

MORAY OFFSHORE WINDFARM (WEST) LIMITED

**Floating LiDAR Buoy Deployment Marine Licence Application
Supporting Information**

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8460005-DCOAM-001-MLS
Final
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1.0	01-05-2018	Final	Information to support the application for deployment of scientific instrumentation, the sequential deployment of a Floating LiDAR Buoy at the Moray East and Moray West Offshore Wind Farm Sites.	<ol style="list-style-type: none"> 1. Moray West 2. Moray East 3. MS-LOT

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Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS

Final

01-05-2018

Revision 1.0

TABLE OF CONTENTS

1.	SCIENTIFIC INSTRUMENT DEPLOYMENT	5
1.1	INTRODUCTION	5
1.2	PURPOSE	6
1.3	LOCATION AND TIMELINE.....	6
1.4	DEPLOYMENT METHODOLOGY	11
1.5	OPERATIONS AND MAINTENANCE (O&M)	12
1.5.1	SCHEDULED MAINTENANCE	12
1.5.2	UNSCHEDULED MAINTENANCE.....	12
1.6	DECOMMISSIONING.....	13
2.	SAFETY	14
2.1	SECURITY OF THE DEVICE AND RISK REDUCTION FOR LOSS OF EQUIPMENT	14
2.2	POSITION MONITORING AND NAVIGATION AIDS	14
2.2.1	OBSTRUCTION LIGHT.....	14
2.2.2	RADAR REFLECTOR.....	14
2.2.3	ST. ANDREW'S CROSS.....	14
2.2.4	AUTOMATIC IDENTIFICATION SYSTEM (AIS).....	15
2.2.5	POSITIONING ALARM SYSTEM	15
2.3	EMERGENCY RESPONSE.....	15
2.4	HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT	15
2.5	STANDARDS AND CODES.....	16
3.	FLOATING LIDAR BUOY SPECIFICATION.....	17
3.1	MOORING SYSTEM.....	20

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS

Final

01-05-2018

Revision 1.0

LIST OF FIGURES

Figure 1 - EOLOS FLS200 LiDAR Buoy.....	5
Figure 2 – Environmental Designations and Floating LiDAR Deployment Locations 1 and 2	7
Figure 3 – Floating LiDAR Buoy Deployment Locations	8
Figure 4 – Location 1: Floating LiDAR Buoy Validation Trial Deployment at the Moray East Site	9
Figure 5 – Location 2: Floating LiDAR Buoy at the Moray West Site	10
Figure 6 - Top left: Lifting down installation option, FLS200 + mooring on vessel deck; Bottom left: FLS200 towing operation; Right: FLS200 lifting to vessel deck with upper mooring	11
Figure 7 - Main Dimensions 1	17
Figure 8 - Main Dimensions 2	18
Figure 9 - EOLOS FLS200 LiDAR Buoy - Instrumentation	19
Figure 10 - Left (Upper mooring bottom view for the FLS200 Buoy) Right (FLS200 Buoy mooring scheme)	20

LIST OF TABLES

Table 1 – Floating LiDAR Buoy Deployment Locations and Durations.....	6
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Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS

Final

01-05-2018

Revision 1.0

1. Scientific Instrument Deployment

1.1 Introduction

Moray Offshore Windfarm (West) Limited (known as Moray West) are proposing a scientific instrumentation deployment of a Floating LiDAR Buoy to measure the wind resource at the Moray West Offshore Wind Farm Site (Moray West Site). Moray West propose to use the 'EOLOS FLS200 LiDAR Buoy' (Figure 1) to collect wind resource data at the Moray West Site. Section 3 provides more detailed information on the specifications of the EOLOS FLS200 LiDAR Buoy.

Moray West have employed EOLOS Floating Lidar Solutions (EOLOS) to carry out the scientific instrument deployment. EOLOS will contract a Marine Contractor for the installation, Operations and Maintenance (O&M) and decommissioning of the Floating LiDAR Buoy.



Figure 1 - EOLOS FLS200 LiDAR Buoy

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS
Final
01-05-2018
Revision 1.0

1.2 Purpose

The main purpose of the meteorological campaign is to collect accurate wind and metocean information from the Moray West Site that will be used to conduct energy yield assessments, for the design of the Moray West Offshore Wind Farm and, given the importance of the weather downtimes at offshore sites, for defining the construction and O&M strategies.

1.3 Location and Timeline

Moray West propose to deploy the Floating LiDAR Buoy at two locations in the Moray Firth, one short-term validation deployment in the vicinity of the Moray East Offshore Met Mast location and a second longer term deployment at the Moray West Site (Table 1 and Figures 2 – 5).

Table 1 – Floating LiDAR Buoy Deployment Locations and Durations

Deployment Location Number	Deployment Location Name	Latitude WGS84 (DDM)	Longitude WGS84 (DDM)	Deployment Duration (months)
1	Validation Trial Deployment	58° 10.707' N	2° 49.679' W	1 month
2	Moray West Site Deployment	58° 5.381' N	3° 0.877' W	12 months

