HiPRWind

High Power, high Reliability, Off-shore Wind Technology

PROJECT DELIVERABLE REPORT

DELIVERABLE D3.2

Final Operation and Maintenance Protocol for the Floating Prototype

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Abstract

This document contains a summary of the work carried out in the framework of T3.1 ‘Definition of an O&M protocol’ before the project suspension. The report gathers the requirements for the O&M activities and the access to the floating prototype.

A first approach to a market analysis has been included. This activity was incorporated in the last period of the project, when new partners joined in the consortium. QI energy expertise in this kind of studies was considered as an added value to the O&M task.

WARNING NOTE. The Deliverable is not finished and has been partially elaborated due to the project suspension. However, some conclusions and findings have arisen until the moment this document was written and are consequently reflected on it.

Keywords: Final Design, Floating Platform, RAO, Fatigue, Stress Concentration Factor, Seakeeping, Structural Calculation, Mooring, Chain, Towing, Corrosion Protection, Access System, Ballast System, Fully Coupled Model, Uncoupled Model, Damper, Towing, Dynamic cable, Load Case, Stress Analysis, Nodes

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Annex: 120923 Hiprwind_Access_rev2.pdf

1 Purpose and scope

A first approach to identify the main issues and requirements to the floater design and the WT started for the original emplacement and turbine model. The aim of the protocol is to ensure the prototype operation and safety access and maintenance to maximize the working time.

For this reason, and to ensure that it will be still valid for the new conditions of the project, the previous work developed by the original partners has been be reviewed and checked by Ingeteam Service, who has also added some additional comments, suggestions and recommendations; the reviewed version is presented in the following sections.

In addition to the O&M activities, a first approach to a market analysis has been included, taking advantage of QI Energy expertise in this field.

The document is divided in six sections; the first one introduces the access procedure to reach the Platform, then the maintenance vessel support, the maintenance and repair specifications adapted to a floating structure. All the health and safety aspects are also commented to minimise risks. Then an inventory of the relevant rules and standards with application to the floating structures is revised including standards in process. Finally the market analysis is highlighted to the extend of the available information and the limitations of the unknown final location.

2 Access system for the floating structure

2.1 Fendering

During the operational phase the access system is the only way to enter the floating structure. There will be no helipad on the structure or other means of transportation available.

The access system should be capable of handling standard maintenance vessels used at fixed foundation offshore wind farms, including larger vessels which will be needed in the case of maintenance or even repair work where materials and parts need to be handled using the small crane on top of the structure to load and unload weights up to, at least, 300 kg.

To provide personnel access by boat the floating structure should be fitted with a "boat landing" comprising a ladder and two fenders per access point. The fenders are positioned on either side of the ladder and project out from the pile, allowing a small vessel carrying maintenance crew to temporarily secure itself alongside the ladder to transfer personnel.

During such fendering operations a vessel docks or pushes against an installation leg to allow persons to step over to a ladder. Fendering the vessel may also permit transfer of cargo with a suitable crane and available deck space.

Image 1 - Fendering

For fendering operations it has to be taken in account some basic concepts that are exposed below, in addition to the requirements exposed at DNV-OS-J201, OFFSHORE SUBSTATIONS FOR WIND FARMS October 2009.

The leg of the installation shall be designed to withstand loads and impacts from the largest expected size of service vessel and the maximum vessel size and approach speed shall be clearly marked on the leg. Platform designs shall meet requirements of Section 3 H600 (Ship traffic) and Section 4 D (Variable functional loads) of DNVOS-J101. It is also important to take in account that for service vessel collisions, the risk can be managed by designing the support structure against relevant service vessel impacts.

For this purpose the limit state shall be considered as a ULS (98% quantile in distribution of annual maximum load or load effect - Load or load effect with return period 50 years). The service vessel designs and the impact velocities to be considered are normally specified in the design basis for structural design. See also DNVOS-J101 Section 4 D “Variable functional loads” for further details. It is also very important to highlight that no J-tubes, umbilicals, cables or risers shall be positioned on or within legs where fendering operations are expected.

It has been suggested to include a second boat landing system, in an opposite direction, which will provide redundancy and a safer access to the platform that would widen the window of accession dates related with wind direction. At both landing systems, even if it is finally installed only one, fenders shall be installed at either side of the ladder capable of withstanding vessel impact.

2.2 Ladders – ascending and descending (see also DNV-OS-J201)

Ladders and associated intermediate platforms or structures shall comply with ISO 14122 and should only be used where the following minimum criteria are met:

a) It is demonstrated that stairs or a lift are not a reasonably practicable option.
b) A maximum ladder height of 6 m shall be used where practicable.

An intermediate or rest platform should be installed where ladder runs are higher than this and where they could not impact a vessel during fendering and transfer operations. Where impracticable, it shall be demonstrated that a person can rest using a suitable fall arrest system without impacting its operability through such operations. Indeed, tidal variations may require single ladder heights in excess of 6 m. Where ladders longer than 9 m are required, a resting platform should be fitted and the platform should remain clear of the transfer vessel at the highest astronomical tide.

The ladder rungs should be square with an edge facing upwards to minimise the risk of slipping in wet, icy or fouled conditions and self-closing gates, which meet the requirements of ISO 14122-4, shall be used at the top of ladders fitting a “hatch open” lock.

At the upper part of the ladder either safety cages (hoops) with at least 5 vertical slats or a fall arrest system (meeting local requirements) with appropriate harness anchor points shall be installed.

- Fall arrest Yoyo system (retractable lanyards fixed to the top of the ladder) is recommended.
- Note: New local requirements have to be informed by FlexWT consortium.

Image 2 - Hywind solution with Yoyo System

2.3 Small Crane on Floater

Operators stepping over from a boat are not allowed to carry any cargo, tools, baggage or spares with them which have to be lifted separately by a small crane system, with marked SWL (safe working load) of at least 300 kg, to lift tools and spares from the boat onto the structure. The platform will be provided with crane system accessories like ropes, sheaves, carabineers, cover… And in case it is manual, it has to be foreseen a power supply close to it to get power supply for electrical winch.

It should be possible to open the handrails at certain points (hinged gate, that can be securely locked in open and close positions, avoid that cables or other equipment has to be disassembled to open them) to allow easier lifting of larger components or injured personnel on stretcher as in emergency situations, the crane can be used to lower injured personnel onto the boat (either man riding capability, or using descent equipment as on the turbine). Around the crane area anchoring points are needed for 22,2kN load (worst case EN 795, EN 30508 and Osha) next to the opening on both sides, to allow workers to secure themselves during lifting operations.

Image 3 - offshore platform crane

The access to the transition piece to the tower will be through a walkable corridor, as the installation of a walkable Tramex covering the whole surface has been rejected due to design restrictions, anyway it has been requested a design modification to enlarge the base platform in order to handle tools and spares during maintenance interventions. All the walkways, just like the aforementioned steps and ladders have to be manufactured with slip resistant surface.

