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Metocean Plan for the New York Offshore Study Area

Final Report

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Report Number 16-35

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Metocean Plan for the New York Offshore Study Area

Final Report

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Abstract

The objective of the Metocean Plan (MOP) is to provide recommendations for a floating LiDAR deployment to gather wind resource data at a site within the New York Offshore Planning Area (NY OPA). The intent is to define what would be required to collect data at a quality level sufficient for developers and financiers to use when developing a wind farm.

This MOP was originally drafted as a document pertaining to the New York Wind Energy Area (NY WEA) and feedback was sought on a draft version in late 2016 through a NYSERDA Request for Information (RFI 3396). The comments received through this RFI have been included in this version of the MOP, however the document as a whole has been updated to enable its use at a generic site within the NY OSA.

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Acronyms and Abbreviations

AEP	Annual Energy Production
AIS	Automatic Identification System
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
Carbon Trust Roadmap	Carbon Trust Offshore Wind Accelerator roadmap for the commercial acceptance of floating LiDAR technology
Developer	The contracting party and end-user of a floating LiDAR system
DMAC	Data Management and Analysis Contractor
DOE	Department of Energy
DOI	Department of Interior
FLS	Floating LiDAR System
FLSS	Floating LiDAR System Supplier
GW	Gigawatt
HSE	Health, Safety and Environment
IEA RP	IEA Wind Annex 32 Recommended Practices for Floating Lidar Systems Issue 1.0, Feb 2016
IEC	International Electrotechnical Commission
KPI	Key Performance Indicator
LiDAR	Light Detection and Ranging
Measnet	Measuring Network of Wind Energy Institutes
MOP	Metocean Plan
NEPA	National Environmental Policy Act
NREL	National Renewable Energy Laboratory
NOAA	National Oceanic and Atmospheric Administration
NWP	Nationwide Permit
NYSERDA	New York State Energy Research and Development Authority
NY WEA	New York Wind Energy Area
NY OSA	New York Offshore Study Area
OSHA	Occupational Safety and Health Standards
OWA RP	Offshore Wind Accelerator Recommended Practice for Floating LiDAR Systems
ROI	Return on Investment
RP	Recommended Practice
SAP	Site Assessment Plan
SD	Standard Deviation
FLS Supplier	Floating LiDAR System Supplier
USACE	United States Army Corps of Engineers
UXO	Unexploded Ordnance

Executive Summary

This document is NYSERDA's Metocean Plan (MOP) for use within the New York Offshore Study Area (NY OSA). The MOP is part of NYSERDA's overarching Master Plan for Offshore Wind in New York State which includes supporting the deployment of 2.4 gigawatts of offshore wind by 2030.

The objective of the MOP is to define the requirements of a floating LiDAR deployment to gather wind resource data at a site within the NY OSA. Other metocean data would also be collected simultaneously such as wildlife and vessel movement data.

Floating LiDAR data collection is the only method considered in this document. The key reason is that the confidence in floating LiDAR technology has greatly increased in recent years. However, deployment of floating LiDAR requires a robust set of requirements to ensure bankable data is obtained and that developers and financiers are sufficiently comfortable to use the data when further developing the wind farm.

Floating LiDAR devices should follow the Carbon Trust Roadmap for commercial acceptance and meet all the requirements of Stage 2 to be considered for deployment. The devices should also carry out a pre-deployment verification alongside a trusted reference source, which has been expanded to include onshore LiDAR and platform mounted LiDAR due to the lack of fixed offshore met masts in U.S. waters. The pre-deployment verification should take place in waters representative of the sea states expected within the NY OSA to minimize uncertainties from the data.

Floating LiDAR systems should be sited away from sensitive environmental receptors such as benthic habitats, and protected areas. Human considerations such as fishing and shipping should also be considered, alongside hard constraints such as unexploded ordnance. Location may also be impacted by the variability of wind resource across a prospective wind farm and devices should be positioned to maximize the ability to understand this.

Deployment should run for an absolute minimum of 12 months, although it is recommended that 24 month campaigns are carried out dependent on the permits available.

Floating LiDAR system suppliers should be required to support Developers in obtaining and complying with any permits required to deploy the systems. It is noted that BOEM is currently undertaking a review of the permitting system for floating LiDAR buoys under their Site Assessment Plan process. Therefore, any updates to this should be considered prior to deployment.

The floating LiDAR system supplier will be responsible for the maintenance of the devices during the deployment and the devices must be able to fully function for a full six months without an offshore maintenance visit. The devices must be monitored on an on-going basis during the deployments.

Floating LiDAR systems collect measured quantities of wind speed and direction, turbulence intensity, and air temperature, pressure, and humidity along with height and datum used. This data should be collected across a minimum of five heights which are representative of the rotor swept area of a typical wind turbine that might be installed in the area. The system should also measure metocean quantities such as significant maximum wave height and mean wave period, as well as current profile.

A separate data management and analysis contractor should be employed who is completely independent of the floating LiDAR system supplier. This contractor would be responsible for collecting, transferring, and storing the raw data as well as analyzing the data in relation to KPIs set out in Carbon Trust's Recommended Practices for Floating LiDAR document. The contractor would also provide technical assistance at the campaign design stage and assist in any queries throughout the duration of a campaign. Upon completion of the deployments, devices must be fully decommissioned to minimize any residual impacts once removed.

1 Background

1.1 Introduction

NYSERDA seeks to bolster the development of both distributed and large-scale renewable energy resources, like offshore wind, to meet the State's Clean Energy Standard. This ambitious policy mandates 50 percent of all electricity consumed in NYS by 2030 comes from renewable energy sources. Offshore wind will work together with land-based wind farms along with other renewable energy technologies like solar, to create a cleaner energy system across the State.

In NYS, wind turbines are currently only on land while offshore wind turbines have been operating continuously in Europe since 1991. Seeking to create a 21st century energy system, Governor Andrew M. Cuomo called for the development of an offshore wind strategy in the 2016 State of the State address. Known as the Master Plan, the State's strategy will provide a comprehensive roadmap to advance offshore wind in a manner that is sensitive to environmental, maritime and social issues while addressing market barriers and lowering costs. Furthermore, in his 2017 State of the State address, Governor Cuomo pledged a commitment to develop 2.4 GW of offshore wind in NYS by 2030.

The Master Plan envisions NYSERDA conducting predevelopment assessments, studies and surveys, and in-depth analysis of field data with the goal of reducing and mitigating risks of offshore wind development. Reduced uncertainty leads to lower development and energy costs. By NYSERDA conducting predevelopment assessments in collaboration with State stakeholders, local environmental and economic interests will be better protected.

This document comprises a Metocean Plan (MOP) for a prospective offshore wind farm within the NY OSA. Its goal is to set out the recommended parameters for a wind resource assessment that NYSERDA or a developer could carry out at a potential offshore wind farm site. The aim of the MOP is to define the scope of a wind resource assessment that would provide bankable and reliable wind resource data for a wind farm developer in an effort to reduce uncertainty and risk while increasing attractiveness to developers and investors.

1.2 Document Structure

The document covers all the variables that feed into the planning and execution of a successful wind resource assessment. This includes the project management and organizational structure of a campaign followed by technical details of floating LiDAR validation and selection of location and duration of the deployment. As permits are a requirement when deploying the systems, the current permitting process is described in this document. Finally, the maintenance and logistical issues regarding a deployment as well as data collection and analysis are described in order to ensure the smooth operation of the campaign and successful dissemination of results.

The end user of the data is referred to throughout the document as the Developer.

At each stage, the requirements of a floating LiDAR system (FLS) supplier are clearly set out, along with any recommendations that should be considered when suppliers submit their proposals to a Developer. The requirements of a data management contractor, who should remain independent, are also set out to define the line between the two and maintain the integrity of any data collected.

1.3 Site Background

1.3.1 History

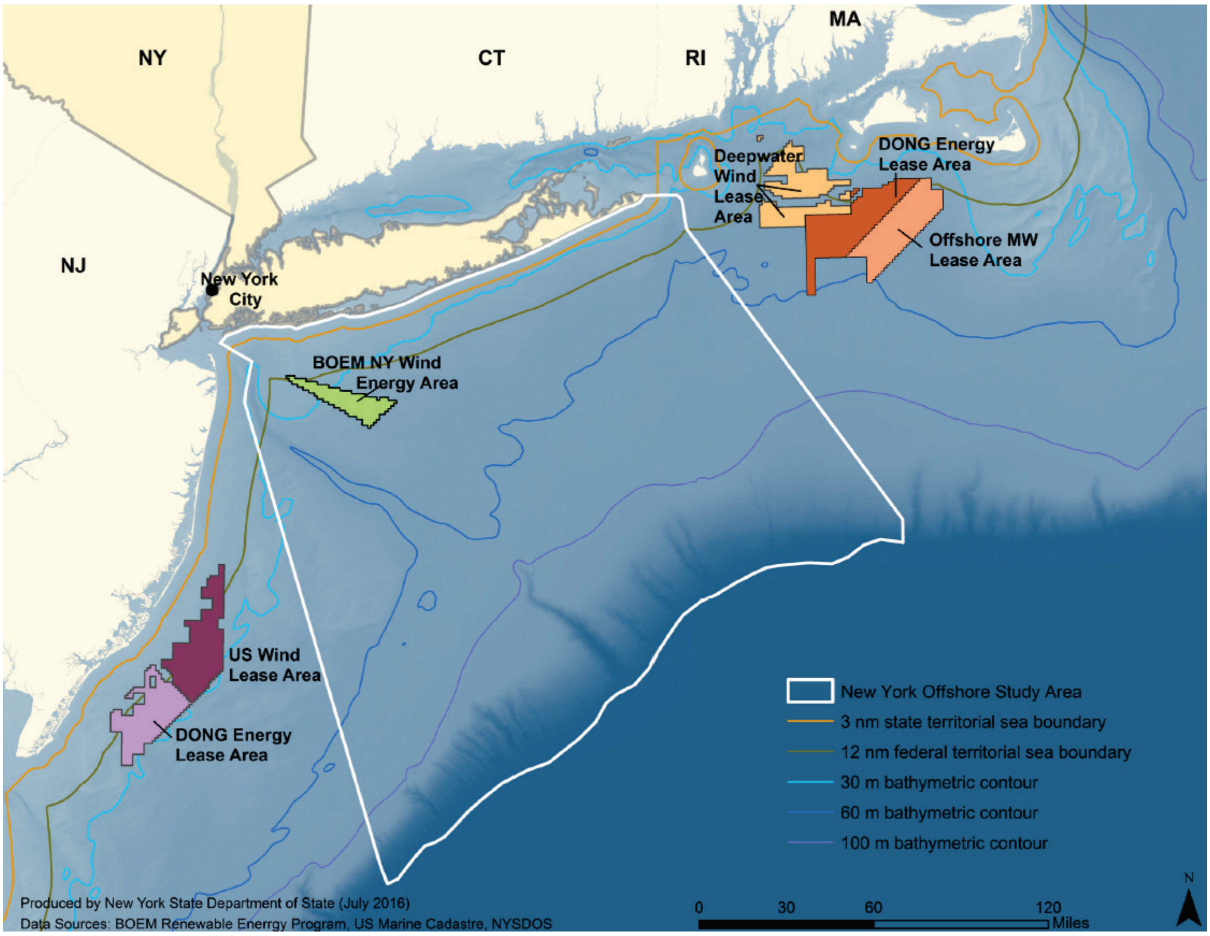
The NY OSA is an area off the coast of the State of New York. The NY OSA is defined in the Blueprint for the New York State Offshore Wind Master Plan[1] and covers approximately 16,740 square-miles from the south shore of Long Island and New York City to the continental shelf break. The intention is to carry out predevelopment studies in this area to identify key areas for future offshore wind sites.

