

Magallanes Array

EMEC Fall of Warness Test Site Navigational Risk Assessment Addendum

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Document History

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1 Introduction

1.1 Company background

Magallanes Tidal Energy is a leading developer of tidal energy technology. We are the recently established UK branch of Magallanes Renovables and have been set up specifically to commercialise the Magallanes technology, leveraging the unparalleled expertise of the UK supply chain to do so. Magallanes Tidal Energy is registered in Scotland, established in 2020.

Founded in 2007 Magallanes Renovables was created with the sole purpose of developing and commercialising a cost-effective tidal technology, overcoming the hurdles that have historically held the sector back. Our philosophy is simplicity and cost-effectiveness, which has led us to develop breakthrough systems, solving the many challenges encountered with innovative and cost-effective solutions.

Our technology is centered around a simple and reliable surface floating platform that leverages existing technology from the mature wind and naval industries, minimising technology risk. Our platforms deliver high output with low installation and maintenance costs.

We are a highly experienced multidisciplinary team with innovation, sustainability and quality as our core values. We have deployed and tested a full-scale platform in the unforgiving environment of the Orkney Islands. Previously we developed and tested 2 scale models to inform the full-scale design.

Key team experience

Our multidisciplinary and highly skilled team has been the main driver of our success, each individual is in charge of one of the working areas for technology development. Important decisions are taken in quorum and teamwork is part of our open working structure.

In addition, Magallanes Renovables has collaborated very closely with skilled partners in different business and technology areas needed to develop a ground-breaking system in tidal energy generation.

Since its inception, the company has been involved in multiple R&D projects focused on developing floating tidal turbines.

Work completed:

- 2007 to 2011 – concept development and evaluation including partial systems tests at small scale – e.g., 1:30 turbine and rotor
- 2011 to 2012 - 1:10 scale model constructed to evaluate and validate the concept. Prototype tested in Bay of Vigo and Scotland with positive results.
- 2013 to 2015 – Design of full-scale platform and systems.
- 2016 to 2017 – Construction of full scale, 1.5MW platform in Spain
- 2018 to 2018 - Sea-trials of full-scale platform around Vigo.
- 2019 onwards - Platform installed and grid-connected at EMEC, Scotland in early 2019, where it operates currently.
- 2020 – upgrades to key systems on the full scale platform

The accumulated project experience in areas of structural design, marine operations, control systems, energy production, mooring systems, etc. has allowed us to achieve the goal of having a demonstrated and validated floating platform.

1.2 Technology background

Magallanes was established to investigate and develop new methods of extracting electrical power from tidal currents.

The first prototype of the platform was designed 2008 - 2009 with the aim of fulfilling the following requirements:

- floatability;
- simplicity;
- sturdiness;
- minimal moving parts
- facilitation of maintenance

Significant numbers of alternative designs were assessed during this stage of development, as well as simulations aimed at optimising the platform's stability under different wave spectra, wind and tidal currents.

Throughout 2010, the knowledge acquired in the previous stages was put into practice to develop a 1:10 scale model of the platform. The scale model was constructed in 2011 and tested during 2012. Both dry dock and sea trials were carried out in Spain and Scotland (EMEC).

With the data obtained from 1:10 scale model, the Company improved the platform design and upgraded the test programme, proving different components integrated into the platform.

All this enabled the further development of a full-scale prototype, whose design began in 2013 and assembly finalised in 2015. This was aimed at moving forward in the optimisation of the platform and, therefore, achieving a more efficient and effective device. This 45-meter floating platform had two 21-meter-high output rotors with a combined capacity of 1.5 MW. The launch of the 'ATIR' took place in April 2017, in Vigo, as it can be seen in the figure below.



Figure 1| Evolution of the Magallanes Tidal Energy Technology

During these first prototype tests, we proved and validated the technology, and currently we are focused on the design and development of a fully commercial product based on our existing

platform, as well as the validation of our performance, Operations & Maintenance procedures and advancing our manufacturing readiness level.

The final achievement was obtaining high-performance output, with low CAPEX and OPEX costs to demonstrate the most reliable, robust, efficient, proven and competitive platform in the tidal energy market.



Figure 2| Launch of the Prototype ATIR platform

1.3 Project background

The first full scale prototype ATIR device has been deployed and operated at EMECs Fall of Warness tidal test site, which has enabled us to assess its performance in real sea conditions throughout the annual seasonality cycle. This testing has allowed us to progress the ATIR towards commercial viability.

This proposed project will see two additional platforms deployed for up to 25 years at the EMEC Fall of Warness site, beginning in 2029. These 2 new platforms will be installed alongside the single platform installed by Magallanes Tidal Energy in an earlier project in Berth 1.

The project aims are as follows:

- Verify and validate the commercial version of the technology with an independent electrical power performance assessment.
- Demonstrate the long term operational performance of a small array of the technology in a real, open sea environment.
- Develop a business and marketing strategy to assist identification of potential customers.
- Develop the supply chain for further, commercial projects.

Data obtained from this period of testing will be crucial for the future projects as it provides valuable information regarding long term operation, maintenance, together with electrical performance.