Moray Offshore Windfarm (West) Limited

8460005-DCOAM-001-MLS

Floating LiDAR Deployment Marine Licence Application Supporting Information

Final

01-05-2018

Revision 1.0

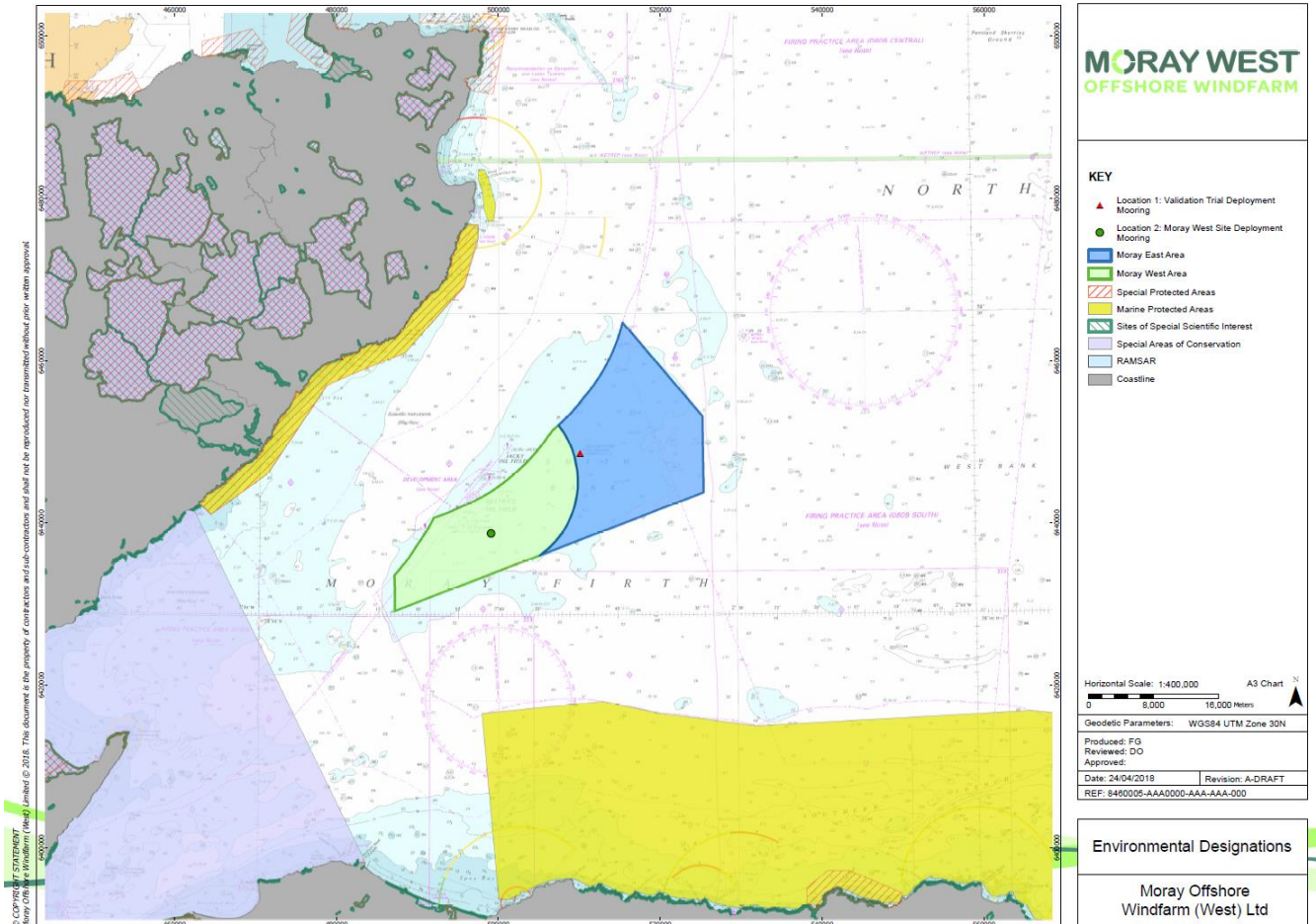


Figure 2 – Environmental Designations and Floating LiDAR Deployment Locations 1 and 2

The proposed Floating LiDAR Buoy deployments are not predicted to have any significant impacts on the environment. As can be seen from Figure 2, the proposed deployment locations are not located within any designated conservation or shellfish harvesting areas and are not predicted to have any effect on these areas.