The tower will be accessible through the inside of the transition piece. A crane with at least the lifting capacity of the one in the floater is suggested for installation inside the nacelle, substituting the original hoist, once the final wind turbine model is decided and therefore still pendant to plan.

See also the document attached “120923_Hiprwind_Access_rev2” by ACCIONA.

3 Vessel support & requirements

FlexWT consortium may contribute with existing local facilities (http://www.vivawind.no/) which will include a fleet. It is needed to collect all the information of the existing means to evaluate if they are enough, to the date no information have been provided to HiPRWind partners. By the moment it has been identified fleet requirements:

- Service vessels
- Repair and transport vessel
- Fast rescue boat (in nearest port)
- Use of installation vessel (cable and mooring handling vessel) during operation.

They are also still to be defined some relevant issues, waiting for relevant information by FlexWT consortium:

- Existing facilities at new location.
- Communications (between boat, port and turbine)
- Conduct of navigation
- Navigation equipment
- Role of boat crew in emergency cases such as fire, man over board, evacuation procedure

4 Maintenance and repair specifications

After the suspension of the project, it has been decided to use a different turbine: General Electric GE1.5, in this technology there are different models and although it is still not decided the exact one to be used, this do not affect its maintenance.

This turbine is usually maintained twice per year: 1 intervention focused on hydraulic systems and oil substitution, and the other one also includes general electro-mechanic preventive maintenance.

- These interventions will be performed in this case as they are in an onshore wind turbine.
- Additional tasks will be included in the maintenance procedures, related to the new offshore conditions.

The turbine has to be marinized, and some elements will be added, replaced, coated or insulted and these changes have to be taken into special consideration and included in the maintenance program once all the changes to be introduced in the turbine have been decided.

To ensure proper operation of the turbine, periodic visits will be scheduled to check the key and more corrosion-sensitive elements:

- The key elements will be identified and a checklist will be produced. (TBD)
- The frequency of the check-visits will decrease as it is observed that the elements are well preserved and operating normally.
    - It is expected that the first visit will be after the first month from the commissioning, then two months later, then three and so on, until it’s decided if it is enough performing two interventions per year as in an onshore installation.

5 Health and Safety: Operational and safety rules and instructions

5.1 General Access rules

The first golden rule is that only trained personnel is allowed to work on the floater, and must have completed a basic Sea Survival Course (according to International standards), third party personnel, with a maximum of 2 people at a time if external support required, might enter on ad hoc instruction and escorted by trained personnel. Finally, visitors are not allowed on the platform, visit and inspection will be done from boat only.

The manned turbine must have a minimum of two people on-board at any time and a maximum of four, although some operations and scenarios would require at least 3 people, as it will be indicated in the relevant procedures. Whilst the turbine is manned, a safety boat (could be the work boat) must be in standby at the turbine for emergency cases.

The figure of “Offshore operations master” needs to be implemented. He decides on go or no go on a daily basis and has the final responsibility for the safety of the turbine and the personnel working on it. Whenever the turbine is manned an individual must be designated as the “Offshore operations master”. He ensures all crew has received the “safety briefing –turbine”. All people taken on the boat receive the “safety briefing – boat”. In this way, all operations require to be planned, approved and logged in written form prior to the execution by the contracted boat service (or the existing one at the onsite facilities, if any) and the “Offshore operations master”.

Immersion suits should be worn at all times during transit and when working on the outside of the turbine or floater structure in cold conditions (local legislation and weather conditions on the new emplacement have to be checked: probably immersion suits are a must due to the new colder conditions). They are designed to delay the onset of Hypothermia.

Some emergency instructions and procedures including exercises will be developed for the personnel visiting the turbine at a regular basis: “Man Overboard Recovery”, “Abandon Turbine Procedure” and “Fire Fighting Procedures”.

5.2 Qualification of personnel

Required safety training of personnel:

- Sea survival course
- Safe Working at Heights / Ladder Safety Training Course
- Man over board training
- Fire emergency training
- Rescue operations training - evacuation of injured personnel
    - Rescue & Evacuation from Height

5.3 Safety equipment

On vessel

- Emergency equipment for rescue operations.

On floating structure

- Liferaft - 6-man valise.
- Horseshoe buoy and Dan buoy.
- Fire extinguishers and smoke alarms.
- Medical Kit.
- Auxiliary power.
- Emergency rations and drinking water.
- Thermal sleeping bags.

Personal safety equipment:

All personnel shall be provided with appropriate personal protection equipment including safety harness, head protection and a high visibility life jacket. A survival suit shall always be available for use.

The life jackets have to be EN 399 maritime standard approved, and it will be evaluated the need of Personal Locator Beacon (PLB: This electronic device is activated in contact with water (or by the person itself) and the radio signal can then be used to retrieve the person from the water by the boat crew or SAR crews).

This equipment will include, besides the standard from wind turbine operations (overalls, helmets, shoes...), thermal Protective Suits (at water temperatures below 10 ℃) according to standard EN ISO 15023:2013.

Life lines and Shock Absorbing Lanyards according to standard EN354/355: Whenever the lifelines are in use they must be secured to a strong point on the turbine or floater structure. Lanyards are Available in lengths up to, but never exceeding 2m, lanyards must have energy absorbers to comply with European Standards. In a fall a user will travel the length of the lanyard before the fall is arrested. Restraining devices to prevent people from getting too close to the edge of a building have to be also taken into consideration.

For workers who are required to work at heights, on poles and other structures in a supported position Work Positioning Devices/Restraint Belts according to EN358/EN359 will be required, enabling them to have both hands free for working. These devices are NOT intended for fall arrest.

In a work situation where there is a fall potential a full body harness must be worn (EN361/prEN1496/1497/1498/020895). Many varieties are available, from harnesses with a single rear D ring, to full multi-purpose harnesses with elasticated webbing and lumbar support. Other types regularly in use include sit harnesses, rescue harnesses and even harnesses with built in life jackets. (Chest and rear D rings only should be used for fall arrest purposes).

Ingeteam HSE dpt. will double-check and test in real operation, but harness with built in life jackets are preferred at first.

Image 4 - Sea Wind Worksuit

6 Inventory of relevant rules and standards

- DNV-OS-J201.
- DNV-OS-J101.
- EN ISO 14122.
- EN 795 .
- EN 30508.
- EN 399.
- EN ISO 15023.
- EN354/355.
- EN358/EN359.
- EN361/prEN1496/1497/1498/020895.

7 Market Analysis

7.1 Introduction

A top-down approach has been adopted, trying first to benchmark and make use of the discoveries and conclusions of other in-execution projects related to floating offshore technologies. Then, the O&M solutions in such projects where submitted to a SWOT analysis considering economic factors. Some call conferences took place with Ingeteam to discuss conclusions who, at same time, was in contact with the other WP partners. A tentative Cost analysis was then implemented for the best identified solution. The Key blocks of factors affecting the O&M were also announced and a sensibility analysis was planned to be done to determine the impact of those factors in the increase and/or cost reduction. A set of recommendations was the last deliverable scheduled.