The NY OSA is the same area identified as the 'New York Offshore Planning Area' by the New York State Department of State in their 2013 document 'New York Department of State Offshore Atlantic Ocean Study'.[2]

NYSERDA's contribution to the acceleration of offshore wind deployment is in harmony with the wider DOE/DOI U.S. Offshore Wind Strategy.[4] The strategy document aims to define the vision of the offshore wind energy policy and its ambition to deploy 86 GW of offshore wind capacity in U.S. waters by 2050. This includes areas of particular focus where it is acknowledged that there is work required to increase the knowledge and skill base of the U.S. as well as to apply lessons learned from Europe. One of the focuses is in wind resource assessments and ensuring the U.S. adopts the latest technological advances to minimize the cost and maximize the data quality of its developments. The aim of this is to increase the attractiveness of the U.S. as a country to build and invest in offshore wind.

The State's strategy is also for 50 percent renewable energy by 2030,[4] a key part of this is offshore wind. Not only is the goal linked to a capacity target, but NYS also aims to deploy this at least cost.

Figure 1-1. Map of NY OSA (1)



1.3.2 Summary of Existing Information

To date, there is limited metocean information and data available specific to the NY OSA. Work carried out by the NYS Department of State provides the most focused collection of existing data in this area.[2] Most pertinently for this report it referenced coarse wind modeling carried out by NREL in 2010,[7] which indicated good levels of wind resource across the NY OSA. While this modeling does not provide all the answers, it gave an indication that further work should be carried out and that there is significant potential for offshore wind in the area.

NYSERDA has since carried out more focused studies for the NY WEA, which indicated mean wind speeds of approximately 8.8 m/s (±0.3) within this area. Whilst the focus of this MOP is not on the NY WEA, this remains a positive indication that wind speeds in the wider area are high enough to consider wider expansion of offshore wind. This supports the conclusions drawn from NREL's modeling.[7]

To date, work has focused on collating existing information. With the publication of the Blueprint for the New York State Offshore Wind Master Plan there is now a structure in place to build on this and collate new data. Actions cited in the Blueprint include measurement meteorological data, and therefore, this MOP provides a basis for future campaigns that may endeavor to carry out this action. Furthermore, the data collected may also be fed into future data analysis and modeling to inform future decision making.

1.4 Goals of the MOP

The core goals of the MOP are:

1. Accelerate the deployment of offshore wind energy development off the coast of the State.
2. Reduce the cost of offshore wind and maximize the benefit for rate payers in NYS.
3. Obtain and publically disseminate high quality, bankable metocean data sufficient to conduct a robust wind resource assessment for yield prediction purposes or to inform further studies to better understand the wind resource in the NY OSA.

The MOP is made available to the public for future use or adaptation for any site within the NY OSA or for further strategic planning by NYSERDA. NYSERDA recommends the use of the MOP to ensure the services and materials specified in the procurement are appropriate for collecting high quality, bankable data.

Statements of responsibility and activities in the MOP were developed to emphasize their relative importance. They are divided into two primary categories, requirements and recommendations. Within these categories directed statements such as “will,” “must,” “should,” “could,” etc., are included to further refine or highlight the relative need.

2 Collaboration and Coordination

2.1 Requirements and Recommendations

2.1.1 Floating LiDAR System Supplier (FLSS)

2.1.1.1 Requirements

- The floating LiDAR supplier will be required to report directly to the Developer.
- The floating LiDAR supplier and the Data Analysis and Management Contractor must be independent entities with no commercial ties or conflicts of interest.

2.1.1.2 Recommendations

- Any proposal to deploy an FLS may also incorporate additional data collection such as wildlife and/or AIS data however this must not compromise the integrity of the primary data collection.
- The FLS supplier should endeavor to seek efficiencies during installation, operation, and decommissioning to minimize cost and maximize data collection.

2.1.2 Data Management and Analysis Contractor (DMAC)

2.1.2.1 Requirements

- The DMAC will report directly to the Developer.
- The DMAC must be completely independent of the FLS supplier.
- The DMAC will be responsible for certifying the verification of the FLS.

2.1.2.2 Recommendations

- The DMAC may be required to provide services to store or process any additional data (such as wildlife and/or AIS data).
- The DMAC may also be engaged, as required, to provide technical assistance with initial analysis of relevant metocean design parameters or further outputs to the Developer such as long-term, climatologically adjusted datasets to inform energy yield predictions.

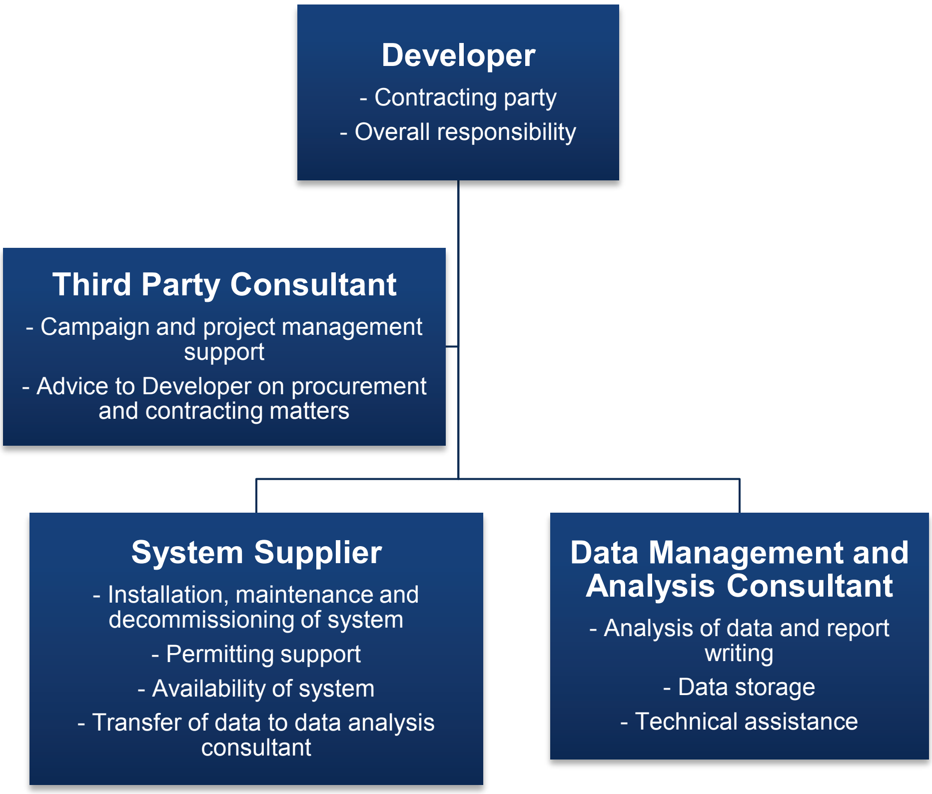
2.2 Coordination

2.2.1 Project Organization

The structure of the parties involved in the Metocean Campaign is set out in Figure 2.1 - Organizational Structure of the Metocean Campaign. As the contracting party, the Developer would retain overall coordination and management of the campaign however they may, as desired, procure the support of a 'Third Party Consultant' to assist with project management and practical support. Responsibilities between these two parties may vary dependent on the level of management of the campaign required. The FLSS (buoy, LiDAR, mooring, etc.) will work independently of the DMAC in order to retain the objectivity of the data. It is also advised that the DMAC and the Third-party Consultant remains independent to ensure a clear boundary between data integrity matters and contractual and practical matters. It is strongly advised that all parties work together from the start of any such campaign in order to improve coordination and maximize the benefit and efficiencies of a deployment.

The anticipated division of responsibilities are provided within Figure 2-1.

Figure 2-1. Organizational Structure of the Metocean Campaign



2.3 Interfaces

There will be several interfaces throughout the campaign and it is therefore important to highlight some of the key areas and the expectations therein.

2.3.1 Developer/Third-party Consultant – FLSS

- The Developer/Third-party Consultant should coordinate with the FLSS to obtain key specifications of the FLS to be deployed. This will inform permitting requirements as well as safety and navigation requirements that ultimately the contracting party will be held accountable for.

- If the contract between the two parties is a data service contract—that is the Developer is purchasing the data from the system and not the system itself—there will be a requirement to undertake regular reviews of performance of the system throughout the campaign to ensure the system is meeting the standards expected within the contract. (It is recommended that this is carried out regardless of the contract structure.)

2.3.2 Developer/Third-party Consultant – DMAC

- The Developer/Third-party Consultant should seek technical assistance in campaign design. The DMAC is responsible for advising on technical issues pertaining to bankability and quality of data and should feed this information into the planning stage as necessary.
- The DMAC may also be required to provide technical input during the campaign on an ad hoc basis (for example should there be an outage for a sustained period).
- The Developer/Third-party Consultant and DMAC should maintain regular contact throughout the campaign, and the DMAC should flag any major anomalies or concerns in the data as soon as practicable.
- The DMAC may also be required to produce additional outputs at the request of the Developer to inform annual energy production (AEP) calculations or other studies as appropriate.