Moray Offshore Windfarm (West) Limited

8460005-DCOAM-001-MLS

Final

Floating LiDAR Deployment Marine Licence Application Supporting Information

01-05-2018

Revision 1.0

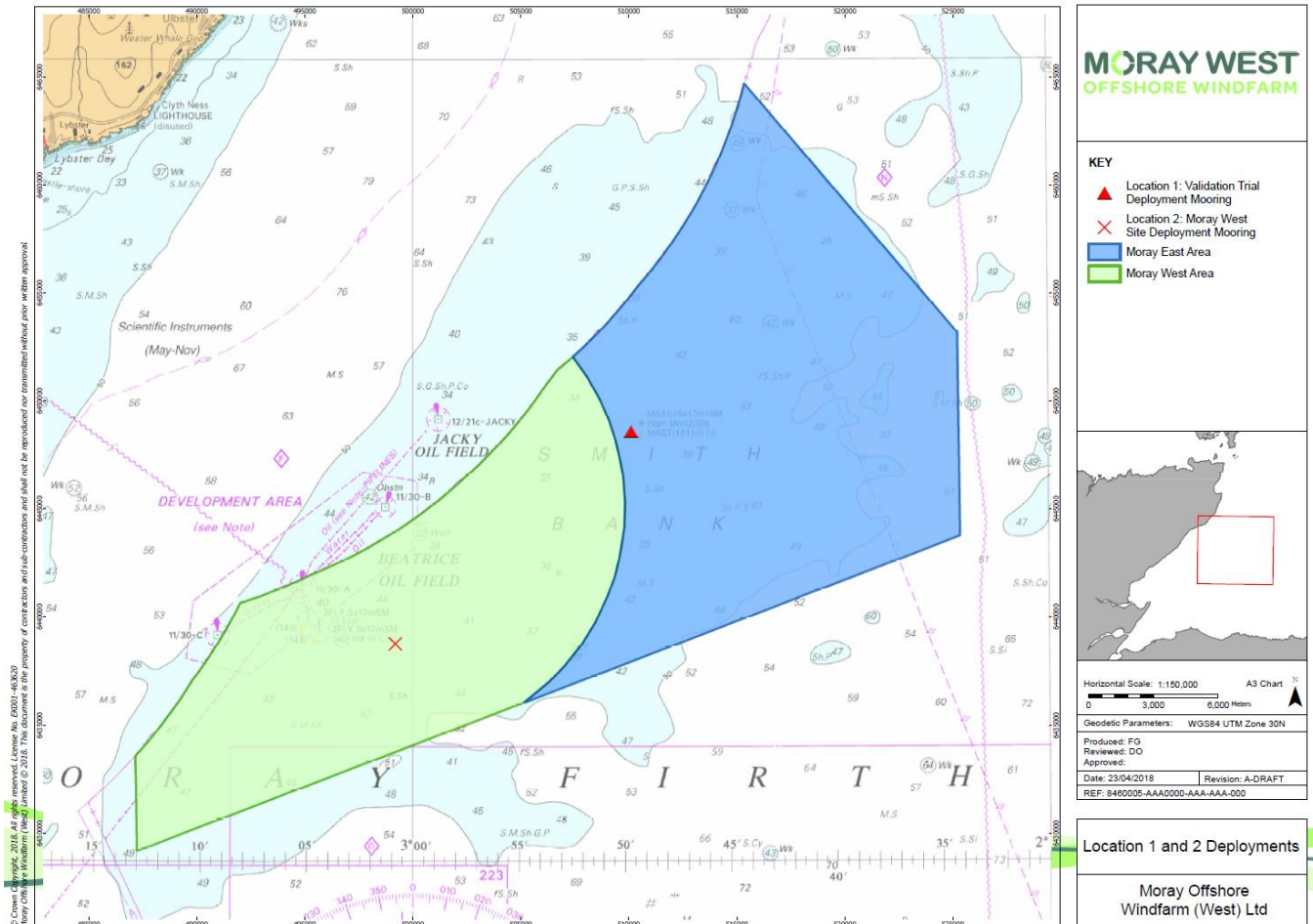


Figure 3 – Floating LiDAR Buoy Deployment Locations

The distance between Location 1 and Location 2 is approximately 15 km (Figure 3). Of note but not represented on the map is the presence of a known wreck. This is possibly the Sunbeam, a British Merchant sailing vessel (Schooner), which was sank on the 4th July 1915. This wreck is located 2.45 km west of the Moray West Site deployment and will not be impacted during installation, operation or decommissioning of the Floating LiDAR Buoy.

Moray Offshore Windfarm (West) Limited

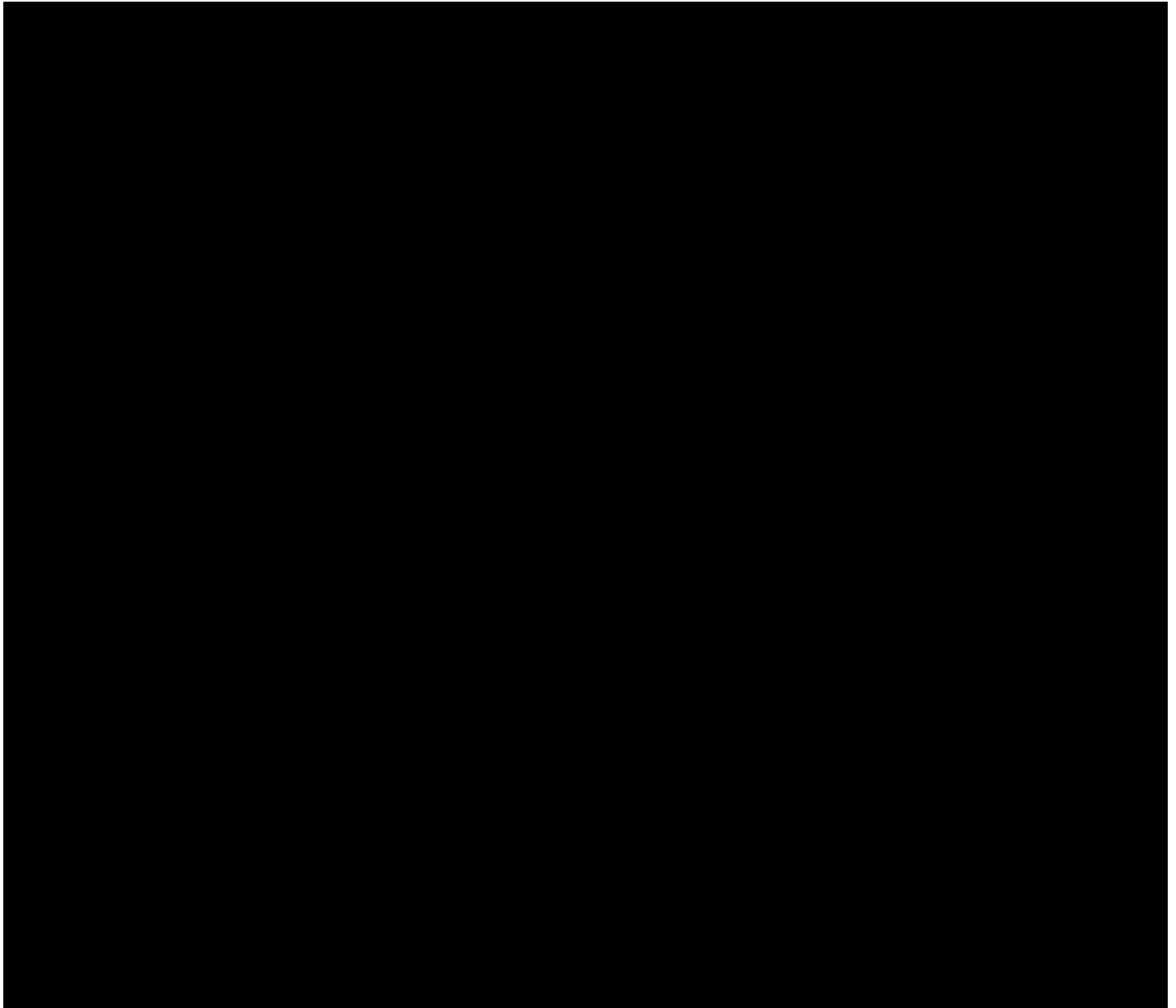
Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS

Final

01-05-2018

Revision 1.0



Moray Offshore Windfarm (West) Limited

8460005-DCOAM-001-MLS

Final

Floating LiDAR Deployment Marine Licence Application Supporting Information

01-05-2018

Revision 1.0

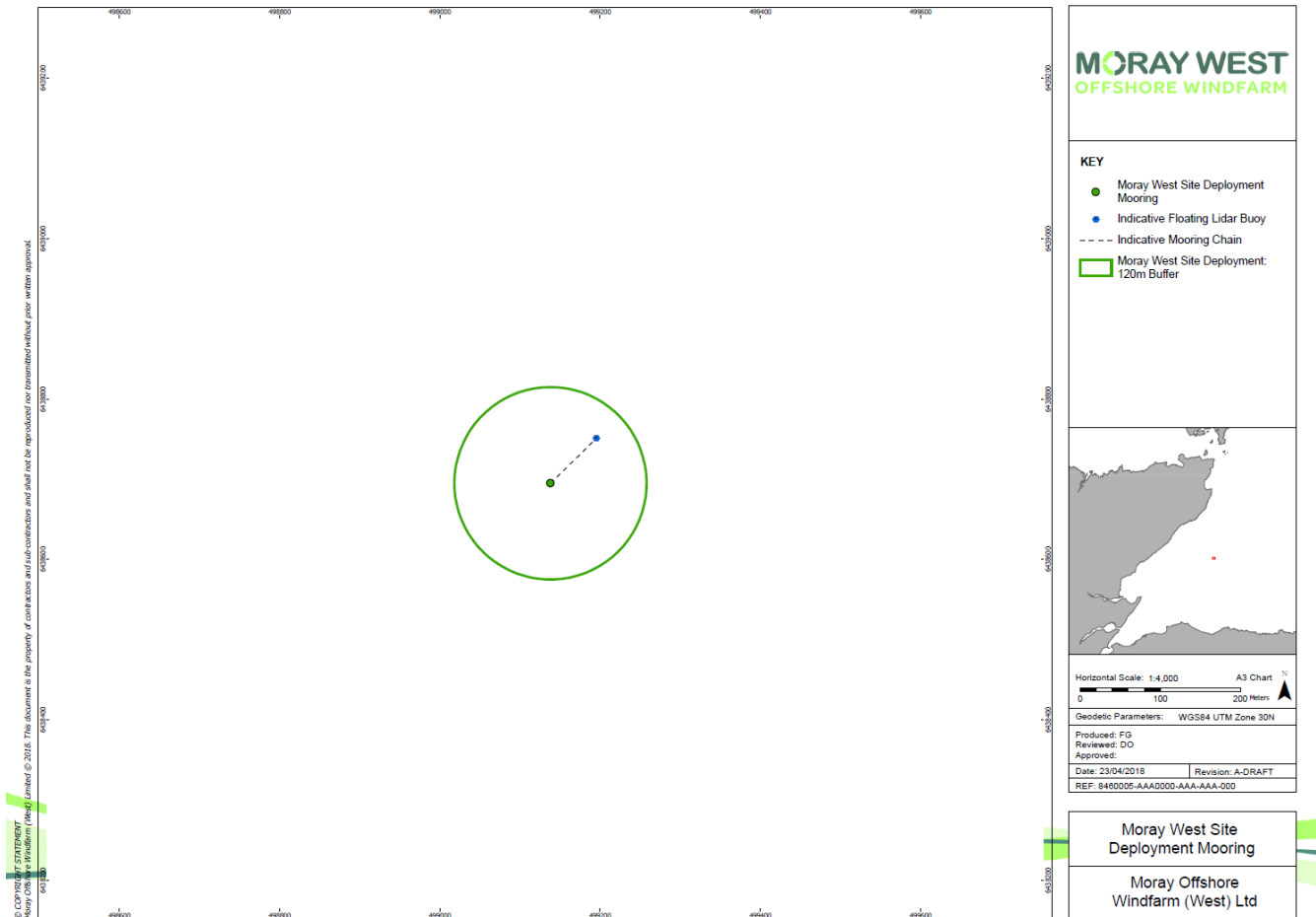


Figure 5 – Location 2: Floating LiDAR Buoy at the Moray West Site

Figure 5 presents the location of the Floating LiDAR Buoy at the Moray West Site. Unfortunately, detailed bathymetry is not available at this location and therefore has not been presented. The water depth however is known to be between 44 – 48 m.

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS
Final
01-05-2018
Revision 1.0

1.4 Deployment Methodology

Moray West have contracted EOLOS Floating Lidar Solutions to carry out the scientific instrument deployment. EOLOS will sub-contract a Marine Contractor for the installation, Operations and Maintenance (O&M) and decommissioning of the Floating LiDAR Buoy. All vessel contractors (Marine Contractor) used in the project will be certified according to the national codes of practice, laws and regulations.

Once the EOLOS FLS200 LiDAR Buoy (the Buoy) is completely checked quayside and ready for deployment, there are two possible ways of deployment (Figure 3):

- Towing (preferred).
- On vessel and lifting down from vessel deck.



Figure 6 - Top left: Lifting down installation option, FLS200 + mooring on vessel deck; Bottom left: FLS200 towing operation; Right: FLS200 lifting to vessel deck with upper mooring

The type of vessel used for deploying the Buoy to and from each deployment location will be a shallow draft anchor handling tug / utility type vessel. Once details of this vessel are confirmed they will be communicated to Marine Scotland Licensing Operations Team (MS-LOT).

Moray Offshore Windfarm (West) Limited

8460005-DCOAM-001-MLS

Final

Floating LiDAR Deployment Marine Licence Application Supporting Information

01-05-2018

Revision 1.0

The deployment vessel will transport and install the Buoy at Location 1 (Validation Trial Deployment) for a period of one month. The duration of this operation will last up to two days and the vessel will return to a selected local port/harbour.

After the Validation Trial Deployment, the deployment vessel will travel to site, remove the Buoy from Location 1 and transport and install it at Location 2 (Moray West Site) for a period of twelve months. The duration of this operation will last up to two days and the vessel will return to a selected local port/harbour.

Moray West (and EOLOS) will inform MS-LOT, Crown Estate Scotland (CES) and issue a Notice to Mariners in advance of any installation and maintenance works as well include a notice in the Kingfisher Fortnightly Bulletin.

Additional information on deployment methodology is included in the draft EOLOS Launch and Recovery Manual that accompanies the marine licence application.