Existing funds have come from two separate funding sources: European Grants and the equity investment from the founder of Magallanes Renovables. These sources will secure the continuous development of Magallanes Renovables technology until its commercialisation, as well as the process of securing future projects.

2 Project overview

2.1 Device description

The full scale floating tidal devices to be deployed at EMEC under this proposed project consist of a surface floating platform (upper block), with a nacelle and rotors directly below it (lower block) and a 'mast' (vertical block) connecting the two.

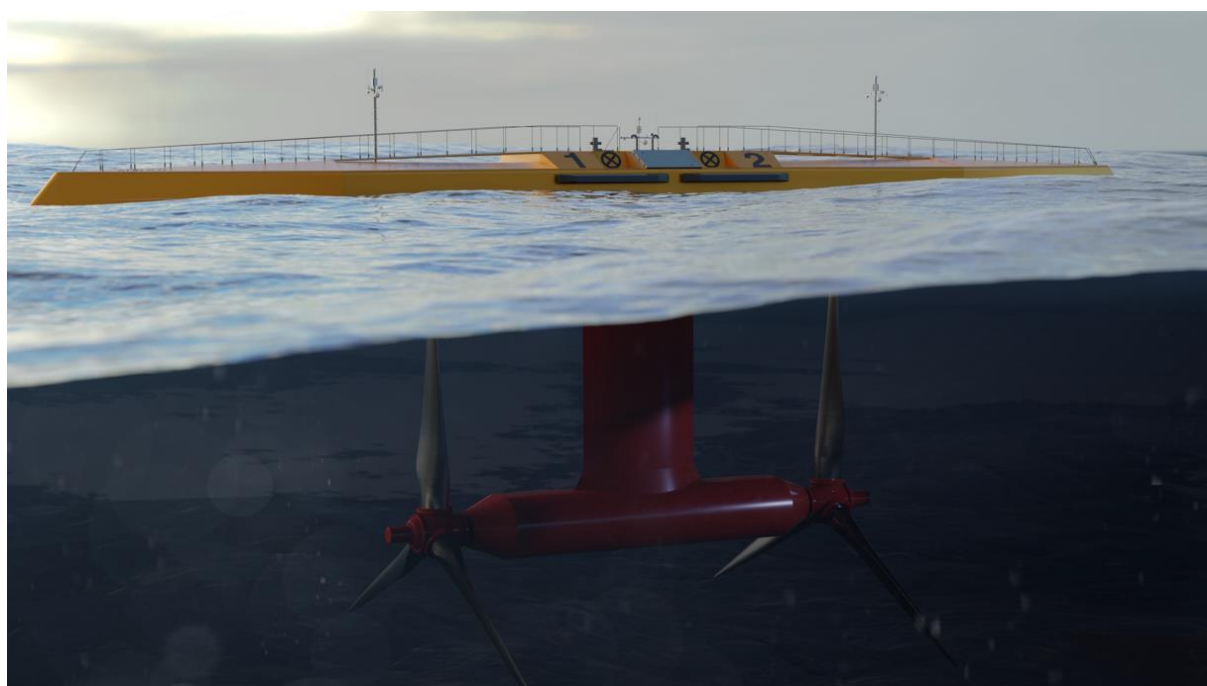


Figure 3| ATIR platform showing 'blocks'

This floating tidal energy converter has a total length of 55m, 6m of beam, a minimum draft of 18.5m without blades and 29m with blades. Its maximum weight with ballast is approximately 600tons.



Figure 4| ATIR from above

It has two counter-rotating horizontal axis turbines in series, one behind the other, so that it counteracts the efforts of one turbine with those of the other to avoid list and yaw. Each rotor consists of 3 blades with a rotor diameter of up to 24m.