2.3.3 DMAC – FLSS

- The DMAC should certify the verification and validation of the FLS by the FLSS.
- The DMAC should certify that commissioning of the FLS is carried out correctly by the FLSS and that there are no potential issues that may affect the integrity of the data collected.
- The DMAC will be required to carry out regular checks on the data provided by the FLSS. The FLSS will be required to provide this data on request as necessary, and provide the final raw data at the end of the campaign to the DMAC for analysis.

2.4 Areas for Collaboration

2.4.1 Within the Wind Energy Area

2.4.1.1 Wildlife Data

While deploying an FLS, there will be the opportunity to simultaneously collect other data in addition to the required metocean data (section 8.2).

While high-quality wildlife surveys are designed to provide a more complete understanding, leveraging a metocean buoy deployment with a wildlife survey can bring additional value. For example, the next generation of floating LiDAR devices are being designed to incorporate additional environmental sensors such as marine mammal hydrophones and bird and bat acoustic detectors. Data could also be obtained using infrared thermal imaging cameras or standard cameras. Alternatively, a hydrophone could be deployed separately, but using the same vessel located near the FLS to maximize efficiencies relating to vessel charter and personnel cost.

This data could be useful in providing initial indications of the timing and density of aerial vertebrates or marine mammals in the area as well as for providing baseline projections of ambient noise to feed into any future environmental impact assessment that studies the impacts of operations such as piling on receptors.

Prospective FLSS should consider how their systems may be able to accommodate such additional sensors when submitting their proposals. However, it should be made clear that the primary data collection (metocean) should not be compromised and critical power should be prioritized to the primary sensors.

2.4.1.2 Chemical and Biological Data

Additional sensors can also be fitted to buoys to provide further information on chemical data within the water. Such sensors can measure dissolved oxygen and chlorophyll production, which can help developers plan for potential marine growth issues during the operation of a wind farm.

2.4.1.3 Automatic Identification System (AIS) Data

In addition to wildlife data, AIS data could also be collected using the FLS. AIS sensors are used on ships to identify and locate vessels for safety reasons. The range of a typical AIS system is up to 20 miles. Collecting AIS data would provide a valuable source of data for a prospective environmental assessment and could serve as an important secondary data source for vessel density information when planning wind farms in the NY OSA.

AIS data is also used in identifying marine traffic relating to commercial fishing in the area and could provide valuable input into assessing the potential impact of a wind farm on commercial fishing.

2.4.1.4 Camera

A camera may also be fitted to an FLS to provide additional information on visibility and to monitor bird activity and potential vandalism.

3 Floating LiDAR Selection and Validation

3.1 Requirements and Recommendations

3.1.1 Requirements

- The LiDAR used for the system selected for must be verified through onshore tests in accordance with the guidelines set out in IEC 61400-12-1, Annex L.[9]
- The FLSS (type) must have reached Stage 2 of the Carbon Trust Roadmap using one of the following offshore references:
  - Fixed offshore met mast.
  - LiDAR mounted on a fixed offshore platform.
  - Onshore met mast sufficiently close to shore with minimal flow disturbance.
  - LiDAR located onshore or on a pier with minimal flow disturbance.
- The FLSS (unit) must undertake a predeployment verification before deployment, following RP89 and 91 of the OWA RP.[8]
- During the deployment, data will be reviewed by the DMAC on an on-going basis to check for any obvious errors or technical issues.
- Upon conclusion of the campaign, the data collected will be analyzed by the DMAC to check for any systematic errors. If evidence of errors is found, the DMAC may require a two-week onshore verification to identify and investigate these errors.

3.1.2 Recommendations

- LiDAR models that demonstrate they have previously met the KPIs set out in the Carbon Trust Roadmap[9] on at least two different offshore trials and on more than one buoy design should be preferred.
- Any pre-deployment verification and validation should take place in sea states as representative of NY OSA as feasible. Proposals that consider this along with a strategy to accommodate this and evidence of minimizing the uncertainty within measurements will be favored.
- FLSS should consider whether their system can mount more than one LiDAR and describe how this could impact the uncertainty of their measurements.

3.2 Selection of Floating LiDAR

3.2.1 Overview

When developing an offshore wind site, detailed data must be collected regarding wind speed, direction, and other metocean conditions. This is to inform optimal site layout, design and operation, and perhaps more importantly, to understand the predicted wind resource at the site for a given design of wind farm.

There are two stages in this assessment: the first is to collect data at the site upfront, and the second is to analyze the raw data in conjunction with the proposed wind farm design to translate this into an expected annual energy production (AEP) estimate. This information is relied upon by funders and advisers when assessing the risk of project developments. Therefore, it is essential that the wind resource data and measurements are seen as reliable, accurate, and bankable for the purposes of AEP calculations regardless of project funding structure.

This data can be collected in a number of ways, including met masts, fixed and floating, and even scanning LiDARs. When deciding which option is most appropriate for a given campaign, one of the main considerations is finding the best balance between upfront cost and uncertainty reduction. This uncertainty evolves with the project as data gathering exercises generally become increasingly costly.

When collecting onsite data, there are a range of options available. These include meteorological masts and various forms of LiDAR measurement systems, including floating LiDAR, scanning LiDAR and fixed vertical profiling LiDAR among others. Different options will be appropriate for different sites, and so there is no one-size-fits-all approach as each deployment must be assessed on a case-by-case basis. As there is no guarantee that the wind farm will be developed, the upfront investment of a full met mast may not be the best approach and you could reach similar conclusions with lower cost methods such as floating LiDAR deployments. This also leaves the option open, if the data collected is favorable yet marginal, to collect further data through a met mast deployment, or in a more likely scenario, further floating LiDAR deployments.

3.2.2 Approach for NY OSA

This document is focused on the use of floating LiDAR to collect data so the construction of a met mast is not required. The key reasons are that the confidence in floating LiDAR technology has greatly increased in recent years as significant advances have been made in the technology. There are a range of devices available on the market with numerous validation campaigns and trials conducted globally. This collective understanding and experience in the technology, as well as the track record of delivering accurate and reliable data, has underpinned floating LiDAR’s role. Indeed, a number of projects are now choosing to install fewer met masts or do away with them altogether, and replace with FLS’. This move greatly reduces the cost of developing a zone in many cases, offering greater confidence and flexibly to developers and advisers alike.

It should be noted that the information in this section is based primarily on a number of key documents, including the OWA Floating LiDAR Recommended Practice (OWA RP), the IEA Floating LiDAR Recommended Practice (IEA RP), the Carbon Trust Offshore Wind Accelerator Roadmap for the commercial acceptance of floating LiDAR technology (Carbon Trust Roadmap) and the IEC61400-12-1 CDV/Annex L.[8,9,10] Although these documents were primarily drafted for the European market, this section follows the recommendations and requirements cited. In a number of key areas, the recommended approach goes over and above what is stated in the various standards and recommended practices in order to reflect that these recommendations are being made for a U.S. project.

3.2.3 Turbulence intensity measurements

Turbulence intensity measurements will be taken by the FLS. Once the wind resource is assessed in more detail alongside available turbulence calculations, a review can be made as to whether further onsite measurement is required.

Although not strictly within scope of this MOP, it is worth noting the differences in approaches when evaluating turbulence measurements. Assessing turbulence informs turbine performance modeling and wake modeling in energy yield calculations, and is also necessary for structure design and turbine selection. To date, the use of LiDAR (both fixed and floating) for turbulence assessments remains a research topic [11], and met masts are currently the only way to accurately gain this information through onsite measurements.

However, turbulence and extreme wind data could be determined by other means. If an onshore met station indicates low turbulence, then this could be assessed to conservatively apply to the offshore site, which may allow a lower-turbulence turbine class and a relatively cheap support structure design. On the other hand, if high turbulence is indicated, it would be required to prove that less severe conditions apply offshore (as is usually the case) through modeling, which is inevitably more uncertain than measurements.

If onsite measurements are required, a quasi-static spar buoy or platform instrumented in the same way as a met mast could be used instead of a fixed structure. However, this approach has not yet been seen in the market and would need further study and consideration before deployment.

3.2.4 Site specific considerations

For site data nearer to shore, scanning LiDAR or Doppler radar could be options, however, these would not be advised as they are not yet commonly used for AEP assessments (although this may change in future).

The two technologies currently used for wind resource assessment are primarily met masts and floating LiDAR. Although met masts have historically been favored, recent developments and validation of FLS' have greatly increased the confidence and understanding of this technology. For example, a recent paper by DONG Energy[12] has stated that it is "difficult to see met masts in DONG Energy's future." The same paper provides a very cogent description of how wind resource measurements add value to an offshore wind farm development. Floating LiDAR offers a number of advantages over met masts including:

- Significantly reduced upfront capital expenditure. FLS' cost $2-3 million compared to a met mast at around $15 million depending on the site.
- Increased flexibility. Floating LiDAR devices can be moved around a site if required and offer greater flexibility of deployment locations.
- Accelerated deployment. The timescales required to deploy FLS' are generally significantly less than required for a met mast due to reduced technical challenges and permitting timelines.
- Measurement ability. LiDAR systems are typically able to measure to higher altitudes than a conventional met mast thus increasing the flexibility of measurement requirements and are more suitable for contemporary offshore turbines.