1.5 Operations and Maintenance (O&M)

1.5.1 Scheduled Maintenance

Maintenance is scheduled to take place every 6 months. An offshore check will be performed according to this programme and therefore one maintenance check is scheduled to take place half way through the campaign at Location 2. The duration of scheduled maintenance is expected to last up to two days. Accessing the Buoy according to health and safety requirements will be performed to execute maintenance checks. Visual inspection will be performed to ensure buoyancy, stability, absence of damages or vandalism, dirt and overall condition.

It may be required that the Buoy is brought onshore to perform additional corrective maintenance works. The Buoy's properties allow onshore works to be performed (if required) at a harbour close to the Moray West Site, optimizing schedules and minimising periods of unavailability.

Moray West (and EOLOS) will inform MS-LOT, CES and issue a Notice to Mariners in advance of any scheduled maintenance as well include a notice in the Kingfisher Fortnightly Bulletin.

1.5.2 Unscheduled Maintenance

Moray West (and EOLOS) will monitor in near real time the Buoy's system, operational state and the quality of data recorded. An automatic system will generate different alarms (see Section 2) to both ensure and to advise specific personnel in case of any incident. Each one of the alarms is associated to a specific EOLOS action protocol. The list of EOLOS' safety and data quality protocols include:

- Protocol 1 – Missing data
- Protocol 2 – Data updated
- Protocol 3 – Data error
- Protocol 4 – Out of position
- Protocol 5 – Operational error
- Protocol 6 – Safety error
- Protocol 7 – Power error

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS
Final
01-05-2018
Revision 1.0

Predictive maintenance is carried out to avoid potential data loss, in addition to any incidence or anomaly that may affect the system's safety, integrity or hinder future operations. Any recorded incident will be analysed and managed independently. If necessary, a scheduled/unscheduled maintenance check will be performed as soon as possible. Moray West (and EOLOS) will inform MS-LOT, CES and issue a Notice to Mariners in advance (if possible) of any unscheduled maintenance as well include a notice in the Kingfisher Fortnightly Bulletin (if possible).

1.6 Decommissioning

After the wind resource and metocean data gathering campaign, Moray West will fully decommission the EOLOS FLS200 LiDAR Buoy to ensure total recovery of all material from the Moray East and Moray West Sites. The Buoy will be collected, the moorings detached from the buoy and loaded onto a vessel, and the buoy with all of its equipment transported to port/harbour. All elements of the mooring systems will be removed at the end of the metocean data gathering campaign.

The duration of decommissioning is expected to take up to two days. Moray West (and EOLOS) will inform MS-LOT, CES and issue a Notice to Mariners in advance of these operations as well include a notice in the Kingfisher Fortnightly Bulletin.

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS

Final

01-05-2018

Revision 1.0

2. Safety

2.1 Security of the device and risk reduction for loss of equipment

Moray West and EOLOS are aware that the risk exists of loss of equipment (and therefore of loss of data) when carrying out deployments at sea. This is the reason why strong precautionary measures (outlined below) are taken in order to minimise this risk:

- Detailed design and dynamic simulations of the mooring system.
- Simple and robust mooring structure and configuration to minimise failure.
- High flexibility and fast response in operations to facilitate the recovery of the equipment in the unlikely event that it moves off station. The high availability of the necessary vessels to operate the EOLOS FLS200 LiDAR Buoy, allows for rapid recovery in case of emergency.
- Sufficient memory capacity for more than 21 continuous months of data measurements, as well as of storage/backup generation, in order to minimise the impact of missed weather windows or difficulties retrieving the equipment.

2.2 Position Monitoring and Navigation Aids

The following sections describe the multiple Aids to Navigation (AToN) that are fitted to the EOLOS FLS200 LiDAR Buoy as outlined in the IALA Maritime Buoyage System (MBS) and positioning systems. Also, the complete structure and all the visible components are painted in yellow marine RAL 1023 according to IALA Guideline document no. *1015-Painting Aids Navigation Buoys*.

2.2.1 Obstruction light

A Carmanah M701 self-contained LED obstruction lamp has been installed on the Buoy. The lamp is programmed to display an amber group flash 5 every 20 seconds repeating (Fl (5) 20s) according to IALA regulations for Aids to Navigation (AToN) for an Ocean Data Acquisition Systems (ODAS) buoy visible from 3NM. The Navigation/Obstruction light is self-sufficient with regards to power including its own solar panel and battery with average 5-years life. It is CE approved as per EN 60945:1997.

2.2.2 Radar reflector

The Buoy has a passive radar reflector giving a homogeneous response inside a wide angle. It is an ideal passive responder, perfect for highlighting. The reflector is delivered with 3 points of measurement (0°/-15°/+15° of sight at 0°). The reflector can be used from S band to Ku band. It requires no power supply nor maintenance.

2.2.3 St. Andrew's cross

The Buoy is provided with a yellow St. Andrew cross as a special mark according to the IALA regulations for Aids to Navigation (AToN) for an ODAS Buoy.

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS

Final

01-05-2018

Revision 1.0

2.2.4 Automatic Identification System (AIS)

According to the IALA regulations, the Buoy will be equipped with an Automatic Identification System Aid to Navigation transponder (AIS-AToN) to avoid any hazards or risk during the Performance Period. After the management and request of the MMSI to the local authorities, as ODAS special mark, and depending of the local requirements, it will be installed a type 1 or type 3 AIS-AToN.

2.2.5 Positioning Alarm System

In event of a catastrophic failure of mooring or tethering, the Buoy is provided with a real time GPS and Iridium satellite communication system enclosed in the same unit, Skywave DMR-800 Inmarsat D+ satellite transceiver. This device is powered by two backup batteries.

During normal operation, a message with its position is sent every day at 07:00h UTC. An area where the Buoy is expected to move is defined (watch circle), depending of the mooring site-specific length. Therefore, in cases where the FLS200 Buoy appears to be out of the watch circle, a message with the position is sent hourly by satellite. That alarm system allows the recovery of the FLS200 Buoy.