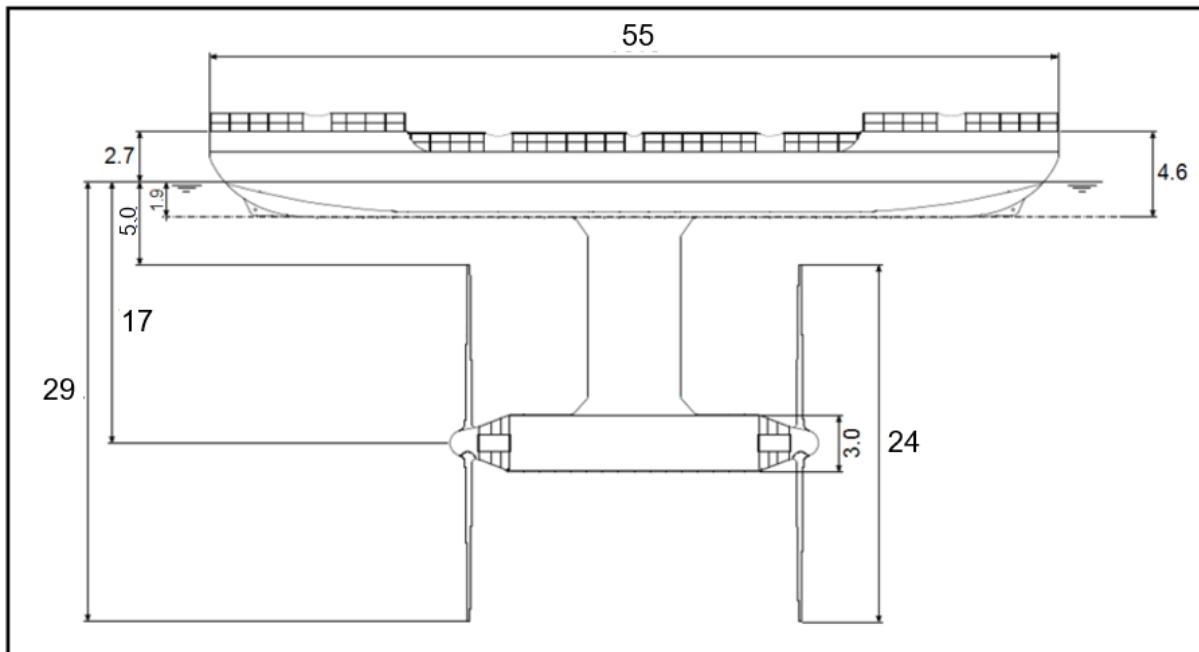


Figure 5| Indicative overall dimensions of the device

Each rotor is equipped with a generator of 850kW of nominal power, and an associated frequency converter; allowing for a peak power of up to 1.7MW; however, the nominal power is limited to 1.5MW. It's moored to the seabed through four mooring lines, two at each end. The device is able to orient itself to different directions of current in a passive way and to generate energy efficiently on both the ebb and flood currents.

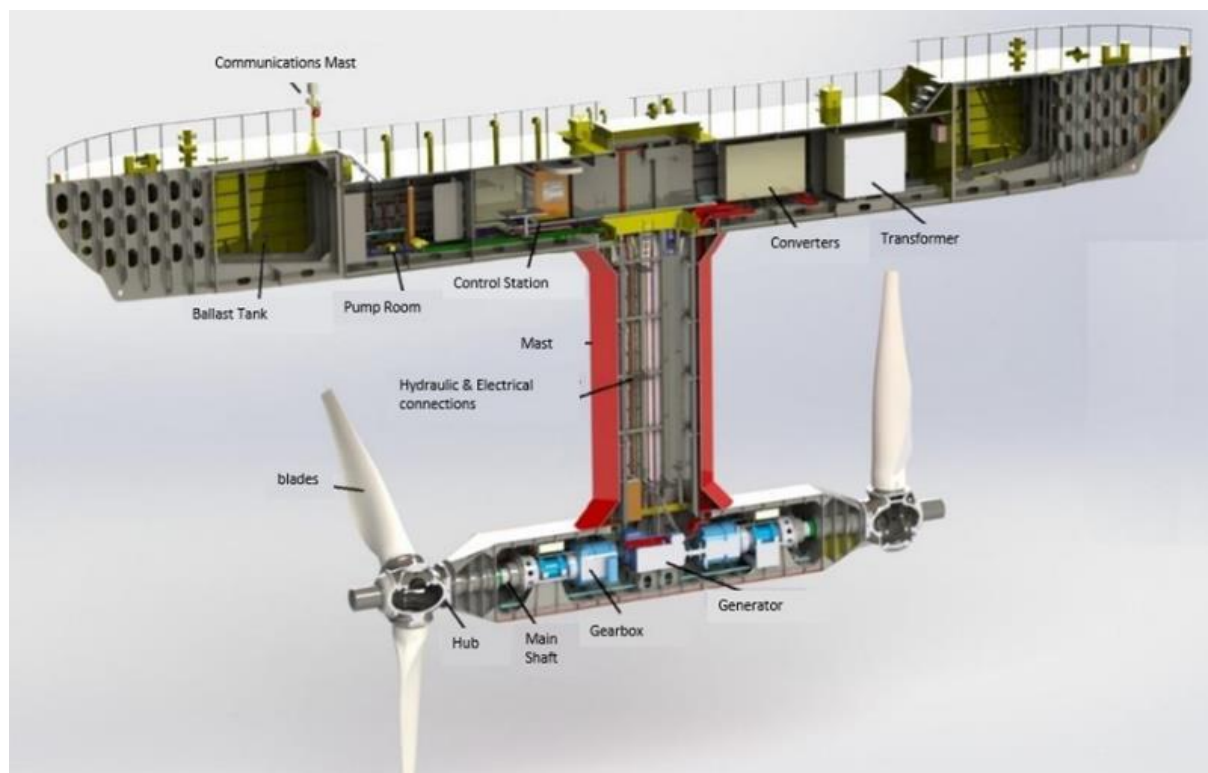


Figure 6| Main components of the ATIR platform

The floating platform (upper block) is the visible part of the device. It has an upper deck, where the entrance hatches are located. It also has 2 inaccessible compartments on both ends of the block, which are part of the variable ballast system. The accessible part of this block is composed of 3 main rooms, the first of them houses pumps and emergency systems, the other 2 have been designed to accommodate transformers, frequency converters, electric panels and other auxiliary electrical or electronic systems.

The mast (vertical block) fixes the nacelle (lower block) to the platform (upper block). It is a hollow space through which the communication and low-voltage cables connect the equipment housed in the nacelle with the parts of the electrical systems within the upper block. Rigid pipes for environmental acceptable lubricant supply and draining, among others, are also installed in the mast. It also allows access to the lower block for inspection and maintenance.