7.2 Benchmark

RTD projects analysed where divided in relation to the technology applied:

- Semi-submersible, A number of large columns linked to each other by connecting bracings. The columns provide the ballast and flotation stability (column-stabilized). DEMOWFLOAT - Demonstration of the WindFloat Technology. Ref.: 296050. Portugal. Similar to HiPRwind.
- Sparbuoy. Traditionally a steel or concrete cylinder with low water plane area, ballasted with water and/or solid ballast to keep the centre of gravity below centre of buoyancy. HYWIND. Statoil.
- Tension Leg Platform (TLP). TLPs normally have a large centre column, with number of submerged “arms” to which the tension legs are attached. PelaStar. Glosten Engineers (USA).

Some other projects has been analysed through the CORDIS data base and the very useful data base provided by http://www.4coffshore.com

7.3 SWOT analysis

In relation to our HiPRwind structure, the SWOT analysis derived in some conclusions which where compared with the other alternatives.

In the fabrication and installation, a welded structure is constructed or assembled on-shore or in a dry dock. Transport to site is done by using conventional tugs. Fully equipped platforms can float with drafts lower than 10 meters during transport. Towing to field can typically be done in relatively high wave heights.

In relation to O&M, major maintenance can be done by towing the structure to shore. Most concepts can be reached from all columns in case of in-situ maintenance and service. Some concepts plan to build helidecks on the substructure. Regular inspection of welded connection, both above and below sea-level is necessary in order to identify and mitigate fatigue cracks, corrosion, etc. Nevertheless VIVA the Norwegian test centre for wind turbines associated to FlexWT was in charged to provide the infrastructure, vessels and O&M description. No heliport was foreseen in this case.

Parameters	Strengths /Weaknesses
Structural design	+ The most flexible design with regard to water depth with a typically low draft - Might have larger wave-induced motions that may impact the rotor, tower and blades
Fabrication & Installation	+ Possibility to construct and assemble the structure on-shore or in a dry dock - Expected to be a more complex structure to manufacture: larger amount of welds and connections between structural elements than other philosophies
Decommissioning	+ Easy decommissioning is expected, towing to shore/dry dock.
Operation & Maintenance	+ The stability and low draft enables semi-submersibles to be easily towed back to shore in case of major repairs - Might be more subject to corrosion and ice-loads since much of the structure is close to the water surface

7.4 Operation and Maintenance tentative cost analysis

Offshore wind O&M is the activity that follows commissioning to ensure the safe and economic running of the project. The project must achieve the best balance between running cost and electricity output. O&M occurs throughout the life of the project, which is nominally 20 years. The economics of offshore wind O&M require a balance to be struck between the money spent on maintaining the project and the revenue lost when the electricity output is limited by technical problems. Reducing the cost of the energy produced by offshore wind projects is a major focus for the offshore wind industry. Finding ways to reduce the cost of O&M services and optimising asset performance have important roles to play.

However, Floating wind energy structures are typically designed for being towed back to shore using cheap, standardized vessels when a major repair is called for. Again, the location is crucial to determinate the best option (in situ maintenance or towed back). For bottom-fixed wind energy, a costly and weather sensitive jack-up vessel is needed for the major maintenance activities. Because of this, floating wind energy farms are likely to have relatively low operational costs thanks to lower equipment and material cost for service and maintenance work. It should however be noted that there are variations between the different concepts. By the contrary, small repairs offshore could be more difficult due to platform instability.

When considering the cost of energy, there are several perspectives and approaches to consider. OPEX and CAPEX are the main features examined to evaluate the economic potential of the project. In terms of CAPEX, floating wind energy is estimated to be approximately 10-20 % more expensive than bottom-fixed wind energy[1].

[1] The Crown Estate – UK Market Potential and Technology Assessment for floating offshore wind power

Generally speaking, CAPEX in a floating device can be divided in WTG (40%), Substructure (25%), mooring and anchoring (10%), electric infrastructure (5%), installation (10%) and others (10%) with approximately 3 to 4.5 Million €/ MW[2]

However, when considering a wide time span, in example 20 to 30 years, quantification of the expenses in different phases of the project becomes important due to capital costs and risk placement. This is often referred to as a Life Cycle Cost Analysis (LCCA). Usually, the LCCA is divided into five main phases, distinguished by the different operating conditions and capital intensity;

1. Development and consenting (D&C)
2. Production and acquisition (P&A)
3. Installation and commissioning (I&C)
4. **Operation and maintenance (O&M)**
5. Decommission (DECOM)

We have focused our analysis in this report in the O&M phase.

O&M design for HiPRWind project, depends mainly on distance to shore, depth to the seabed, weather and sea conditions, onshore infrastructure and some other factors. The lack of a final location for the platform, made impossible to determine a precise planning for the activities until this decision was taken. Nonetheless, a preliminary reflexion was done to analyse the coming areas of activity. In this sense, the value chain for offshore wind O&M can be categorised into seven areas of activity:

- **Onshore logistics** relates to the port-side activity, warehousing and on-site office space.
- **Offshore logistics** – equipment, planning and resources required to move people and equipment at sea including work boats, offshore bases and helicopter services and jack-up services (both likely excluded in the HiPRwind case)
- **Turbine maintenance** – the technicians and equipment needed to inspect and repair the wind Turbines.
- **Export cable and grid connection** – the technicians and equipment needed to inspect and repair the connection of the offshore power plant to the onshore power transmission system, including onshore and offshore electrical substations and export cables
- **Array cable maintenance** – the technicians and equipment needed to inspect and repair the susbsea cables that connect the turbines to create a unified power plan.
- **Foundation maintenance** – the technicians and equipment needed to inspect and repair the turbine foundations and sub-sea structures
- **Back office, administration and operations**– performance monitoring, electricity sales etc.

[2] The Crown Estate – UK Market Potential and Technology Assessment for floating offshore wind power

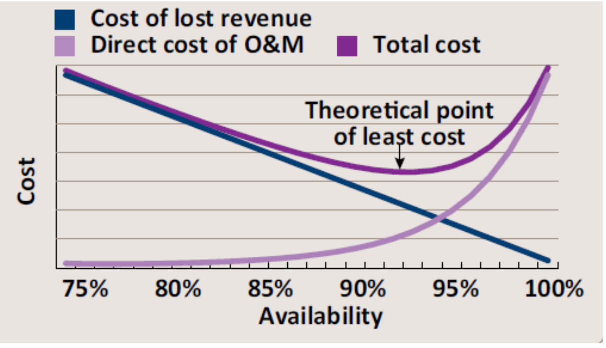
Three types of O&M-strategies can be used 1) calendar based preventive, 2) condition based preventive and planned corrective, and 3) unplanned corrective.

- **Preventative maintenance** includes proactive repair to, or replacement of, known wear components based on routine inspections or information from condition monitoring systems. It also includes routine surveys and inspections.
- **Corrective maintenance** includes the reactive repair or replacement of failed or damaged components. It may also be performed batch-wise when serial defects or other problems that affect a large number of wind turbines need to be corrected. For planning purposes, the distinction is usually made between scheduled or proactive maintenance and unscheduled or reactive maintenance.

