initially applied during the Design Phase, it should be reviewed during Manufacturing, Installation, and Operation phases - including new clusters where latent degradation mechanisms emerge.

ABOUT THE FLOATING WIND JIP

The Floating Wind Joint Industry Programme (Floating Wind JIP) is a collaborative research and development (R&D) initiative between the Carbon Trust and 17 leading international offshore wind developers: bp, EDF Renouvables, EnBW, Equinor, Kyuden Mirai Energy, Ørsted, Ocean Winds, Parkwind, RWE Renewables, ScottishPower Renewables, Shell, Skyborn Renewables, SSE Renewables, TEPCO, Tohoku Electric Power Company, Total Energies and Vattenfall.

The primary objective of the Floating Wind JIP is to overcome technical challenges and advance opportunities for commercial scale floating wind. Since its formation in 2016, the programme scope has evolved from feasibility studies to specific challenges focusing on:

- Large scale deployment
- De-risking technology challenges
- Identifying innovative solutions
- Cost reduction

Stage 3 of the Floating Wind JIP commenced in 2022 and projects are expected to run until early 2027. With several commercial scale floating offshore wind farm projects in design phase and having the ambition to be commissioned by 2030, the industry needs to address several challenges. The 17 Floating Wind JIP partners agreed on six research areas where further understanding and advancement is required to reach full commercialisation of floating offshore wind projects.

Electrical systems	Mooring systems	Logistics	Windfarm optimisation	Foundations	Asset Integrity and monitoring

This Commercial Scale Mooring Integrity Management project addresses the ambitions of the Mooring Systems research area:

Mooring systems

1	Define optimal mooring layout and anchoring for different challenging environments and model subsea interactions.
2	Better understand the integrity of mooring lines through improved monitoring techniques.
3	Understand how geographical and material selection affect the availability and manufacturing capabilities of different mooring and anchoring solutions.

The Stage 2 summary reports can be found here: Phase I, Phase II, Phase III, Phase IV and Phase V.

ABOUT THE CARBON TRUST

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We have been climate pioneers for more than 20 years, partnering with leading businesses, governments and financial institutions to drive positive climate action. To date, our 400 experts globally have helped set 200+ science-based targets and guided 3,000+ organisations and cities across five continents on their route to Net Zero.

carbontrust.com

+44 (0) 20 7170 7000

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