The nacelle (lower block) is significantly smaller than the upper block and is dedicated to the mechanical PTO systems. This block is where the main shafts, gearboxes and generators are located. As the platform is equipped with two counter-rotating rotors, all the components for the PTO system are duplicated (one for each rotor).

Each device has electronic power converters onboard the platform that adapts the energy output to the frequency and phase of the network, in addition, they will also have a step-up transformer that will establish the output voltage of each platform at 11kV - the connection voltage).

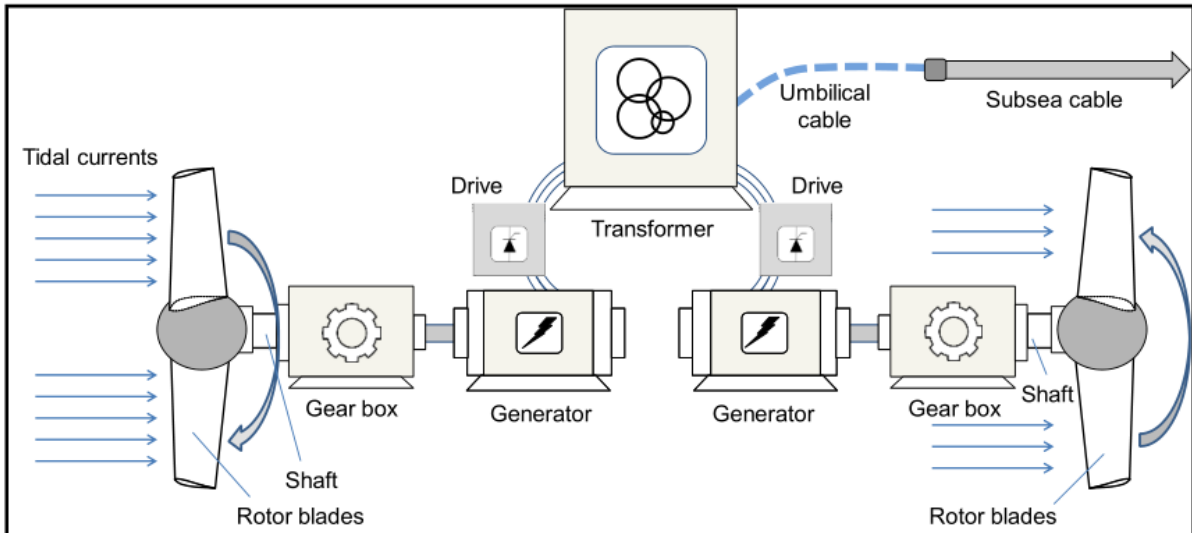


Figure 7| Diagram of electrical power generation from tidal currents

Two options are currently under consideration to connect the platforms to the export cable.

Op1: Ring Connection: the 3 platforms daisy-chained together in a ring, with a single export cable as shown in Figure 8 below. The two ends of the 'ring' will be joined together by a passive subsea hub (/busbar) to ensure that output is not lost for multiple platforms in the event of a cable fault anywhere along the ring. All device interconnection cables will be dynamic cables.

Op2: Star Connection: multiple cable legs connecting the platforms to a single passive subsea hub and export cable, as shown in Figure 9 below. A hybrid version may also be created where the ends of each leg are joined up to make multiple 'rings'. All device interconnection cables will be dynamic cables.

Further optimization modelling will be required to determine the optimum layout for the site.