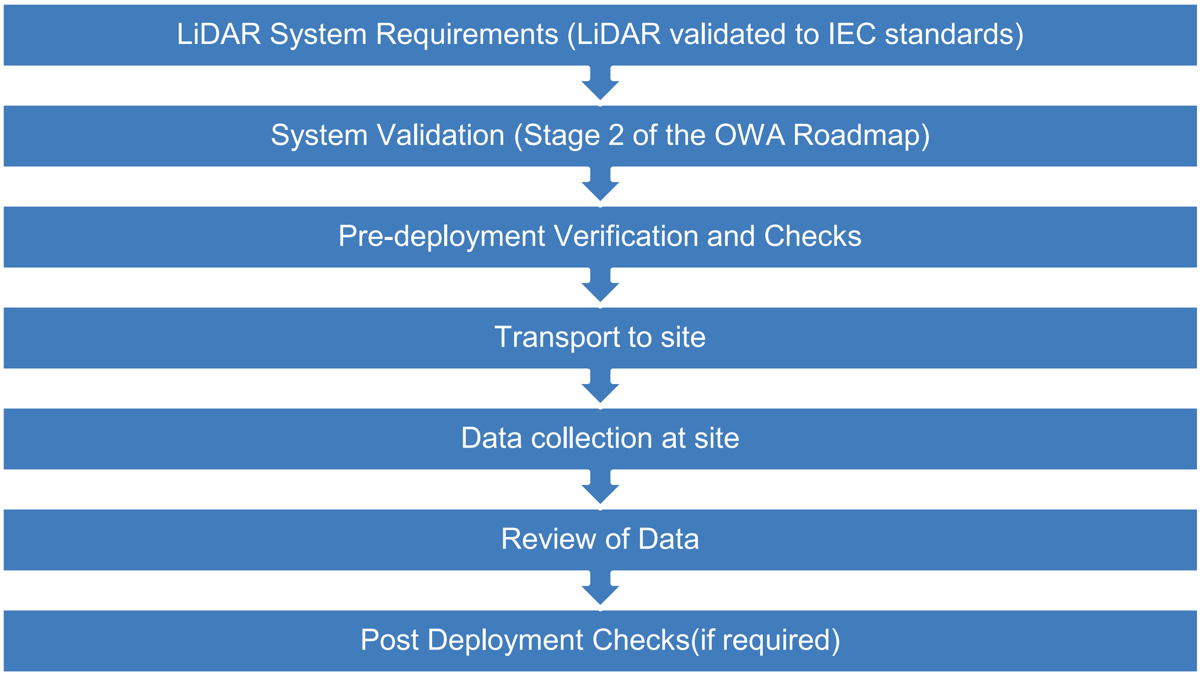
The key advantage of met masts over FLS' is that they have a greater track record of providing wind resource assessment data for both offshore and onshore wind projects.

3.3 LiDAR System Validation and Verification Requirements

FLS validation and verification is key to the bankability and confidence in the data from any offshore campaign. Although many guides and recommended practices set out the requirements for such validation, there is no set approach and many options are open to LiDAR suppliers when validating their system.

There are several stages in the validation process, including a separate validation of the LiDAR itself as well as the performance of the buoy in an offshore environment. Figure 3-1 sets out the main steps required throughout the process with each stage covered in detail.

Figure 3-1. Overview of Validation and Verification Process



3.3.1 LiDAR system requirements

The LiDAR system selected for a campaign must be verified through onshore tests in accordance with the guidelines set out in IEC 61400-12-1, Annex L.[10] The LiDAR should be well accepted within the industry and have been used in numerous onshore or offshore trials with success demonstrating high levels of accuracy and reliability, and meet the best practice criteria set out in the Carbon Trust Roadmap.[9] In addition, the guidelines on verification, industry acceptance and motion compensation as set out in the OWA RP document,[8] including RP57 – 60 inclusive must be followed.

To maximize the confidence in the data, preference will be given to exact floating LiDAR models (not necessarily the system itself) that demonstrate they meet the KPIs set out in the Carbon Trust Roadmap[9] on at least two different offshore trials. Additional preference will be given to LiDARs that have been validated on more than one buoy design.

There is the possibility of mounting more than one LiDAR on the buoy, depending on the buoy design. This has the advantage of increasing the likelihood that one of the systems will be operational. Alternatively, two systems could be deployed at one location to further increase the redundancy available.

3.3.2 System validation

The most widely accepted guidance document for FLS validations is the Carbon Trust Roadmap.[9] However, this document relies on an offshore IEC compliant met mast to validate the floating system. Although there are several in the pipeline, there are currently no operational met masts located in offshore U.S. waters. Therefore, the guidelines set out in the Carbon Trust Roadmap[9] must be adapted to allow for other validation approaches. Typically, campaigns are designed to minimize uncertainty to ensure bankability of data, therefore, a more conservative approach has been recommended than may be required for other campaigns. In the absence of appropriately detailed guidelines, it is advised that the following principles apply.

The FLS must demonstrate reaching Stage 2 as set out in the Carbon Trust Roadmap,[9] with the allowance that this may not be required to be tested against an IEC compliant offshore met mast as required in the roadmap. Instead, it can be validated against another appropriate offshore reference.

It is important to make the distinction between an FLS type and the unit itself. The system validation applies to the type, therefore, if an FLS type was previously validated and met the criteria of Stage 2 in the Carbon Trust Roadmap,[9] then system validation may not be required. However, the floating LiDAR supplier must demonstrate that the use condition and sea state of the validation trial do not bring in too much additional uncertainty similar to the sea states expected in the NY OSA.

The trusted reference source should be among the following:

- **Fixed offshore met mast.** Although this is the standard approach, the process of transporting the FLS any significant distance will raise the uncertainty of the performance of such a system. The preference is for the validation to take place within easy transportation distance of the measurement site itself. There are several plans for fixed offshore met masts to be installed in offshore U.S. waters, and therefore, if these can be used in the requisite time frames this would be acceptable. Alternatively, a technical case or track record of transporting the system may be considered in any proposal provided a sufficiently robust and scientific case is made.
- **LiDAR mounted on a fixed offshore platform**. This platform could be any stable structure, such as an oil and gas platform or offshore wind turbine. It is likely that the platform may contribute to flow distortion around the test buoy, therefore wind directions in the sector surrounding any structure should be excluded from the validation. The reference LiDAR should comply with the validation requirements set out in the LiDAR System Requirements section. As stated, the LiDAR on a fixed offshore platform must be within easy transportation distance of the measurement site itself, otherwise a scientific case must be made for an exclusion.

- **Onshore met mast sufficiently close to shore with minimal flow disturbance**. There is no set requirement for how close or far the met mast must be from shore, but the distance from the shore to the FLS should be maximized, and the distance between the met mast and the floating LiDAR minimized where possible. RP 78 in the OWA RP[8] recommends that the separation between the system and reference should be no more than 500m. However, in this instance, the distance is likely to be greater. The effect on distance and flow distortion should be assessed in detail by a trusted independent technical adviser.
- **LiDAR located onshore or on a pier with minimal flow disturbance**. As with the met mast reference above, the distance from the shore to the FLS should be maximized, and the distance between the reference LiDAR and the floating LiDAR minimized where possible. Although, it is recognized that this is likely to be greater than the recommended 500m maximum distance. Again, the effect on distance and flow distortion should be assessed in detail by a trusted independent technical adviser.

In any of the above cases, the independent assessment of the validation trial should cover the suitability of the reference system. RP77 in the OWA RP[9] must be followed in full.

Overall, whichever approach is adopted or proposed by an FLS supplier, their proposal must detail which validation method is proposed and a technical analysis of the methodology provided showing that it is:

- Clearly justified.
- Mapped back to existing standards, roadmaps and recommended practices.
- Following best industry practice.
- Verified by a trusted independent adviser, similar to the requirement for the data analysis from the validation itself.

3.3.3 Pre-deployment verification and checks

Due to the lack of offshore structures within the NY OSA, the above system validation will not be able to take place within the NY OSA and may have taken place sometime prior to a prospective campaign is planned to commence.

The structure of the predeployment verification falls under the same requirements as the system validation, but would not be required to have as long duration—four to eight weeks depending on wind conditions.

It is recommended that the pre-deployment verification is carried out in representative sea states and FLS suppliers who provide either a strategy to accommodate this or evidence showing that this is a consideration will be favored.

The verification and validation process should be certified by the DMAC.

3.3.4 Review of data

Throughout the deployment duration, the data collected will be reviewed on a regular basis to check for any gaps indicating faults in the system and also to review for any errors in the data. This will be carried out by the DMAC to retain the independence and integrity of the checks. This will allow for a swift remedy of any errors that arise. RP88 in the OWA RP must be followed.

3.3.5 Post-deployment checks

At the conclusion of the campaign the data collected should be analyzed by the DMAC to check for errors. If questions are raised, a two-week onshore verification of the LiDAR itself against either another LiDAR or met mast will be carried out to investigate these anomalies.

4 Location

4.1 Requirements and Recommendations

4.1.1 Requirements

- There are no requirements for this section.

4.1.2 Recommendations

- It is recommended that a Developer choose the location based on the following broad constraints:
  - Environmental factors such as benthic ecology, fish ecology and marine mammals.
  - Human factors such as shipping, fishing, and subsea infrastructure.
  - Wind resource and spatial variation across the prospective wind farm.

4.2 Constraints

There are a number of considerations determining the location of an FLS(s). The following section summarizes the key considerations Developers should take into account when determining the location of an FLS(s).

4.2.1 Bankability

The main consideration for the location of the FLS' is bankability. The principal objective of a wind resource assessment is to collect data on wind speeds that provides sufficient confidence for investors in the annual energy production estimates. This is a crucial step in the predevelopment work affecting the overall value of the lease site and the project, once it is operational.

Other location factors that influence bankability would be the presence of any other structures affecting the free stream measurements of the FLS, or terrain impacts that may disturb the flow and affect turbulence and shear in the area. This is unlikely but should still be considered before selecting a location.

4.2.2 Environmental Constraints

A key consideration of the regulators when deploying an FLS is to minimize the environmental impact it will have. This is required by legislation such as the National Environmental Policy Act (NEPA) [14].

4.2.2.1 Benthic Habitats

In terms of location, the biggest spatial variation in impact will come from the effect of the anchor(s) on the benthic communities such as crushing or smothering organisms or through suspended sediments when deploying and recovering anchor(s).[15] Some habitats are afforded special protection and therefore should be avoided where possible to minimize environmental impact. Further to this, profiling of the area should be carried out to determine if there are any particularly sensitive areas that should be avoided. Seabed sediment characteristics can act as a proxy for benthic characterization, and therefore, benthic surveys are not specifically required prior to the deployment of an FLS.

4.2.2.2 Marine Protected Areas and Other Ecological Management Schemes

It is prudent to undertake a further review of the relevant Marine Protected Areas (MPAs) or other ecological/environmental protected areas in or adjacent to the proposed deployment location(s). It is unlikely that there would be specific requirements prohibiting the deployment of an FLS, however, there may be risks associated with increased vessel traffic in the area or delays to permitting.

4.2.2.3 Other Considerations

While the benthic communities are the most sensitive to FLS deployments, other environmental receptors should be considered as a matter of best practice. This would typically include considerations of sensitive fish species, marine mammals, and birds that might be impacted by the systems and associated operations.