In addition, the FLS200 Buoy is fitted with an additional positioning alarm system. This device sends a message with its position each hour from its own batteries. Therefore, in case of the Buoy going out of the watch circle, in addition to Skywave DMR-800 Inmarsat D+ satellite transceiver message, another message with the position is sent hourly by this device. This redundancy allows Moray West and EOLOS to guarantee recovery of the FLS200 Buoy in the case of an emergency response.

2.3 Emergency Response

An Emergency Response Plan (ERP) will be in place prior to deployment, which will be adapted and customised jointly with EOLOS, the Marine Contractor and Moray West for the deployment of the EOLOS FLS200 LiDAR Buoy.

The ERP is a step-by-step sequence that is used as a checklist in emergency response situations. All roles and responsibilities will be defined unambiguously. Contact details of all relevant individuals and institutions will be provided in the ERP. Every individual on-board the vessel during offshore works will be provided with a hardcopy version of the ERP and will have to keep it within reach at all times.

In particular, the following documentation will be generated together with the Marine Contractor and Moray West for the scientific instrument deployment project:

- Emergency Response Plan (ERP).
- Periodical Safety reporting.
- Accident and Incident reporting.
- Near-miss reporting.

2.4 Health, Safety and Environmental Management

The EOLOS FLS200 LiDAR Buoy has been designed and constructed to a high standard, incorporating appropriate levels of environmental control. The main energy generation system is based on renewable energy sources and all the elements, equipment and coating have been chosen for their suitability to withstand the harshest marine environment.

Moray Offshore Windfarm (West) Limited

8460005-DCOAM-001-MLS

Final

Floating LiDAR Deployment Marine Licence Application Supporting Information

01-05-2018

Revision 1.0

EOLOS is an ISO 9001 (Quality), ISO 14001 (Environment) and OHSAS 18001 (Health and Safety) Certified Company. EOLOS selects appropriate marine contractors by applying the company's Purchases Management Procedure and ensures compliance with EOLOS Quality, and HSE policy by means of applying the company's Business Coordination Activities procedure. EOLOS requires that all marine contractors guarantee compliance with the relevant Health, Safety and Environment legislation by requesting that:

- The Marine Contractor is ISO 9001, ISO 14001 and OHSAS 18001 (or equivalent) Certified, or
- The Marine Contractor has in place a has a quality assurance system that is at least equivalent to a certified quality assurance system. By equivalent, it should be understood a system which: (i) quality assurance is embedded organisation-wide (in policy), adopted by the responsible management, and promoted by that management (e.g. through a quality manual), who must be responsible for the proper set-up, implementation, and control of the quality policy; (ii) presence and organisation-wide implementation of relevant procedures concerning services/finished products, and administration of resources and documents, in which continuous improvement is an important issue to consider, (iii) presence of the internal quality cycle: measurement, analysis, and improvement of quality levels; and (iv) presence of a periodical independent and expert audit of compliance with the quality procedures.
- The Marine Contractor will operate an environmental management system in accordance with ISO 14001 or relevant best practice guidelines and will adhere to relevant statutory requirements.

2.5 Standards and Codes

The deployment and operation of the floating LiDAR system will be conducted to meet the requirements of all relevant legislation and standards. The main standards used for the design, fabrication, transport, installation, operation, maintenance and decommissioning of the Buoy are the following:

- Carbon Trust Offshore Wind Accelerator roadmap for the commercial acceptance of floating LiDAR technology (<https://www.carbontrust.com/media/422195/ctc819-owa-roadmap-commercial-acceptance-floating-lidar-technologies.pdf>).
- Carbon Trust Offshore Wind Accelerator Recommended Practices for Floating LiDAR Systems (<https://www.carbontrust.com/media/673560/owa-floatinglidarrecommendedpractice-25oct2016-final.pdf>).
- IALA Recommendation O-139: The Marking of Man-Made Offshore Structures December 2012.
- IALA Recommendation E-108: The Surface Colours used as Visual Signals on Aids to Navigation
- SOLAS – International Convention for the Safety of Life at Sea.
- DNVGL-OS-E301 Position Mooring.
- DNV RP-C205 Environmental conditions.
- Metocean Design Basis for Tromp Binnen OWF Met Mast, Metoc plc, 6 May 2010, P1375_R2290_Rev2, all rights reserved.
- Design and Analysis of station keeping for Floating Structures. Upstream Segment Recommended practice API-2SK oct 2005.
- VDI2230- Systematic calculation of high duty bolted joints with one cylindrical bolt – Verein Deutscher Engineer – Feb. 2003.

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS
Final
01-05-2018
Revision 1.0

3. Floating LiDAR Buoy Specification

The EOLOS FLS200 LiDAR Buoy is a fully-equipped and autonomous wind, wave and current measuring system based on LIDAR technology that houses a host of meteo-oceanographic instrumentation. The Buoy's structure is composed by three main parts:

- Structural skeleton formed by five cylinders in vertical position, forming a square (with one cylinder in the centre) and attached together by squared profiles. All parts are made with stainless steel.
- Four floaters placed forming a square in upper view of approximately 2 m of side, with a higher diameter of 1.6 m and truncated-cone geometry in their base.
- Shell covering all system composed by stainless steel plates and backing structure.
- The total weight of the buoy is 3 tons (excluding mooring).

The main dimensions are presented in Figures 4 and 5.

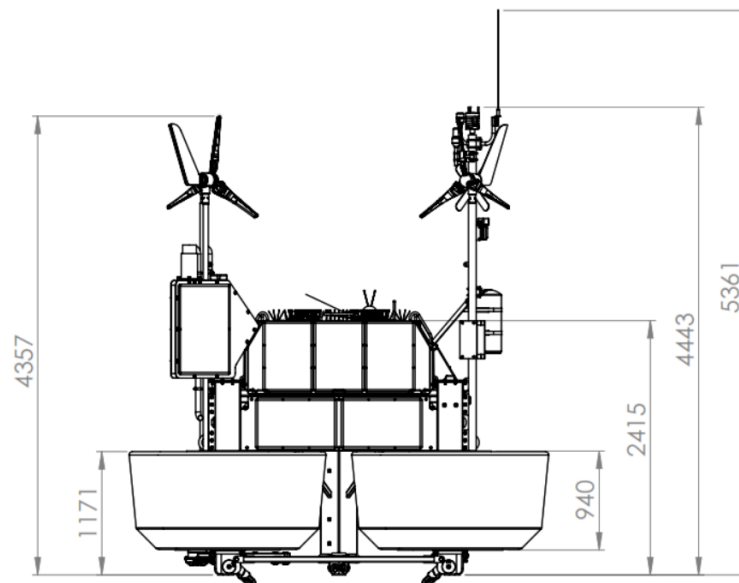


Figure 7 - Main Dimensions 1

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS
Final
01-05-2018
Revision 1.0