Offshore wind O&M involves a diverse range of activities. However, there are a few fundamental concepts that underpin the way that the key players are likely to approach O&M.

Some of the most important factors in shaping O&M are:

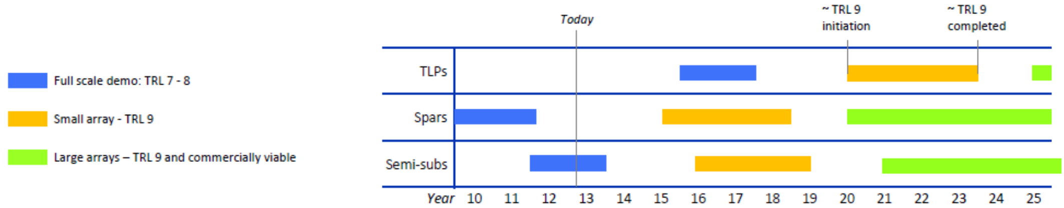
- Availability – as a measure of the performance of the asset



- Scheduled and unscheduled maintenance – the nuts and bolts of keeping a project running smoothly
- Access – overcoming the constraints placed on operations by the weather and sea conditions. Under this concept there are two important definitions to clarify:
  - Transit time – the time needed to shuttle a service crew from the O&M base to the place of work. With limited shift hours available, the time taken to transport crews to and from a maintenance job cuts into the amount of time actually working to maintain the turbines and other plant. The further the project site is from the O&M base, the less time can be spent by crews on active work, given the longer transit time and risk of fatigue.
  - Accessibility – the proportion of the time a turbine can be safely accessed from a particular vessel and is dependent on the sea conditions. For example if, at a particular project, the significant wave height is greater than 2m for 40% of the time, a vessel that can transfer crew and equipment only in wave heights of 2m or less might be said to have 60% accessibility.
- Cost reduction – a continuing focus for the industry as a whole. Cost reductions can be obtained working over the following issues:

- Improved remote monitoring and control to better understand the offshore plant and make previously unscheduled activities more predictable, reducing the logistical burden of putting technicians on turbines.
- Design and manufacturing improvements aimed at boosting reliability, thereby reducing the frequency and cost of unscheduled maintenance.
- Other, more fundamental, improvements such as the development of more reliable, gearless (direct drive) turbines. Non-technical areas for cost reduction, although uncertain, may include greater synergies, sharing of resources such as jack-up vessels or other logistics plant between neighbouring projects and greater competition within the O&M supply chain for a range of contract packages.
- Perfect O&M maximises availability, at least cost, by ensuring the best possible access to offshore plant, minimising unscheduled maintenance and carrying out scheduled maintenance as efficiently as possible – ultimately resulting in the lowest possible cost of energy

There is another aspect which determine the type of O&M service provided and this is the time to market. The Technology Readiness Level fixes in some way the allocation of resources as business model changes significantly in case of a 1,5 MW size, 6 MW size (this is the coming trend) or a WT floating park with several floating units in operation. According to the document "UK Market Potential and Technology Assessment for floating offshore wind power", time to market is depicted in the following chart. As it can be seen, semi-sub systems (applied to HiPRWind), are still in TRL 7/8, so the services for O&M must be adapted also to this demo phase.



According to the project size, the following assumptions are considered:

- Only one specialised maintenance vessel will be used. Average travel time depends on the final location which it is unknown at the time this report is writing.
- Two annual maintenance of 24 h with two technicians assisted by small maintenance vessel. A larger preventive maintenance every 10 years is also assumed, requiring twice the time. In addition subsurface inspection every 3 years assisted by a diving vessel is required.

In addition, it must be highlighted that according to Ingeteam, “the turbine has to be marinized, and some elements will be added, replaced, coated or insulted and these changes have to be taken into special consideration and included in the maintenance program once all the changes to be introduced in the turbine have been decided”. They have decided that “the first visit will be after the first month from the commissioning, then two months later, then three and so on, until it’s decided if it is enough performing two interventions per year as in an onshore installation.”

- Condition based replacement of smaller components with predictable wear is expected to take eight hours by two technicians. Replacement of larger parts is assumed to take twice the resources.
- All of the operations are expected performed at site. Minor incidents can be repaired without the assistance of a crane vessel. Corresponding expected repair time is 4 hours
- Major repairs will require a tug vessel moving the offshore turbine the onshore facilities and expected repair time is 48 h with the aid of four technicians. According to Ingeteam, the manned turbine must have a minimum of two people onboard at any time and a maximum of four, although some operations and scenarios would require at least 3 people, as it will be indicated in the relevant procedures. Whilst the turbine is manned, a safety boat (could be the work boat) must be in standby at the turbine for emergency cases

It is difficult to estimate costs of operation and maintenance at this stage with no information of the final location, but some referenced figures can be provided.

According to Ingeteam comments, there are four categories of O&M costs, which are described in this section:

I. Plant Operations. Plant operation is a fixed annual cost, based on proprietary database of offshore wind plant cost data. This is the category in which taxes and insurance are included. It is not possible to fix a figure at the present state of development.
II. Schedule and unscheduled maintenance. Turbine maintenance cost is a fixed annual cost, for a given distance from port. The annual cost may include scheduled and un-scheduled maintenance depending on the distance to port. The turbine was already selected by Fraunhofer. Major turbine revision will include:
    a. Verification analyses for the turbine and nacelle
    b. Structural design and analyses of the tower
    c. Arrangement of equipment and access in the tower
    d. Corrosion protection (painting)
    e. HSE requirements and equipment related to operation (eks. Rescue from Nacelle)
    f. Fabrication of the tower
    g. Transport to the installation site
    h. Installation of tower and equipment

i. Planning of access and transport of spare parts/components (this may influence required equipment as cranes and other arrangement)

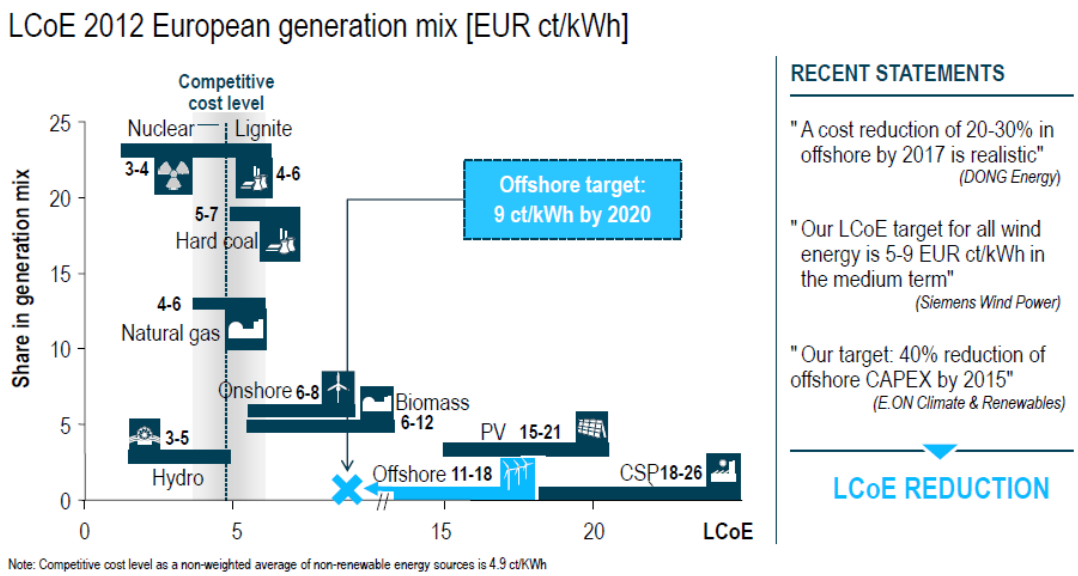
Although, it is difficult to calculate at this stage, the cost of this service for a 1.5 MW WT, could round between 75.000 € to 100.000 €/year.