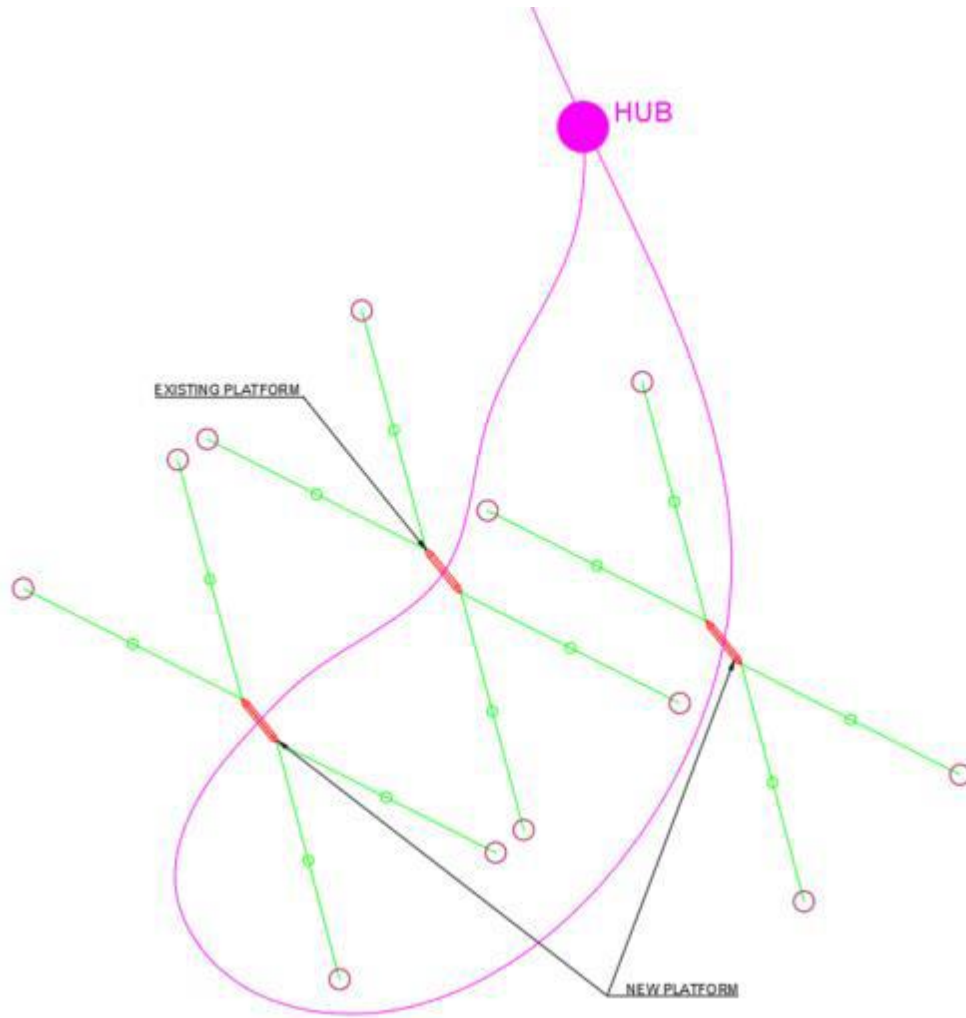


Figure 8| Ring cable concept

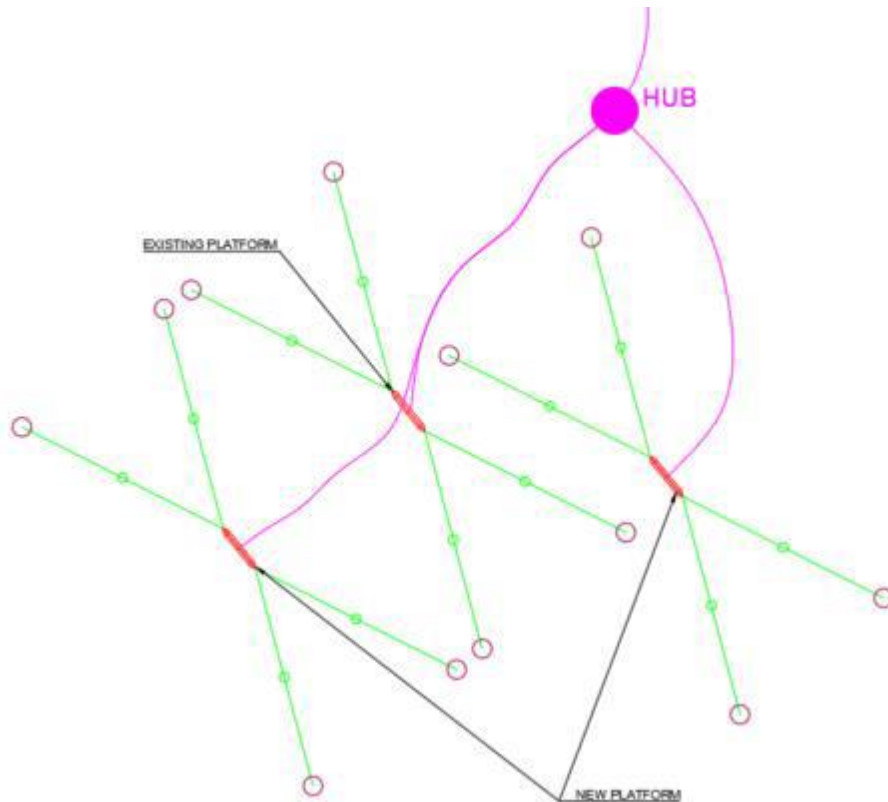


Figure 9| Star cable concept

The export and umbilical cables will be secured / stabilised with the use of up to 30 rock bags (consisting of graded rock in a mesh 'bag') or mattresses (a 'flexible' matrix of linked concrete blocks) up to 8 tonnes each.



Figure 10| Examples of rock bags and concrete mattresses

2.2 Mooring system

The mooring system consists of 4 mooring lines, 2 at each end fixed to the platform, the mooring lines are redundantly dimensioned so that even if a line breaks, the other line on that side is capable of holding the platform on station.

The following parameters are currently estimated for the site, based on preliminary engineering analysis and modelling undertaken:

- Hull Attachment - A single padeye at the bow and stern, to which a single shackle is connected and from which two mooring lines are attached.
- The chain length from mooring attachment point to anchor: approximately 192.5m (76 and 11mm chain).

- The total length of chain per leg (including excursion limiters): approximately 372.5m.
- Mooring footprint diameter = approximately 500m (250m radius).

See diagram below.