Due to the small-scale of operations, it is unlikely that these would affect the siting of an FLS.

4.2.3 Human Constraints

As well as environmental factors, human constraints also play a part in determining the location of FLS'. Of particular importance are:

- Shipping activity.
- Leisure activity.
- Commercial fisheries.
- Subsea infrastructure such as telecoms cables and gas pipelines.

Other factors such as visual impact, radar signature, and diving may also have an impact on the wind farm location. However, these are unlikely to impact the location of an FLS.

4.2.3.1 Shipping Activity

Shipping activity is particularly important as an FLS can represent a navigational hazard to sea users. As a matter of best practice, systems should be deployed in areas outside of heavy shipping traffic and should especially avoid shipping lanes. A buffer around busy areas should also be explored to provide extra protection against risks such as anchors or ships heading off-course.

4.2.3.2 Subsea Infrastructure

An FLS should also be sited away from subsea infrastructure—in particular oil and gas pipelines or telecoms cables. Operators typically request a buffer around their assets to minimize the risk of anchors puncturing pipelines or severing cables. Puncturing or damaging such infrastructure can cause health and safety concerns, as well as having financial repercussions for the Developer.

Shipwrecks and unexploded ordnance (UXO) should also be reviewed as these are a health and safety concern for the mooring of FLS'.

Typically, subsea infrastructure is well mapped in the region. However, a bathymetric survey is advised ahead of deployment in order to determine any micro-siting requirements, and to minimize the associated risks.

4.2.3.3 Leisure Activity

Leisure activity, particularly sailing, can also affect the location of an FLS. LiDAR systems should avoid areas of high density so as to limit the impact a buoy might have on their activities and reduce the risk of collision.

4.2.3.4 Commercial Fisheries

Commercial fishing is prevalent within the NY OSA. The main risks associated with the deployment of FLS' in the vicinity of fishing operations is the risk of nets tangling with the mooring lines, anchor drags damaging the system and/or moorings, and vessel strike with the buoy. Therefore, it is favorable to locate the FLSs outside of areas of higher density.

4.2.4 Physical Constraints

4.2.4.1 Wind Resource

The most critical physical constraints relating to the location of FLS' is the potential wind resource and the spatial variation across the zone. It is also important that wind speed is measured in a free stream and there are no obstructions causing turbulence or atmospheric instability affecting the validity of results.

With respect to the NY OSA, it is likely there would be no obstructions to cause turbulence unless the area within question was close to shore. Therefore, the most important consideration will be ensuring an accurate representation of resource is obtained and include any spatial variation across the development area in question. For this reason, it is recommended that FLS' are located at extreme locations within the proposed wind farm, and it should be ensured that the two locations are close enough to minimize uncertainty of an AEP calculations.

MEASNET is often used as outline guidance[15] with the use of a 10km buffer around any prospective location to accommodate all turbines within the wind farm. It should be noted that this is guidance for onshore wind farms in simple terrain, and therefore, for offshore applications this is considered conservative and systems could be located further away from one another without affecting the bankability of data. It is advised that an independent technical expert is consulted on such issues on a case-by-case basis.

In the event of only deploying a single FLS, the spatial variation across the zone and wind speed gradients will be harder to obtain, and therefore, the main priority should be to locate the system as centrally within a prospective wind farm as practicable.

4.2.4.2 Water Depths

Water depth can also affect the location of FLS'. Generally, lower water depths are preferred to minimize cost and risk associated with mooring lines. Wind turbines are also likely to be deployed in lower water depths and it follows that the FLS' should be deployed in the same place.

4.2.4.3 Currents

Currents have the potential to affect the placement of FLS' if they are particularly strong at any one time especially with relation to access and maintenance of the systems. Local data should be evaluated on a case-by-case basis to determine whether any particular areas within the NY OSA are particularly prone to strong currents. Data is available from the National Data Buoy Center[21] and U.S. Met-Ocean Data Center,[22] which can help to inform this decision.

4.2.4.4 Waves

The wave environment may also affect the placement of FLS'. Systems should be sited away from areas frequently experiencing severe wave heights, both to minimize potential damage to the device and to ensure the device can be accessed regularly as required. Data is available from the National Data Buoy Center [21] and U.S. Met-Ocean Data Center,[22] which can help to inform this decision.

5 Duration

5.1 Requirements and Recommendations

5.1.1 Requirements

- Data collection must take place for a minimum of 12 months.
- LiDAR system suppliers will be required to provide quotations for optional 18 and 24 month campaigns should permits allow it, and these durations should be strongly favored for wind resource assessments.

5.1.2 Recommendations

- LiDAR system suppliers should assist in providing input to assessments of inter-annual variability and thermal stability to inform whether even longer campaigns may be required.

5.2 Selection of Deployment Duration

Campaigns should aim to be carried out for a full 24 months where possible, however, in certain circumstances permitting issues may prevent this and therefore a minimum of 12 months is recommended.

5.2.1 Bankability

The typical reason for collecting wind resource data is to provide estimates of AEP to feed into financing decisions for the developers and investors in offshore wind farms.

One of the main ways of achieving this is ensuring the campaign duration is appropriate. There is limited public guidance on achieving bankable data, however the industry accepted minimum is 12 months, but this is often dependent on a number of factors including existing data at or near the site. In addition, duration considerations can be affected by the number and type of data collection methods used.

Banks and investors will associate a risk with different durations and penalize capital depending on the perceived risk. As FLS' are perceived as a higher risk than traditional fixed bottom met masts or indeed platform mounted LiDAR, campaigns should seek to address this risk by maximizing the length of campaigns where possible.

5.2.2 Review of Previous Campaigns

Appendix B lists the publically available information on floating LiDAR campaigns carried out to date. Most of the floating LiDAR campaigns to date have been validation trials and provide little data to support a decision on a wind resource assessment. Of the wind resource assessments that have been carried out, the minimum duration is 13 months at Walney Extension. Burbo Bank Extension also ran a campaign for 16 months. Both of these sites are extensions to existing wind farms, and the understanding of the wind resource in the area is already much better than the NY WEA. Therefore, it can be reasonably expected that any campaign for the NY WEA should aim to be longer than both of these campaigns.

The Lake Michigan wind resource assessment took 28 months over a number of locations and is not a true representation of a wind resource assessment. A more similar study is the wind resource assessment at Virginia Beach, near Dominion’s Lease Area, which is undertaking a campaign for 19 months.

6 Permitting

6.1 Requirements and Recommendations

6.1.1 Requirements

- FLSS will provide information to support any permit applications.

6.1.2 Recommendations

- FLSS' with a working knowledge of the U.S. permit system and a track record of compliance with them will be preferred.

6.2 Permits Required

A key part of the buoy deployment will be obtaining the necessary permits in order to proceed with the campaign. The following section outlines the current permits required, the permitting authority and the typical timeframes in order to obtain the permits. It should be noted that this section focuses on the current legislation, however, BOEM may alter this process as a result of the ongoing implementation of the DOE and DOI's National Offshore Wind Strategy.[19] Action 2.1.1 of the strategy document states that feedback has been received stating that the SAP process for meteorological buoys is overly onerous. Therefore, the SAP process will be reviewed and potentially eliminated for this purpose. In the event that this is the case, revised guidance will be provided by BOEM, which should be reviewed to ensure this MOP remains up to date.

6.2.1 Site Assessment Plan (SAP)

For sites within areas leased from BOEM, the main permit currently required is through the Site Assessment Plan (SAP). This is enforced through legislation made by BOEM through the lease agreement at 30 C.F.R. 585.600.[20] The SAP will be the ownership and responsibility of the Developer. However, it is anticipated that key input will be provided by the FLSS.

The SAP will describe the activities to be carried out in order to characterize the lease, particularly the installation of the FLS'. Key information on such parameters including size, mooring detail, maintenance activities, health and safety features, and pollution prevention measures will need to be included. Much of this will come from the FLSS.

The SAP is managed by the Developer and will be submitted to BOEM within one year of the lease agreement being signed under the requirements. BOEM will facilitate the review of the SAP and coordinate the approval of the necessary permits, with the exception of the USACE Nationwide Permit 5.

6.2.2 Nationwide Permit 5

The United States Army Corps of Engineers (USACE) administers the Nationwide Permits for activities in federal waters. Nationwide Permit 5 (NWP 5) pertains to the deployment of scientific measurement devices. An FLS qualifies under the regulations as a scientific measurement device and will be required to adhere to the general conditions set out as part of the Nationwide Permit 5. This permit would be required in all circumstances, including if a system was to be deployed outside of a BOEM lease area.

The developer would retain overall responsibility for obtaining this permit. However, the FLSS will provide much of the information to apply for this permit.

It is important to note that the permit's requirements pertain largely to FLS supplier carrying out most, if not all, of the offshore activities. Therefore, it will be of vehement importance that the FLSS is familiar with these requirements. These include such requirements to maintain navigational safety lighting, maintaining any device, and following the correct protocol in the event of discovering historic artefacts at sea. FLS suppliers that can show familiarity in complying with such requirements will be favored in any tender process.

7 Logistics and Maintenance

7.1 Requirements and Recommendations

7.1.1 Requirements

- A fully detailed mooring design will be required in any proposal from the floating LiDAR supplier and the FLSS should have, or have sub-contractors with, experience in the local waters (or waters similar to those off the coast of NYS) to ensure the design is robust.
- The FLSS will provide an 'Operations and Maintenance Plan' covering the following issues:
    - The FLS will be fully decommissioned with minimal impact on the sea bed and surrounding habitat.
    - The FLS will be able to fully function for six months without a maintenance visit.
    - The FLS supplier will be responsible for maintenance activities.
    - The LiDAR supplier shall observe and comply with all relevant and current statutory requirements, approved codes of practice, and industry guidance on HSE matters.
    - The FLS supplier will continually monitor data availability, power, data quality, and location throughout the deployment and assure that data flows to the DMAC for review.

7.1.2 Recommendations

- To be most cost-effective and to mobilize quickly in the event of an emergency, it is recommended that one of the ports listed within section 7.2 is used as the base port for operations due to their proximity to site, but also ability to handle and store an FLS.
- Power systems should consider safety, redundancy of any generation technology, battery storage life, and optimization for maintenance.
- Installation and commissioning processes in-line with the OWA RP[8] is encouraged.
- The FLSS should aim to replace the entire system in no longer than three weeks from the point that the fault is known.