III. Equipment and Foundation maintenance. Equipment and foundations maintenance is a fixed annual cost. Regularly occurring structural inspections are included in this category. The HiPRwind hull is expected to have a similar level of inspection effort required as a bottom-fixed foundation, namely a regularly scheduled, remotely-operated vehicle (ROV) based visual inspection in-situ. It is not anticipated that the HiPRwind hull will be removed from service for repairs or maintenance during its service life.

The Key blocks of factors affecting the O&M need to be clarified and the sensibility analysis is pending. At the present stage of development, no final figures (contribution to LCOE and O&M costs) can be calculated as the following information is not available; sensors and cables specifications, the installation and replacement procedure, whether or not is possible to replace them once the prototype is installed and in operation and how critical is the sensor for the correct and safe operation of the prototype, if redundancy is required both for the sensor or for the information provided…

7.5 Conclusions

In order for floating wind energy to become truly competitive, it is not only important to achieve parity with traditional fixed offshore wind energy, but it will have to reach a level where it can compete also with other (renewable) energy sources, such as onshore wind energy and biomass. This has long been the reality for traditional offshore wind and the industry has paid high attention to the topic for several years, learning from experience, undertaking research etc. Even if the trend has been pointing upward the last years is it reasonable to believe that the overall cost level is likely to decrease both for bottom-fixed and floating wind energy.



According to a recent study of Roland Burger consultancy[3], target price for LCOE 2020 of offshore may rounds 9cts/kwh.

Technical improvements, learning effects and supply chain improvements are expected to contribute the most to floating wind energy cost reduction. As the market matures and more and more systems are built, tested and deployed in a large scale, design and manufacturing process optimizations of the substructure and wind turbine will probably be the leading cost reduction factors.

Also more radical inventions coming from research and development is foreseen to have a cost reduction effect, such as horizontal transport of WTGs, more lightweight materials et cetera. The possibility to use alternative material, e.g. concrete, in parts or for the entire substructure could also lower the cost as well as reducing the exposure to steel cost variations.

[3] ROLAND BURGER. Offshore Wind toward 2020. April 2013

HIPRWIND PROJECT

ACCESS

Written by:	Approved by:
Date:	Date:

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1 INTRODUCTION

Description of access mean proposal and personal security for O&M.

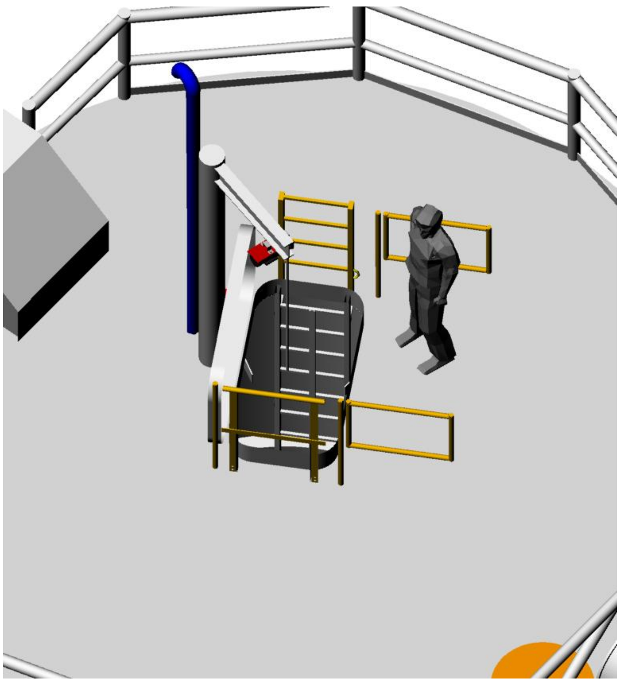
Main question to be solved:

Do we need to comply totally with BV: NI 537 DT R00 E "Guidelines for the Design of the Means of Access for Inspection, Maintenance and Operation of Commercial Ships."

Actually access system do comply IMO-IACS requirements.

2 ACCESS TO COLUMNS

It is proposed to eliminate the top column structure for access and simplify it with a watertight hatch. The minimum dimension (recommended dimension 1600x850 mm) of that hatch should be enough to have easy access by the vertical ladder and to extract any equipment or injured personal with the help of an electrical hoist supported in a "L" structure with a minimum strength to support 22.2 kN



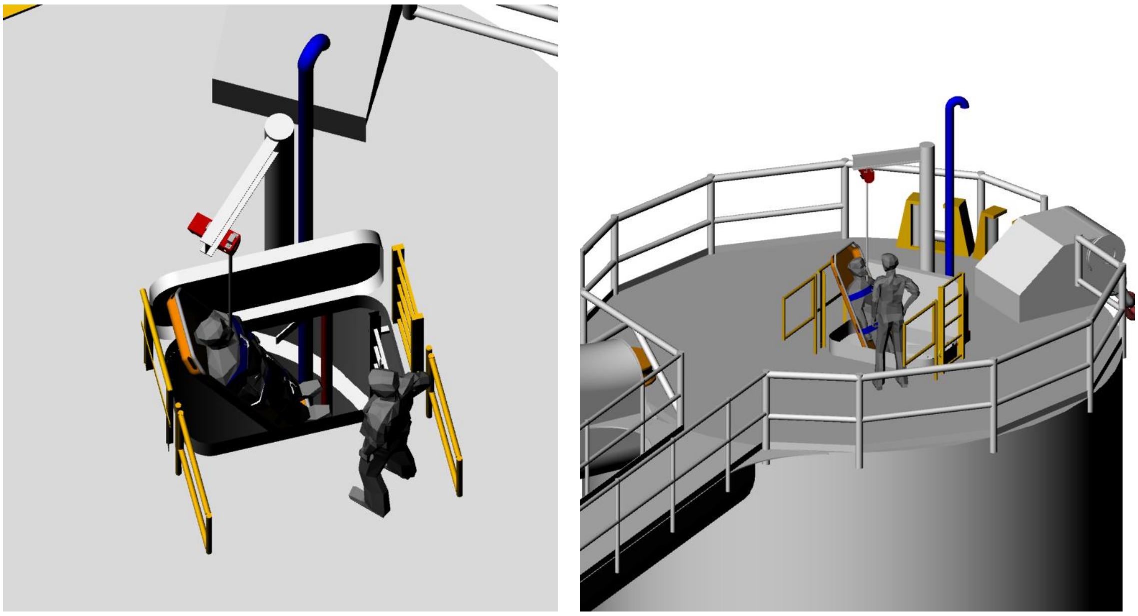


Figure 1: Proposal for the main access hatch to colums

It is recommended to change the ladder radial distribution and the ventilation pipe to have them orientated close to the proposed main electrical tray and sounding pipe (represented in red and blue in the bellow picture), that also reduce the transit in each platform.