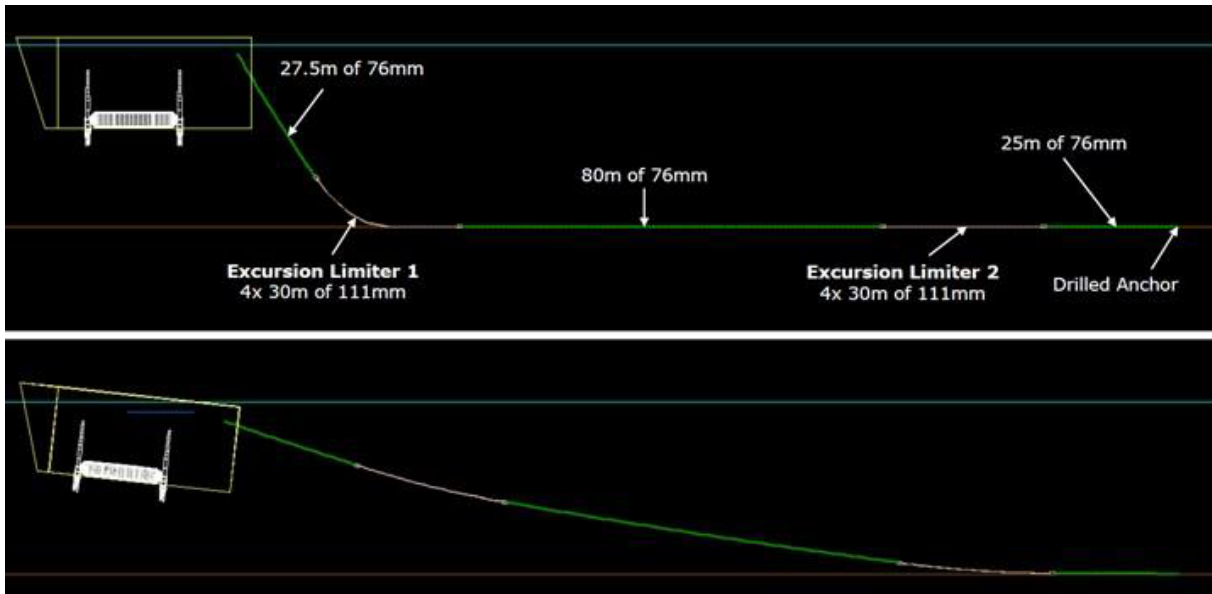


Figure 11| Indicative scheme for the mooring system

Anchor systems will be determined through geotechnical surveys. The preferred solution is drilled pile anchors (see below). These are anticipated to be up to 800mm in diameter, 10m long.

The location so the anchors and their exact size has not been determined yet and will be informed by the geotechnical survey.

However, gravity anchors (as detailed lower down) may be used if conditions do not prove suitable for drilled anchors. Magallanes and partner companies have experience with both types of anchor solutions. A basic scheme of the mooring system to be used is illustrated in Figure 13 below.



Figure 12| Strataloc anchor (left). Tricone (centre) and core (right) anchor piles that will be considered for use at the site (developed by Leask Marine)

If gravity anchors are used, these are anticipated to be chain clump weights with a total capacity (wet weight) varying between 90 and 165Te. Anchor sizes will vary due to the statistically derived environmental loading and the larger environmental forces from the North.