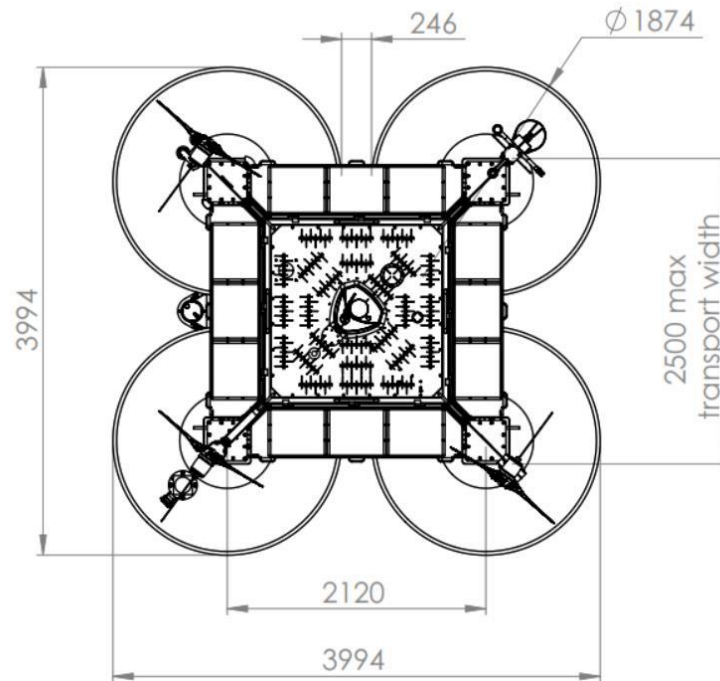


Figure 8 - Main Dimensions 2

Floaters have a toroid shape to allow metallic cylinders inside, containing the batteries utilised to store the energy, produced by the renewable energy sources or fuel cells, in order to supply all the system's electronics. These cylinders are hermetically closed, but they have a valve system to allow the introduction of inert gas. The EOLOS Buoy is equipped with:

- 22 batteries (5 batteries in each perimeter cylinder and 2 back up batteries in the central cylinder).
- 18 solar panels, providing a power up to ~980W.
- 3 wind turbines providing a power up to ~1050W, located at each vertex of the Buoy, except in prow.
- Met mast of 2m height (with respect to the Buoy's roof) installed in the prow cylinder and equipped with redundant met stations and compass.
- 1 LIDAR ZephIR 300M.
- Wave sensor inside the central cylinder.
- Current profiler installed in a support placed in the lower part of the Buoy.
- Zinc anodes to prevent corrosion.
- Inundation sensors.
- Navigation and safety aids such as Radar Reflector, Navigation Lights and St Andrews' Cross (compliant with IALA requirements).

Moray Offshore Windfarm (West) Limited

8460005-DCOAM-001-MLS

Floating LiDAR Deployment Marine Licence Application Supporting Information

Final

01-05-2018

Revision 1.0

- Data loggers, compact flash memory card, Inertial Measurement Units (IMU), and other electronic equipment located in sealed containers to protect them from the marine environment.
- Camera for video surveillance

Figure 6 presents the type of instrumentation that the EOLOS Buoy is equipped with.