7.2 Transport

With respect to transport, the main focus will be on the base port or harbor where the device is both commissioned and maintained in the event any major repairs are required.

This should be identified early on and necessary agreements with the port operator sought. There should be sufficient space and resource to accommodate ad hoc maintenance and repair work, as well as the ability to handle the system for deployment and recovery.

7.3 Power Systems

As different systems have different power capacities, it is not appropriate to be prescriptive of the power requirements for the system. However, listed below are key points that must be considered when an FLSS puts forward a proposal:

- **Safety considerations** - The power will prioritize safety mechanisms such as mooring lights over data capture when power becomes critical. All batteries and fuel cells will be stored and housed with safety as a primary concern. RP6 and RP7[8] must be followed.
- **Redundancy of generation technology** - It is expected that both solar and wind generation will be effective at recharging batteries; the former in summer months, the latter during winter. Other back up generation such as fuel cells should also be considered. As a guide, the system should be able to operate fully for six months with one generation system offline. This would allow sufficient time for repair or replacement.
- **Battery storage life** - A reasonable balance needs to be made between cost and weight efficiency, and redundancy and reliability of the system. Given the distance from shore, it is expected that the battery life is a minimum of four weeks at full operation, however this could be more or less depending on the set up and redundancy of the generation technologies on board.
- **Maintenance** - As the system will be expected to operate without requiring maintenance for at least six months, the entire power systems will be maintained, including inspection, cleaning and/or replacement of the components when the routine maintenance visits are carried out.

7.4 Installation and Commissioning

The FLSS is encouraged to follow the relevant recommended practices within the OWA RP[8] when carrying out installation and commissioning, which includes the following key points:

- Commissioning be carried out at the quayside.[8]
- All verification checks have been carried out to confirm the LiDAR's performance.
- Installation and commissioning be carried out by a suitably qualified contractor, ideally with experience deploying and installation FLS' previously.

7.5 Mooring

One area where conditions are notably different in the northeast U.S. coastal waters to that in Europe is the increased prevalence of extreme weather conditions including hurricanes. Therefore, European developed recommended practices and standards may not be sufficient when deploying in U.S. waters.

The mooring of an FLS primarily affects the safety of the sea users, but also the data availability for the purposes of a wind resource assessment campaign. Therefore, this item is viewed as critical for the floating LiDAR supplier to provide a robust and proven solution when submitting their proposal.

The floating LiDAR supplier will be required to demonstrate that they have (or have sub-contracted) competence and experience in deploying buoys in local waters (or waters similar to those off the coast of NYS). In addition to this, they will also be required to provide an independent report justifying their proposed mooring solution when submitting their proposal. This will ensure that adequate engineering and protection of the mooring occurs.

7.6 Maintenance Requirements

The FLSS will coordinate the maintenance activities, with the oversight of the Developer/Third-party Consultant.

More rigorous maintenance requirements may be stipulated in the final contract with the FLSS. However, for the purposes of this MOP, maintenance is refined to the minimum expected to uphold the integrity of the data. The FLSS should provide upfront an Operations and Maintenance Plan detailing its maintenance strategy in accordance with the requirements in this section.

Due to the likely distance from shore, the buoy will be maintained every six months at most. In reality, unscheduled maintenance trips may be required. In this case, the FLSS should be prepared to undertake additional checks and maintenance (e.g., on the power systems, data loggers, communication systems, buoy structure) while accessing the buoy in order to mitigate the need for additional scheduled maintenance trips.

Should the system fail entirely, for example if the LiDAR fails or buoy is irrevocably damaged, the FLSS must have plans in place to replace the entire system in no longer than three weeks from the point that the fault is known, weather permitting. This will require a standby system that can be shipped in at short notice, or any other solution the supplier prefers.

Prospective FLSS must outline in detail the track record of maintenance requirements relating to their proposed system and set up, ideally including the same components and equipment (communications, data loggers, fuel cells, solar panels, turbines) as will be on the proposed buoy set up. The FLSS will be able to show evidence of previous trials in similarly demanding metocean conditions where the FLS has not required maintenance and reliably collected data for six months or more. Where this is not available, the FLSS will set out why the evidence and track record of the system shows confidence in the system performing well for six months or more.

Maintenance visits must be planned wherever possible to minimize outages and maximize the data collection period. This should include factoring in preventative maintenance to suitable weather windows or seasons in advance.

The FLSS must also follow RP 88 of the OWA RP [8] that stipulates ongoing monitoring of data availability, on-board power system function, LiDAR data quality criteria, and location of where the FLS is carried out. This will be conducted daily for the first two weeks of deployment and subsequently on a weekly basis as a minimum. Finally, this monitoring will also include alerts to trigger reactive interventions.

7.7 Decommissioning Requirements

Full decommissioning of the FLS' is required upon completion of the wind resource assessment. Decommissioning should minimize the environmental impact and maintain the integrity of the components on the device in the case of future deployments of the same device.

Given that decommissioning will occur following the completion of the trial, there are no further issues that might pertain to data quality aside from ensuring that any hard back up data storage is suitably retrieved.

7.8 Health and Safety

The FLSS shall observe and comply with all relevant and current statutory requirements, approved codes of practice and industry guidance on HSE matters, such as Occupational Safety and Health Standards (OSHA) or regulations of The Bureau of Safety and Environmental Enforcement (BSEE).

In addition, an Emergency Response Plan should be provided to all in the project team to identify a chain of command and plan to deal with any emergency situations.

The FLSS shall take all necessary steps to ensure all personnel engaged by them and their supply-chain are appropriately trained and competent, comply with all relevant HSE legislation and guidance, and that they are:

- Fully conversant with the conditions, the hazards and risks associated with the deployment and operation of the floating LiDAR device and the necessary standards relating to the environment including the handling of waste and hazardous materials.
- Fully aware that they are expected to bring immediate notice to their supervisor any health, safety, and environmental risks that they believe not to be under adequate control so action may be taken to prevent potential injuries or other losses.
- Fully conversant with all health, safety, environmental, and all other working instructions and guidance.

8 Data Handling

8.1 Requirements and Recommendations

8.1.1 FLSS

8.1.1.1 Requirements

- The FLS will collect measured quantities of wind speed and direction, turbulence intensity, and air temperature, pressure, and humidity along with height and datum used.
- Wind data will be recorded at a minimum of five heights that cover lowest rotor tip height, hub height, and highest rotor tip height of the anticipated turbine model and two points equidistant in between these three (approximately 40m, 80m, 120m, 160m and 200m).
- The FLS will also record measured quantities of significant maximum wave height, peak, and mean wave period; wave direction; spectra and salinity; current speed; water temperature; and tidal range and water depth.
- Two separate means of communication on the FLS will be required.

8.1.1.2 Recommendations

- Motion compensation algorithms applied to the system should be outlined in detail including whether the same algorithms have been applied on previous validation trials.
- Wildlife data and additional data collection should be encouraged.
- Proven transmission systems and ability to use quicker and more secure methods of transmitting data is preferred.

8.1.2 Data Management and Analysis Contractor

8.1.2.1 Requirements

- The DMAC will have no commercial ties or conflicts of interest with the FLSS.
- The DMAC will be suitably qualified and experienced.
- Data will be analyzed in relation to KPIs as set out in the OWA RP[8] as a minimum.
- Written reports of the data analysis will be provided to the Developer.
- All raw and processed data must be securely stored by the DMAC and made available to the Developer whenever required.

8.1.2.2 Recommendations

- Suggestions of how best to manage the data and provide efficient public access will be viewed favorably.
- Further technical support may be required beyond the minimum processing of data. Such support may include initial analysis of relevant metocean design parameters or further outputs to the Developer such as long-term, climatologically adjusted datasets to inform energy yield predictions.

8.2 Data Collection

8.2.1 Wind Data

The following measured quantities must be collected by the FLS, as per the OWA RP (8):

- Wind speed (10-minute average, min, max, and SD).
- Wind direction (10-minute average, min, max, and SD).
- Turbulence intensity.
- Air temperature, pressure, and humidity.

All quantities will record the height and datum used, as relevant. Data on the FLS' inclination and translational and rotational accelerations must also be recorded for reference in case of anomalies. Humidity, cloud cover, and precipitation must also be recorded in line with the wind speed and wind direction data to assist with correlation.

Wind data will be recorded at a range of heights that cover the lowest rotor tip height, hub height, and highest rotor tip height of the anticipated turbine model and two points equidistant in between these three. For example, a typical MHI Vestas V164 8.0MW turbine might require measurements at approximately 40m, 80m, 120m, 160m, and 200m. Some additional tolerance may be required to accommodate increases in turbine size, although this will be dependent on the capabilities of the LiDAR installed on the floating buoy.

Additional instrumentation such as low-level anemometers or wind vanes must be incorporated and must be of high quality, have sufficient redundancy and be logged with the same parameters as the LiDAR data.

8.2.2 Motion compensation

Some systems, although not many, adopt motion compensation mechanisms to mount on the LiDAR. Where such a system is proposed, previous validation trials must be conducted with the system in place to demonstrate accuracy of the measurements including the motion compensation.

Motion compensation algorithms applied to the system should be outlined in the proposal in detail including whether the same algorithms have been applied on previous validation trials. It is preferable that previous validations be carried out with similar software or post-processing applied to verify the performance of the system as a whole.

8.2.3 Other metocean data

As part of the campaign, it will be important to maximize the deployment of the floating LiDAR buoy and measure other metocean data. This will include as a minimum:

- Significant maximum wave height (30-minute average).
- Peak and mean wave period (30-minute average).
- Wave direction, spectra, and salinity (at or near the surface).
- Current speed and direction (at or near the surface)
- Water temperature (at or near the surface).
- Tidal range and water depth.

Some of this data may be collected through the deployment of additional sensors such as Acoustic Doppler Current Profilers (ADCPs).

8.2.4 Data Transmission

Data will be transmitted from the buoy at regular intervals. Two separate means of communication will be required and the type of communication should switch automatically.[8] Satellite communication would be preferred due to the size of the data being transferred and the inherent coverage issues with cellular networks offshore, however, costs may constrain this. Data retrieval should be primarily done remotely, either from shore or a nearby workboat to minimize the need for crew to transfer onto the buoy for collection.