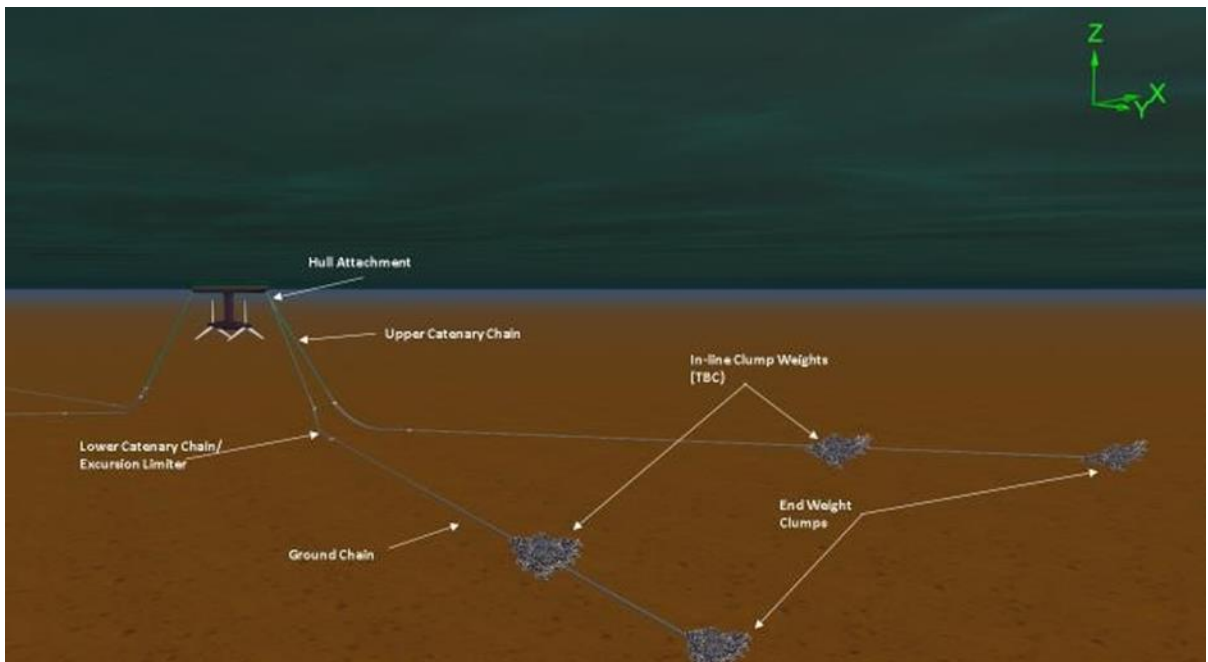
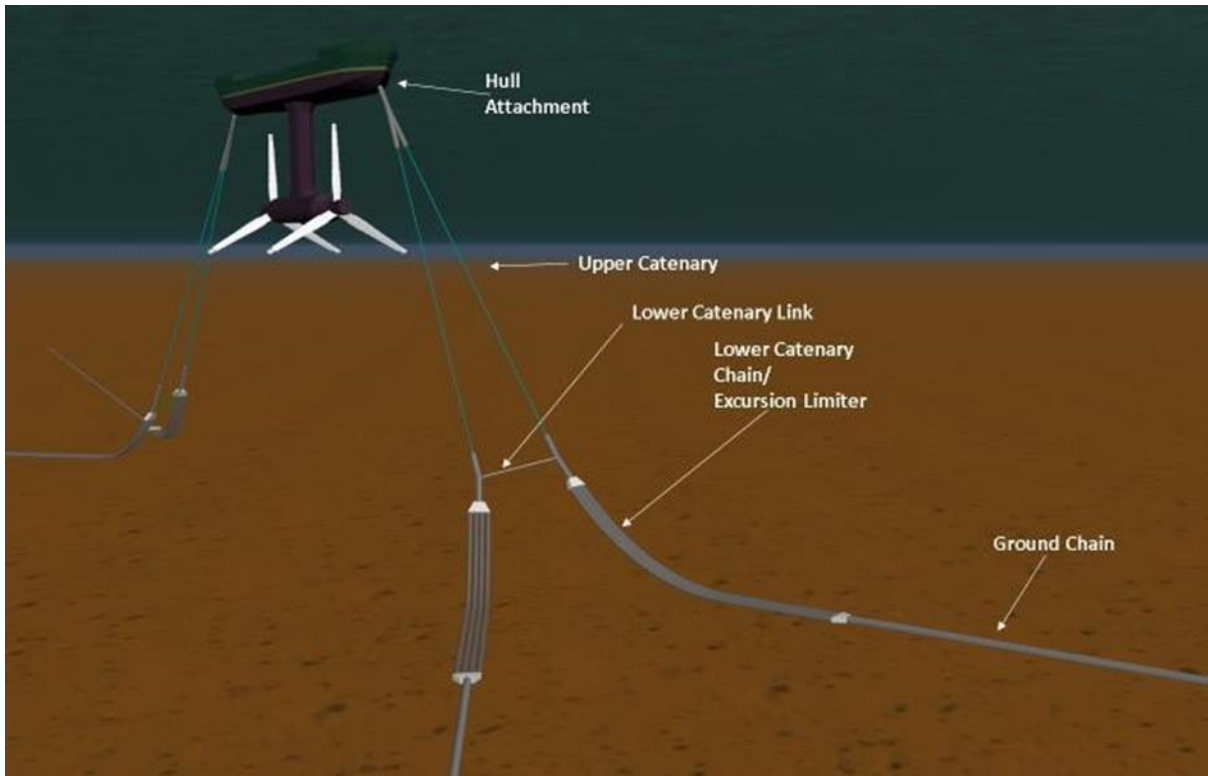


Figure 13| Scheme of mooring system

2.3 Temporary mooring system

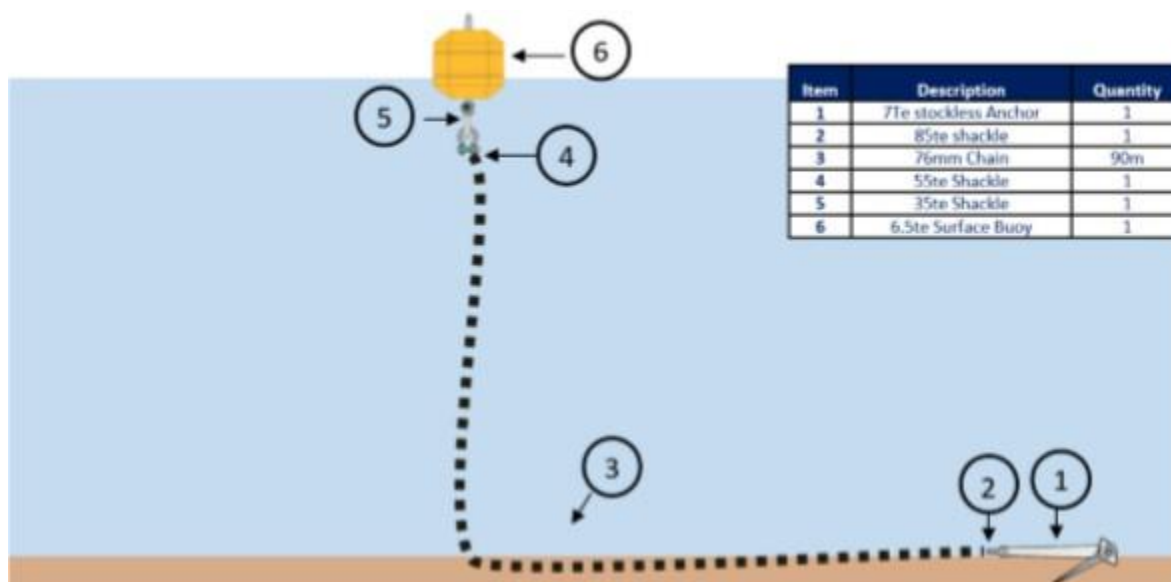
A temporary mooring site, either Deerness anchorage, Scapa Bay anchorage or Shapinsay Sound test site, will be used for installing and removing the blades before device installation and after removal from the Fall of Warness site respectively. It is most likely that the Deerness anchorage site, or Scapa Bay anchorage site will be the most favourable due to water depth requirements and limited tidal flow.