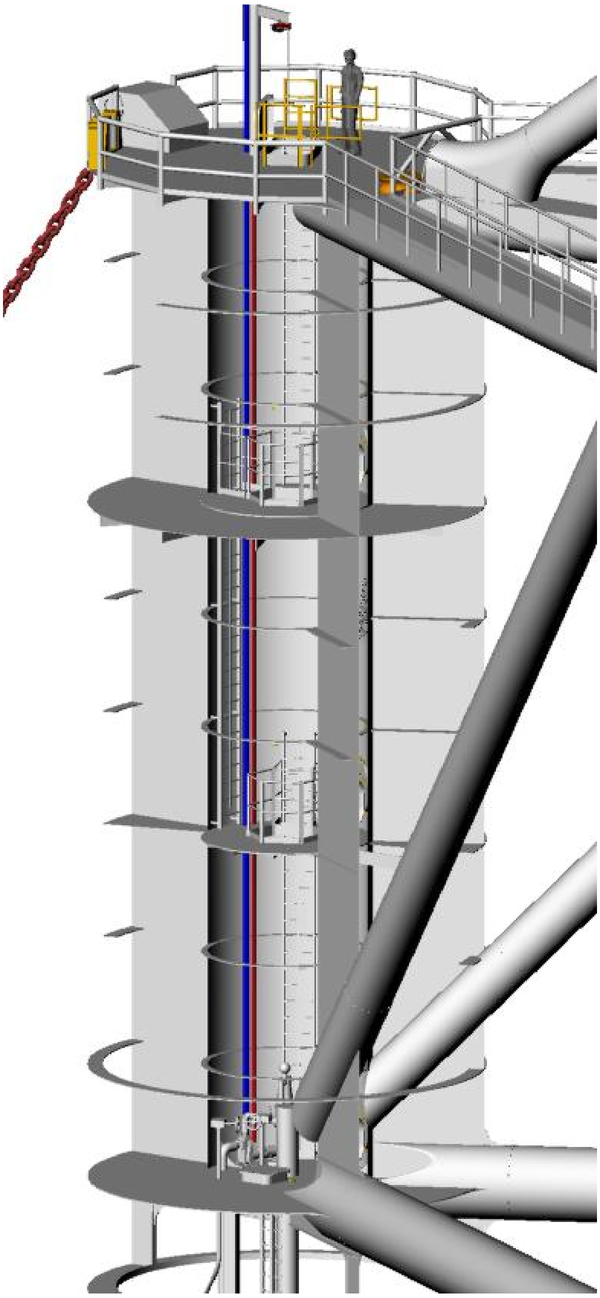


Figure 2: New radial distribution of ladders and main electrical tray (red) and ventilation for the ballast tank (blue)

Ladder should not have cage protective system and shoul have Ladder Climbing Systems as shown bellow.

Figure 3: Ladder Climbing Systems

2.1 MANHOLES TO RADIAL TANKS

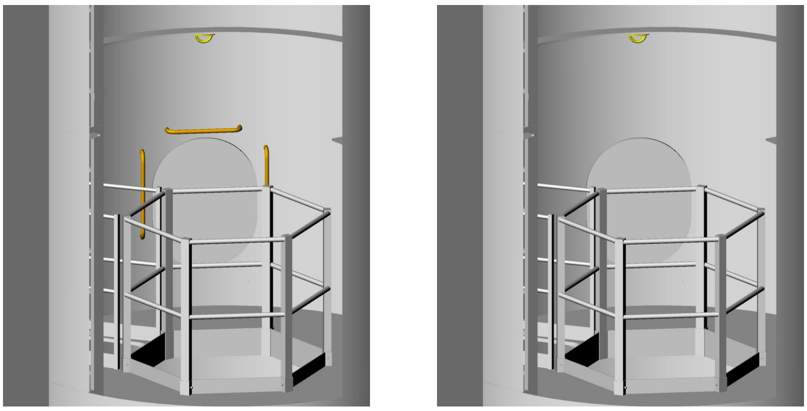


Figure 4: Manholes alternatives

Actually those manholes comply to IMO specification (800x600mm) but not BV guideline (specification of 950x750mm and 3 handles as shown in the previous figure).

We propose not to comply with BV guideline, as Hiprwind manholes are mean of access for periodical (1 year inspection) not for routine O&M access it is considered excessive to comply with the extra requirements form the guideline. It is e proposed to install Anchor points (22.2 kN resistance) in the vertical of each manhole (as shown in the figure) to support any winch, or rescue equipment. That point could be part of the ring stiffener just at the top of each manhole.

Figure 5: Strong anchor points certified

Other point to install 22kN safe anchor point are:

In the vicinity of the hatch access for the ballast tanks.

Figure 6: Strong point for the ballast tank hatch access

In the vicinity of the main hatch access to the columns.