At a minimum, the communications system will allow real-time, or near real-time, monitoring of the status of the buoy and any critical systems including power and LiDAR data retrieval. Ideally, it will also allow real-time transfer of all metocean measurements taken on the buoy also, although this is not critical.

Due to issues regarding outages and potential loss of networks, the FLS will have redundancy measures on board to store data for later transmittal. As per RP 64 of the Recommended Practices for FLS',[8] there should be sufficient data storage on-board to ensure that all data measured for the duration of the campaign is stored and recoverable after the trial in the event communication fails.

Once recovered or transmitted, data will be stored by the data analysis contractor. Data should be stored securely with remote access available to NYSERDA, should it be required.

8.3 Data Management and Analysis

A completely independent DMAC will be contracted to handle and analyze the raw data from the wind resource assessment. The key duties and requirements of this consultant are outlined.

8.4 Data Management

The DMAC will securely store all data from the floating LiDAR supplier and facilitate the transfer of this dataset to their servers.

The raw and processed data will be available to NYSERDA at all times upon request and once the analysis has concluded, the DMAC will provide the Developer with all the data on hard drive disks or electronic transfer. The DMAC may also provide suggestions as to further means of ongoing management of the data.

8.4.1 Data Analysis

The DMAC will be suitably qualified, experienced, and completely independent of the floating LiDAR supplier in order to maintain integrity of the results.

Data will be analyzed in relation to KPIs as set out in the OWA RP[8] unless otherwise advised. This will include KPIs for availability which should be monitored to ensure that availability criteria can be met at the end of the campaign. Data should also be checked in accordance with the parameters set out by DOE in the Metocean Data Needs Assessment of U.S. Offshore Wind Energy.[24]

The DMAC may also analyze turbulence intensity data as required by the Developer and provide reports and recommendations for further work to the Developer, if necessary.

Only data deemed 'good' by the FLSS will be analyzed, following the agreement of a suitable filter (or other means) as agreed between the DMAC and FLSS. The DMAC will employ best practice quality control measures to ensure any filters have been appropriately applied, or that the quality control is in-line with industry best-practice at the time.

The DMAC will provide the Developer with written reports analyzing the data with key conclusions. The raw data should also be made available for further analysis such as AEP estimates and further mesoscale modeling. These reports will include an assessment of uncertainty as prescribed in section 8.6 of the OWA RP.[8]

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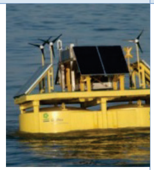
Appendix A – Bibliography of Metocean Information

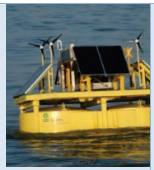
The below table provides a complete bibliography of relevant metocean information relevant to the Metocean Plan.

Source	Description	Link
Predevelopment Assessment of Meteorological and Oceanographic Conditions for the Propose Long Island – New York City Offshore Wind Project Area, NYSERDA, 2010	Published in October 2010, this NYSERDA document provides a specific overview of the NY WEA and the metocean characteristics. The report uses a range of sources including buoys and lighthouses with sensors to report on the meteorological climatology and environment. The report also utilize mesoscale modeling to provide an overview of the wind resource in the locality of the NY WEA.	https://www.nyserda.ny.gov/-/media/Files/EIBD/Research/LI-NYC-offshore-wind-climatology.pdf
Assessment of Offshore Wind Energy Resources for the United States, NREL, 2010	Published in June 2010, this NREL report provides an overarching assessment of the national offshore wind resource. Analysis specific to the NY WEA is not present, however estimates of wind speeds by state (including New York State) are provided and grouped by water depth. The report also expands on the mean wind speed data at 90m/s to provide estimates of offshore wind potential resource in GW.	http://www.nrel.gov/docs/fy10osti/45889.pdf
2016 Offshore Wind Energy Resource Assessment for the United States, NREL, 2016	This report published in 2016 by NREL provides an update to the 2010 report highlighted previously. Similar outputs are provided at a regional scale with no direct analysis of the resource for the NY WEA.	http://www.nrel.gov/docs/fy16osti/66599.pdf
National Data Buoy Center, NOAA, 2016	Access to any of the buoys within the New York Bight is provided through NOAA's National Data Buoy Center—this website hosts the information and data from the buoys currently deployed but also historically deployed. Buoys are typically collecting data on waves, temperature and wind speeds (at low levels, typically 3-5m).	http://www.ndbc.noaa.gov/maps/New_York.shtml
U.S. Met-Ocean Data Center, AWS Truepower	Bibliography of available metocean data for specific areas and for wider U.S. seas. Provide links to relevant websites and data sources.	http://www.usmodcore.com

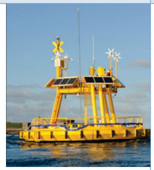
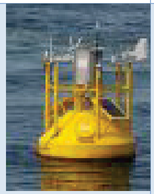
Appendix B – Previous floating LiDAR campaigns

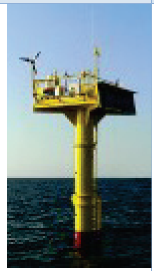
The following table provides publically available information on previous floating LiDAR campaigns – it does not represent a complete, comprehensive list of all floating LiDAR trials to date. Therefore, some trials may not be recorded here.

Location **[Wind farm/met mast, Sea area, Country]**	**Trial name**	**Device** **[LiDAR, Buoy type]**	**Picture**	**Type of campaign**	**Duration**	**Completion date**	**Details**	**Link/Source**
Race Rocks, Strait of Juan de Fuca, Canada	WindSentinel Field Test	AXYS WindSentinel with Vindicator Laser Wind Sensor		Validation trial	1 month	November 2009	Early validation of AXYS WindSentinel system against identical land based sensing equipment. Other sensors included an anemometer, wave sensor, motion sensors, and meteorological sensors.	http://axystechnologies.com/wp-content/uploads/2013/12/Windsentinel-Race-Rocks-trial-report.pdf
North Sea, Belgium		FLiDAR prototype with Leosphere WINDCUBE v2 Offshore LiDAR		Validation trial	1 month	October 2011	Early validation of FLiDAR prototype 15 km of the coast of Belgium. Data validated against fixed WINDCUBE LiDAR device on an offshore communication mast close to the test site.	http://www.3e.eu/flidar-spin-off-launched/ http://www.offshorewind.biz/2011/11/23/flidar-completes-its-trials-in-north-sea-belgium/

Gwynt-y-Môr wind farm zone, Irish Sea, UK	OWA Gwynt-y-Môr validation trial	FLiDAR with Leosphere WINDCUBE v2 Offshore LiDAR		Validation trial	3 months	January 2013	Validation against Gwynt y Môr meteorological mast in the Irish Sea, which includes Measnet-calibrated cup anemometers at 90m and 50m above LAT and a wind vane at 70m. A Waverider buoy was also deployed during the trial.	https://www.carbontrust.com/media/639975/flidar-presentation-ewea-2013.pdf
Lake Michigan, USA	Great Lakes Offshore Wind Resource Assessment Project	AXYS WindSentinel with Vindicator Laser Wind Sensor		Wind resource assessmen t	28 months	December 2013	A varied measurement campaign to assess the collect and analyses wind data essential to the consideration of future wind industry development on the Great Lakes. The scope of the trial included: • Wind data collection and analysis • Wind correlation studies • Directional wave monitoring & compass orientation • Offshore wind modeling • Full range of meteorological sensors • Acoustic sonobat bird and bat detection system • Current sensor / acoustic Doppler profiler	http://axystechnologies.com/wp-content/uploads/2016/10/Great-Lakes-Wind-Resource-Assessment-Project.pdf https://www.michigan.gov/documents/mpsc/Offshore_Wind_Assessment_Overview_3-29-11_348957_7.pdf

Neart na Gaoithe wind farm zone, North Sea, UK	OWA floating LiDAR discretionary project	FLiDAR 4M with a Leosphere LiDAR system		Validation trial / Wind resource assessment	3 months	April 2014	FLiDAR system was validated before and after the trial against the Offshore Renewable Energy Catapult meteorological mast off the coast of Blyth, UK.	https://www.carbontrust.com/about-us/press/2014/09/mainstream-and-dnv-gl-validate-floating-offshore-wind-measurement-device-as-part-of-carbon-trust-owa-programme/ http://www.gl-garradhassan.com/assets/technical/Validation_Report-_FLiDAR.pdf
Burbo Bank Extension wind farm zone, Irish Sea, UK		FLiDAR 4M with a Leosphere LiDAR system		Wind resource assessment	16 months	September 2014	FLiDAR system was validated post trial against an offshore meteorological mast.	http://www.offshorewind.biz/2015/04/24/burbo-bank-extension-first-flidar-calculated-owf-to-be-built/
East Anglia ONE wind farm zone, North Sea, UK	An offshore LiDAR buoy trial against mast reference instrumentation	Fugro OCEANOR SEAWATCH Wind LiDAR buoy with ZephIR 300 Lidar		Validation trial	6 months	November 2014	The system was validated against the IJmuiden meteorological mast. The boy was equipped with the following sensors: • Wave height, period, and direction • 3-axis buoy motion and rotation • Near surface current profile and water temperature • Wind speed and direction • Wind speed and direction profile • Air pressure	http://www.oceanor.com/related/Datasheets-pdf/eneco_lidar.pdf https://www.windopzee.net/fileadmin/windopzee/user/SDB_20150130_DNVGL_Trial_Campaign_Validation_Report_IJmuiden_GLGH-4257_13_10378_266-R-0003-B_final.pdf