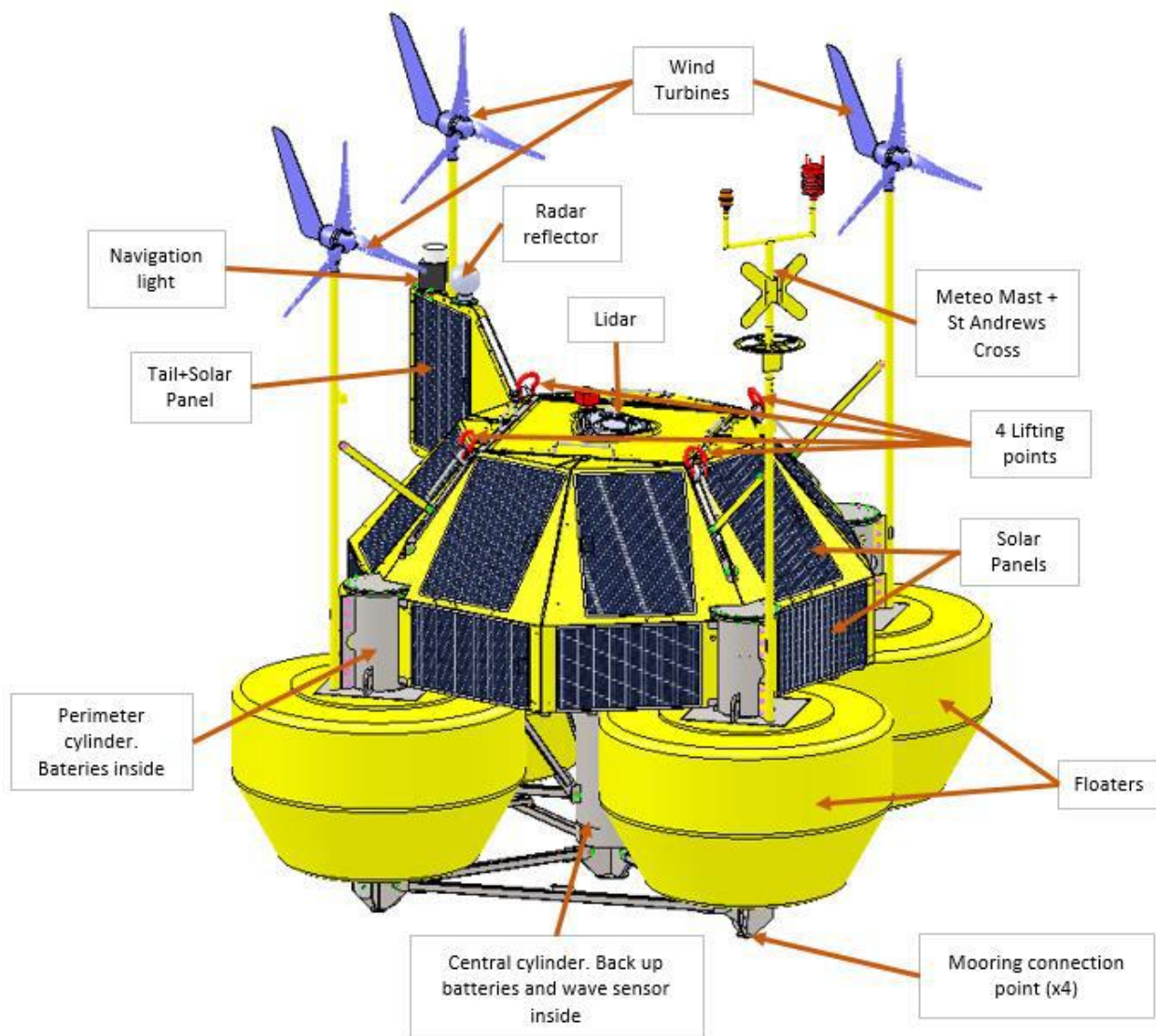


Figure 9 - EOLOS FLS200 LiDAR Buoy - Instrumentation

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS
Final
01-05-2018
Revision 1.0

3.1 Mooring System

EOLOS will undertake a complete dynamic analysis of the mooring system using multibody simulation, including a fully nonlinear model. Several wave models are possible, including the typical irregular wave spectra needed for these projects. The analysis will consider the combinations of currents, winds and waves included in order to establish the suitability of a specific mooring design.

A typical EOLOS FLS200 LiDAR Buoy mooring system consists of two main differentiated parts (Figure 7):

- The upper mooring, consisting of four lines connected as a square to the Buoy gathered in its bottom to a single line (common design for any site).
- The lower mooring, designed specifically for sites (final mooring design and calculations are specifically performed for each project).

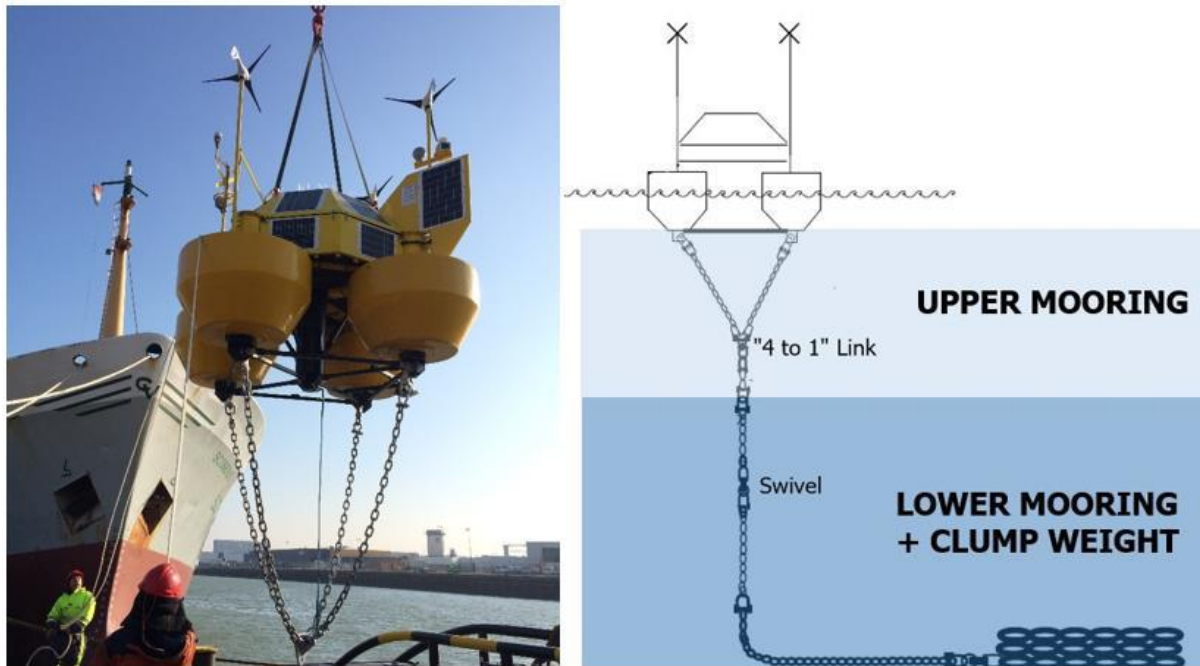


Figure 10 - Left (Upper mooring bottom view for the FLS200 Buoy) Right (FLS200 Buoy mooring scheme)

Mooring line and chain forces have limits depending on the physical characteristics of such elements to resist the deformations induced by the movements of the Buoy. Simulations have been carried out to define the survival limits of the Buoy, comparing the movements and forces over the mooring lines with the proposed thresholds.

EOLOS initial mooring proposal consists of the following parts:

- Four-legged entanglement to the four cylinders of the Buoy structure. To isolate the Buoy structure from the chain, shackles will be used.
- One union piece for the four chains coming from the Buoy. This piece will hold a zinc anode to prevent corrosion. Below the piece, a swivel is placed to absorb net rotation from the Buoy.
- The chain below the union of the four legs is intended to absorb agitation arising from Buoy movement.

Moray Offshore Windfarm (West) Limited

Floating LiDAR Deployment Marine Licence Application Supporting Information

8460005-DCOAM-001-MLS
Final
01-05-2018
Revision 1.0

- The bottom chain will lie on the bottom and provide the catenary behaviour.
- The clump weight to hold the Buoy in place.

Additional information on the mooring system is included in the draft EOLOS Mooring Proposal that accompanies the marine licence application.