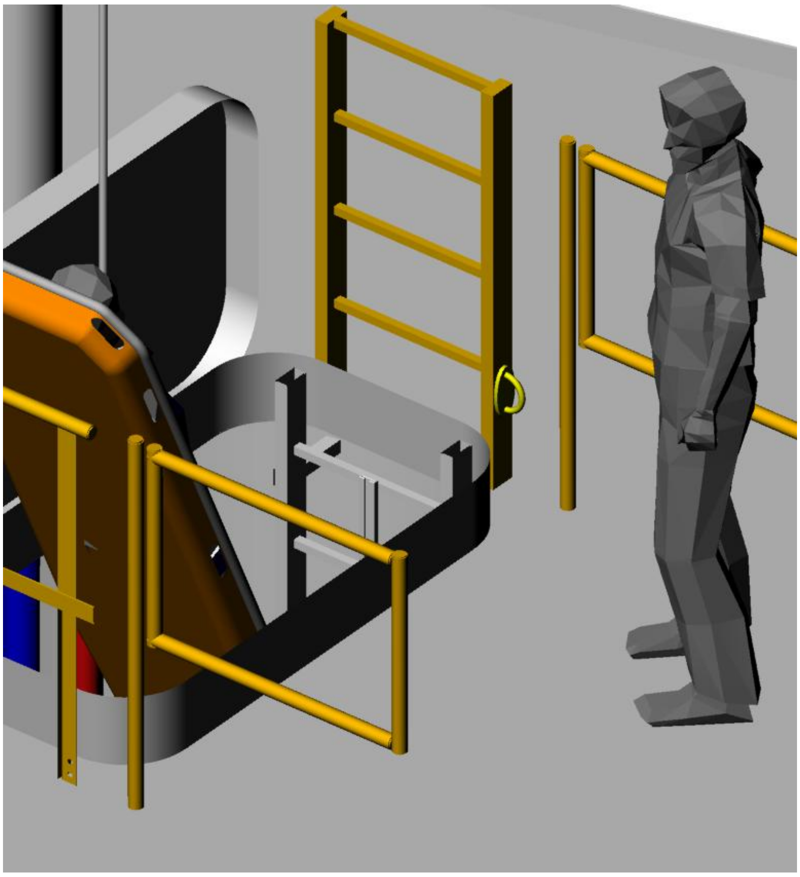
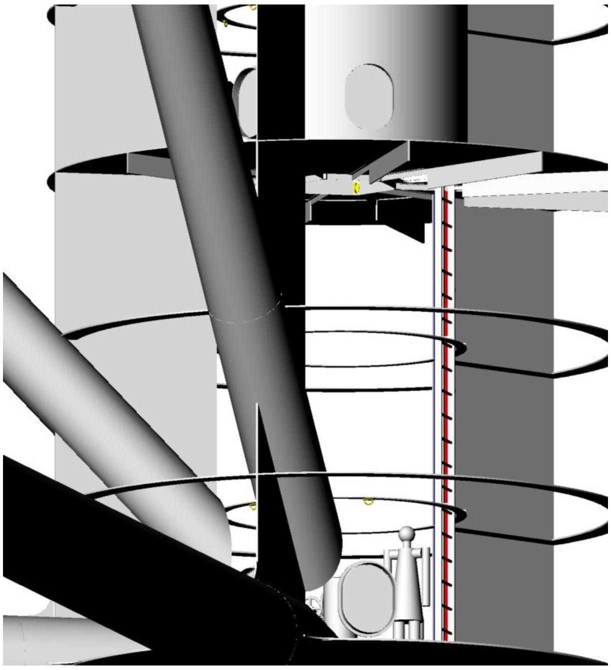


Figure 7: Strong point for the main hatch access



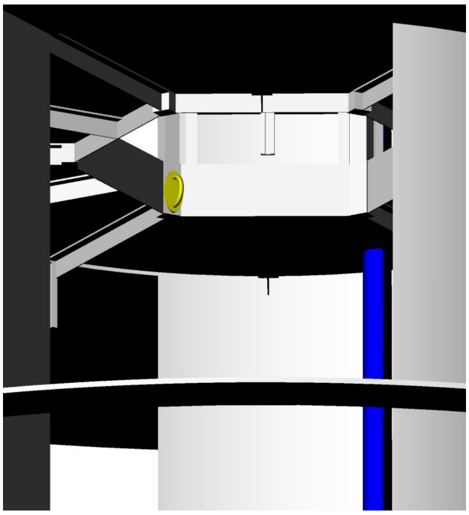
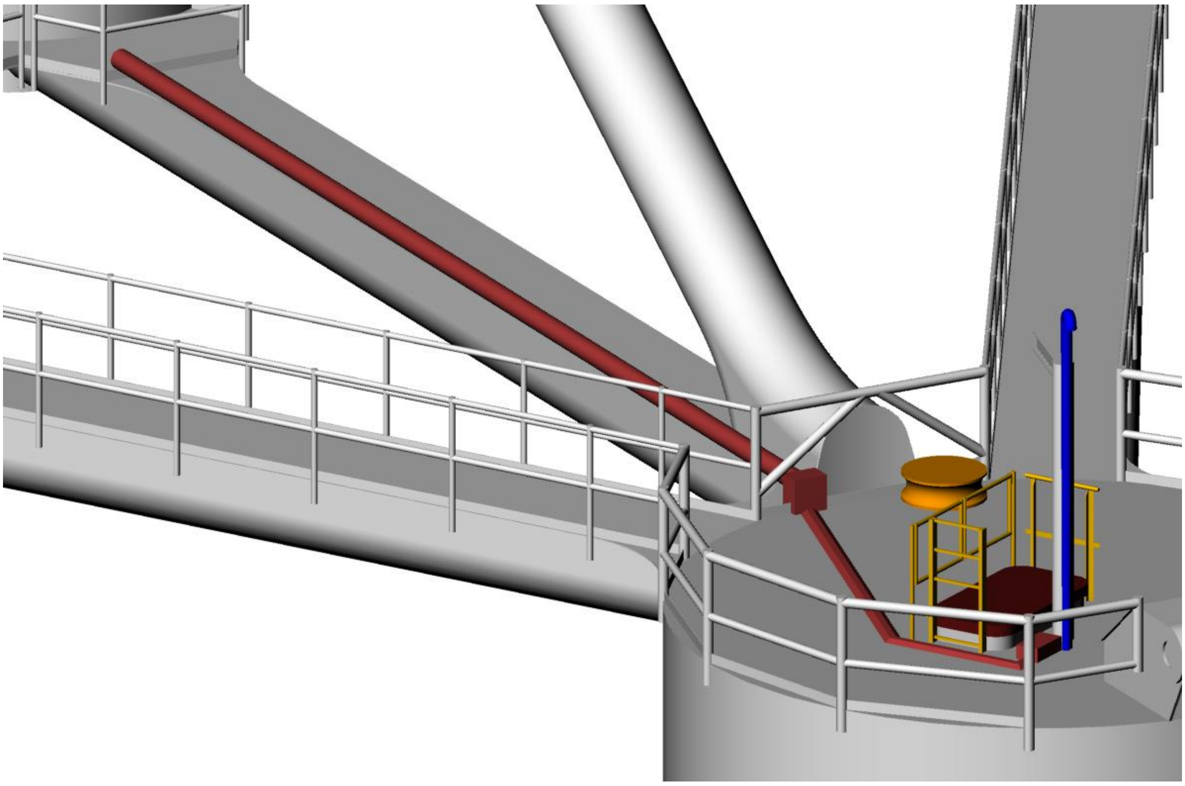
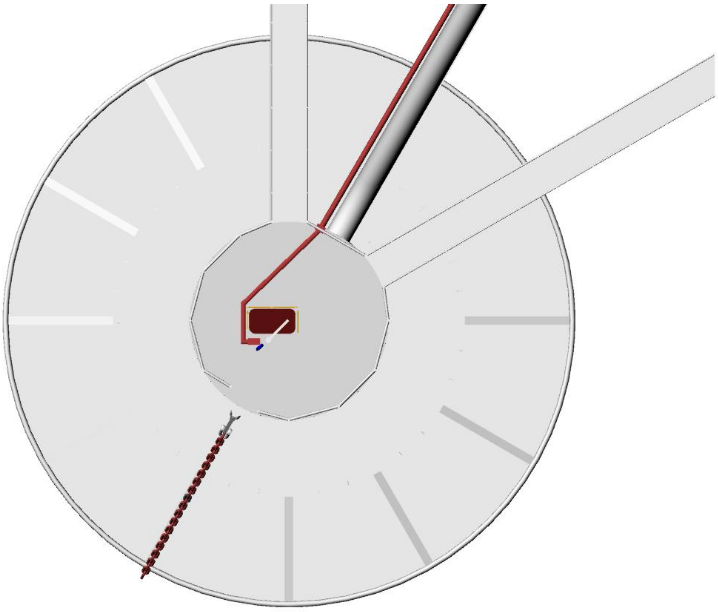