							• Air humidity and temperature	
Saint Marcouf Island, France		Nass & Wind Marine Measurements for Meteorological and Environmental Assessment (M^{3}EA). LiDAR system unspecified.		Validation trial	11 months	December 2014	Device is based on an adapted marine navigation buoy. Validation against onshore fixed LiDAR system. Device LiDAR system unspecified. Other sensors include temperature, pressure, visibility, moisture, location and Acoustic Doppler Current Profiler (ADCP).	http://www.oceanologyinternational.com/__novadocuments/49179?v=635310012225230000 http://nassetwind.com/en/nasswind-smart-services-measure-center/
FINO1 met mast, North Sea, Germany		Fraunhofer IWES Wind LiDAR buoy with ZephIR 300 LiDAR.		Validation trial	Not specified	2014	Validated against FINO1 meteorological mast. Steel hull. Additional sensors: • ADHR and satellite compass record buoy's positions and movements. • Weather station for measurement of	http://www.zephirlidar.com/fraunhofer-iwes-wind-lidar-buoy-verified-fino1/ http://www.windenergie.iwes.fraunhofer.de/content/dam/windenergie/en/documents/Bojenbrosch%C3%BCre_FINAL.pdf

							barometric pressure, air temperature, horizontal wind speed and direction (at low height), relative humidity, precipitation. • AWAC current meter (as autonomous and independent system) for measurement of waves and currents.	
Gwynt-y-Môr wind farm zone, Irish Sea, UK	OWA Gwynt-y-Môr validation trial	Babcock FORECAST with ZephIR 300 LiDAR		Validation trial	16 months	February 2015	Validation against Gwynt y Môr meteorological mast in the Irish Sea. Measnet-calibrated cup anemometers at 90m and 50m above LAT, wind vane at 70m. Waverider buoy. Additional validation against fixed LiDAR (ZephIR 300) on met mast platform.	https://www.carbontrust.com/media/640173/owa-floating-lidar-campaign-babcock-trial-ewea-2015.pdf http://www.zephirlidar.com/babcocks-forecast-floating-zephir-lidar-reaches-stage-2-carbon-trust-owa-roadmap/
Walney Extension wind farm zone, Irish Sea, UK		FLiDAR 6M with single ZephIR 300 type LiDAR.		Wind resource assessment	13 months	June 2015		http://www.norcowe.no/index.cfm?id=422778 [*18 Feb 2015]* http://www.offshorewind.biz/2015/06/24/flidar-reduces-costs-in-combined-operation/
IJMuiden wind farm zone, North Sea, Netherlands	OWA floating LiDAR discretionary project	EOLOS FLS200 with ZephIR 300 continuous wave LiDAR		Validation trial	6 months	October 2015	Validated against IEC-compliant IJmuiden offshore meteorological mast. Additional data collection includes wave (directional) and current information.	http://www.eolossolutions.com/en/blog/press-release-eolos-fls200-successfully-validated-for-offshore-wind-measurements/6

FINO1 met mast, North Sea, Germany	AXYS FLiDAR 6M (WindSentinel), S/N 6NB00160 floating LiDAR device validation at FINO1	AXYS FLiDAR 6M with two ZephIR 300 type LiDARs. **[Note AXYS Technologies Inc. acquired FLiDAR NV in September 2013]**		Validation trial	5 months	November 2015	Validated against the FINO1 Reference Met Mast. Located 310 m to the NW (approx. 340°), west of the wind farm zone.	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13316-266-R-0001-D_signed.pdf
National Renewable Energy Centre (NAREC), North Sea, UK	Narec-F140	FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	1 month	2015	Validation against NAREC Offshore Anemometry Hub, further details unspecified. **(**Note conflicting reports on whether this trial deployed the device with one or two ZephIR 300 LiDARs)	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13316-266-R-0001-D_signed.pdf http://axystechnologies.com/axys-deploys-two-dual-lidar-windsentinel-buoys-at-ore-catapults-offshore-met-mast/
National Renewable Energy Centre (NAREC), North Sea, UK	Narec-F150	FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	1 month	2015	Validation against NAREC Offshore Anemometry Hub, further details unspecified. (Note conflicting reports on whether this trial deployed the device with one or two ZephIR 300 LiDARs)	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13316-266-R-0001-D_signed.pdf http://axystechnologies.com/axys-deploys-two-dual-lidar-windsentinel-buoys-at-ore-catapults-offshore-met-mast/

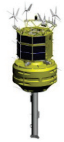
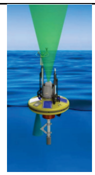
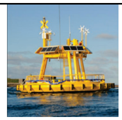
West of Duddon Sands wind farm zone, Irish Sea, UK	West of Duddon Sands AXYS FLiDAR 6M ZephIR F080 pre-deployment validation	FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	6 months	March 2016	Validated against West of Duddon Sands Reference Met Mast, following wind resource campaign for DONG Energy at Walney Extension Wind Farm (described above). Located outside of wind farm to West of met mast on the western edge of the farm zone.	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13446-267-R-0002-B.pdf
Virginia Beach, Virginia, USA **[next to Dominion's Lease Area for Offshore Wind Energy Development]**	Wind-Profiling Lidar Buoy Deployment Plan	AXYS WindSentinel		Wind resource assessment and additional data collection	19 months	July 2016	52 km (28 nm) offshore from Virginia Beach, VA. This is west of Dominion's lease block. Device also collected data on: • Near-surface air temperature, humidity, and pressure • Solar radiation • Waves: Significant and maximum wave height, peak period, directional wave spectrum • Surface water temperature • Water velocity profile • Water temperature and conductivity profile	https://ebs.pnnl.gov/uploads/PR-295256-RFP%20Example%20Deployment%20Plan-Virginia_316201535325PM.pdf http://www.offshorewind.biz/2016/07/19/windsentinels-virginia-offshore-wind-data-now-available/

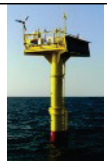
East Anglia wind farm zone, North Sea, UK	OWA floating LiDAR discretionary project	Fugro OCEANOR SEAWATCH Wind LiDAR buoy with ZephIR 300 Lidar		Validation trial	6 months	July 2016	Validated against East Anglia meteorological mast.	http://www.4coffshore.com/windfarms/floating-lidar-deployed-at-east-anglia-one--nid3157.html
Mediterranean, France		BLiDAR LiDAR device not specified in this trial.		Validation trial	6 months	Ongoing	Early validation of the device against a fixed LiDAR located onshore.	http://www.nke-instrumentation.com/news/detail-actualite/article/the-floating-lidar-of-the-blidar-project-begins-a-6-month-validation-campaign-in-the-mediterranean-s.html http://www.blidar.fr/
Mid-Atlantic Wind Energy Area, New Jersey, USA		Axys WindSentinel		Wind resource assessment and additional data collection	Unknown	Unknown	Reports indicate the device was deployed in June 2013 but the duration and validation characteristics of the trial are unknown. Located eleven miles east of Ocean City, NJ, this site is within the Mid-Atlantic Wind Energy Area, in an area Fishermen's Energy ("Fishermen's") proposed to build a 350MW windfarm.	http://www.fishermensenergy.com/press-releases/2013-fe-buoy-fed-waters.pdf http://axystechnologies.com/axys-congratulates-fishermens-energy-on-buoy-deployment/

Demowfloat, Atlantic, Portugal		Axys WindSentinel with Vindicator III simultaneous pulse LiDAR		Wind resource assessmen t	Unknown	Unknown	Reports indicate device was deployed in September 2014 but the duration and validation characteristics of the deployment are unknown.	http://axystechnologies.com/axys-windsentinel-selected-edp-inovacaos-demowfloat-initiative/
Fécamp wind farm zone, English Channel, France		FLiDAR 4M with a Leosphere LiDAR system		Validation trial	Unknown	Unknown	Reports indicate device was deployed in summer 2015. Validation against the Fécamp meteorological mast.	https://www.youtube.com/watch?v=zwASiRge7es http://www.offshorewind.biz/2015/06/24/flidar-reduces-costs-in-combined-operation/
Calvados wind farm zone, English Channel, France		FLiDAR 4M with a Leosphere LiDAR system		Wind resource assessmen t	Unknown	Unknown	Unknown	https://www.youtube.com/watch?v=zwASiRge7es http://www.offshorewind.biz/2015/06/24/flidar-reduces-costs-in-combined-operation/

Hsing-Da Harbor, Taiwan		FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	Unknown	Unknown	Validation trial run by National Cheng Kung University of Taiwan. Validation was carried out against fixed onshore WINDCUBE v2 LiDAR.	http://axystechnologies.com/wp-content/uploads/2016/07/NCKU-Testimonial-Letter.pdf http://www.tsoe.org.tw/downloads/thesis/2014H3.pdf
Borssele wind farm zone (BWFZ), North Sea, Netherlands		Two Fugro OCEANOR SEAWATCH Wind LiDAR buoys		Wind resource assessmen t	Unknown	Ongoing	Fugro OCEANOR has placed two metocean buoys in the BWFZ, which provide meteorological and oceanographic data. The measurement campaign of the buoy positioned in the center of the BWFZ started in June 2015. In November 2015 the second buoy was installed close to the southern border of the BWFZ.	http://www.fugro.com/media-centre/press-releases/fulldetails/2015/06/04/fugro-awarded-contract-to-investigate-wind-farm-sites http://offshorewind.rvo.nl/studiesborssele
Atlantic Ocean, Maine		UMaine DeepCLiDAR with single Leosphere Windcube Offshore LiDAR		Pre-deployment validation	5 months	July 2016	UMaine deployed it DeepCLiDAR off the coast of Maine as part of a pre-deployment validation campaign. The buoy was deployed in February 2016 and recovered in July 2016. The system was validated by AWS Truepower.	https://composites.umaine.edu/2016/10/25/umaine-deepclidar-successfully-completes-pre-deployment-validation-based-carbon-trust-criteria-now-available-commercial-lease-purchase/

Picture references

WindSentinel/AXYS FLiDAR 6M		http://axystechnologies.com/products/flidar-windsentinel/
FLiDAR prototype		http://www.offshorewind.biz/2011/11/23/flidar-completes-its-trials-in-north-sea-belgium/
AXYS FLiDAR 4M		http://axystechnologies.com/products/flidar-windsentinel/
Fugro OCEANOR SEAWATCH		http://www.oceanor.com/related/Datasheets-pdf/eneco_lidar.pdf
Nass & Wind Marine Measurements for Meteorological and Environmental Assessment (M^3EA)		http://www.oceanologyinternational.com/__novadocuments/49179?v=635310012225230000

Fraunhofer IWES Wind LiDAR buoy		http://www.zephirlidar.com/fraunhofer-iwes-wind-lidar-buoy-verified-fino1/
Babcock FORECAST		http://www.zephirlidar.com/babcocks-forecast-floating-zephir-lidar-reaches-stage-2-carbon-trust-owa-roadmap/
EOLOS FLS200		http://www.eolossolutions.com/en/product
BLiDAR		http://www.blidar.fr/#
UMaine DeepCLiDAR		https://composites.umaine.edu/research/DeepCLiDAR/

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