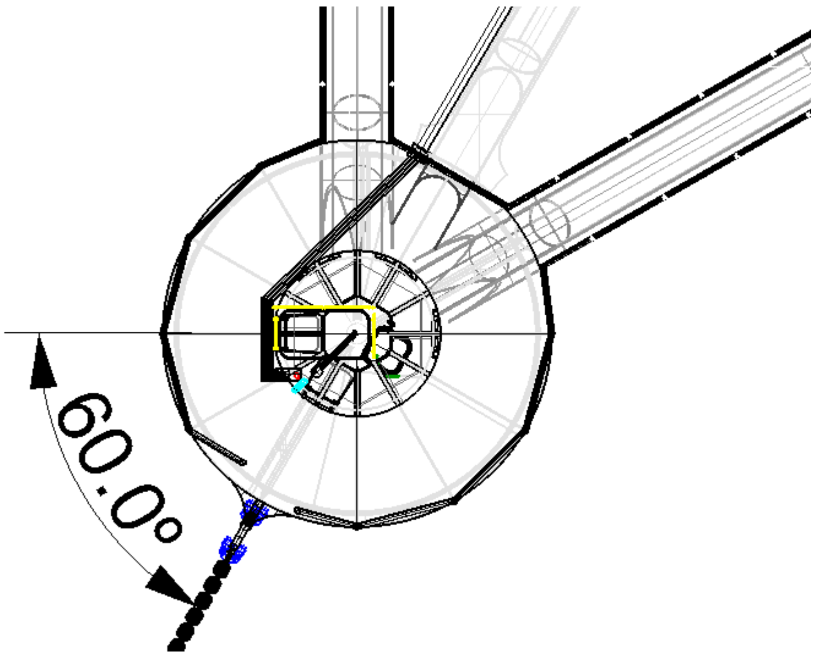
Figure 8: Strong point for a hoist to elevate ballast equipment (pump & filter)

3 ELECTRICAL CABLE PATH.

It is proposed to path the electrical cable form the central tower to the columns trough pipes over the radial braces, once over the top of the Colum it is proposed to path the cables through a pipe or try layed over the floor and covered by a protective case, that proposal that it is not very elegant will allow and easy maintenance and possible replacement, or incorporation of new cables better than conduction it through watertight compartments inside the columns with the need of watertight passage over each bulkhead or vertical subdivision.



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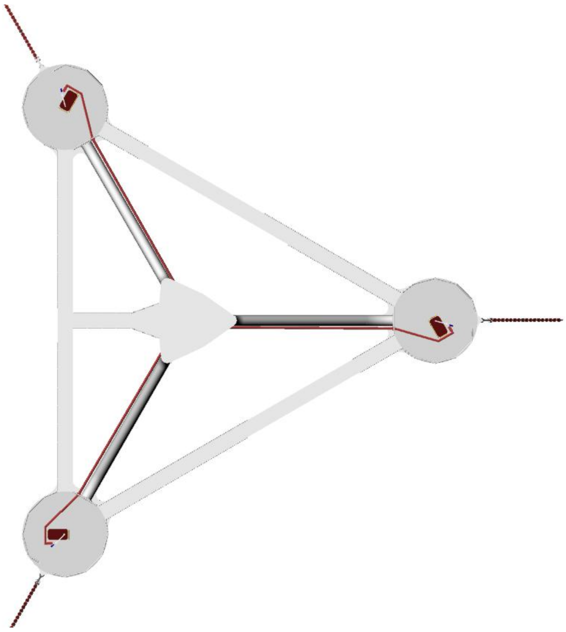

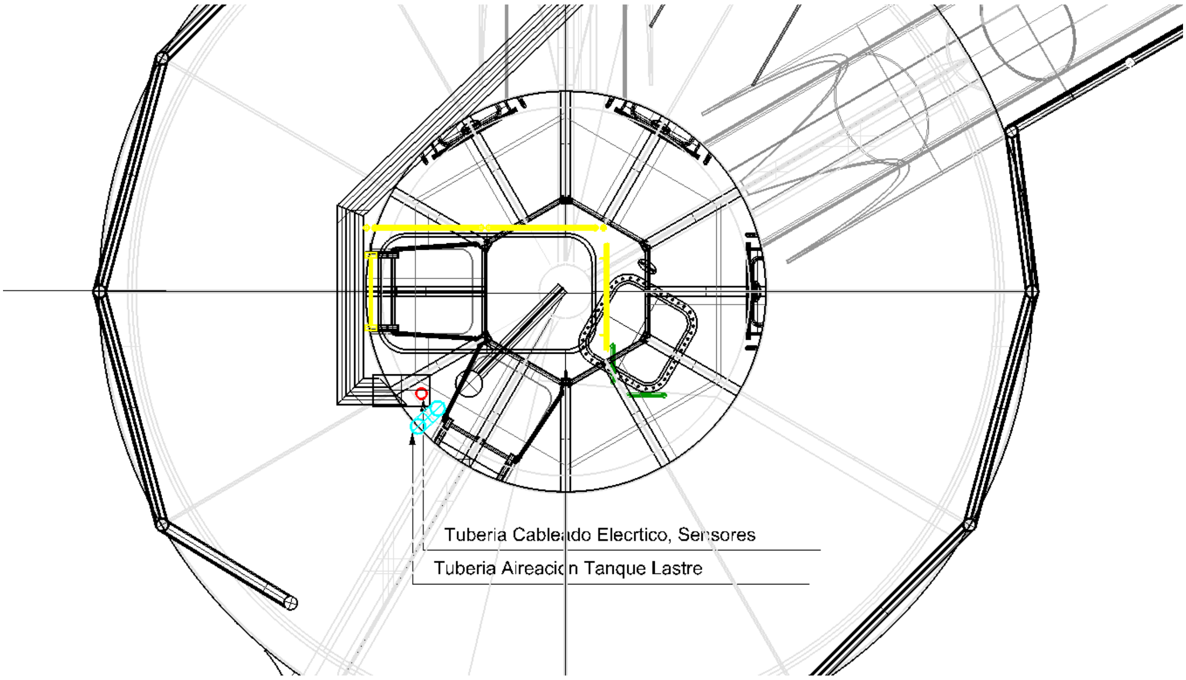
Tuberia Cableado Elecrtico, Sensores
Tuberia Aireacion Tanque Lastre