A multicat vessel will be used to tow the device from site to site as and when required. Moorings used at the temporary sites will only be installed for the duration of blade removal works and will be removed shortly after the device has been towed back to Fall or Warness or southwards for maintenance. The temporary mooring locations were chosen due to the relatively benign conditions required for removing the blades which then allows the transportation of the device by towing to the chosen docks for maintenance. As the current speeds are still quite considerable at the temporary mooring locations, significant maintenance activities are unable to be performed, hence transportation to a dry dock elsewhere.

Details of Deerness anchorage, Scapa Bay anchorage and Shapinsay Sound sites can be found in section **Error! Reference source not found.**

The temporary mooring will use a single point mooring system as shown below in Figure 14, due to the less extreme environmental conditions.

A Notice to Mariners will be issued before any works that require the removal of the device from its moorings and transportation to another site.



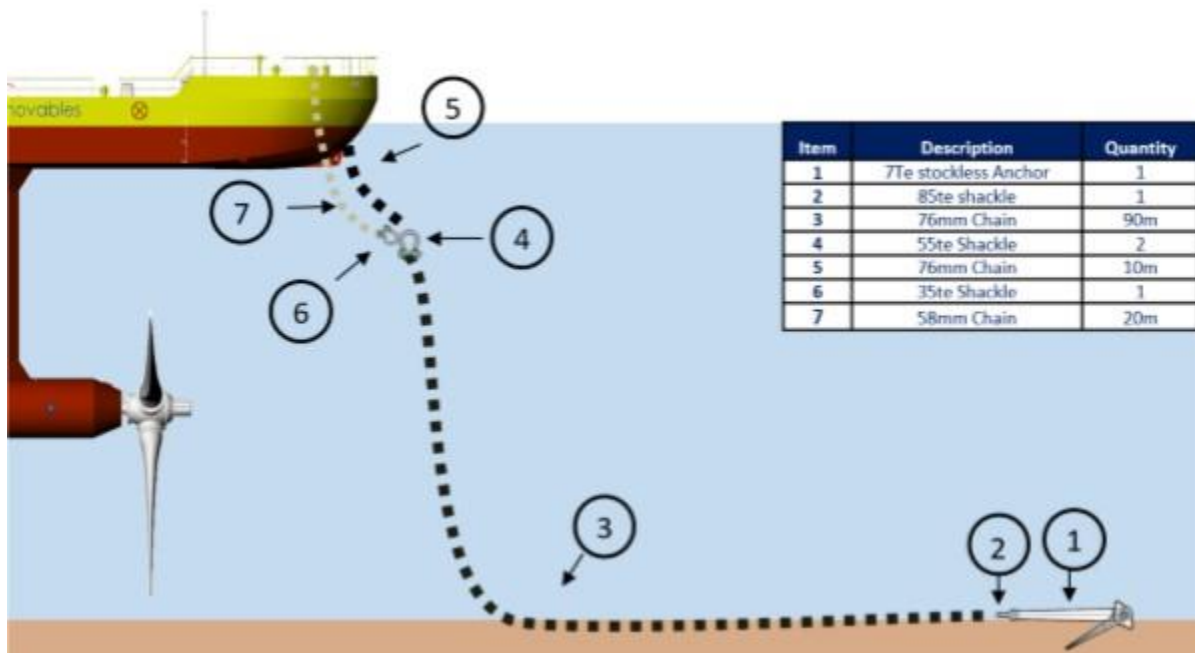


Figure 14| Single point mooring system schematic prior to device installation (Above), and during deployment (Below)

3 Key navigational themes

In order to complete this project-specific assessment, a comprehensive review of the site-wide NRA for EMEC's Fall of Warness test site was conducted. The following navigational themes have been considered during the assessment.

3.1 Vessel routing

The Fall of Warness test site is clear of major vessel routes and vessels currently transiting the site appear to be well aware of the deployments across the site.

3.2 Contact / allision risk

Few vessels navigate within the site and the use of appropriate marking and lighting to alert other mariners to the assets onsite should mitigate the risk of contact. All assets onsite should be charted on the United Kingdom Hydrographic Office (UKHO) charts, this information will be promulgated to the UKHO via Notice to Mariners.

3.3 Effects of tide / tidal streams and weather

Vessels take advantage of the lee behind the Muckle Green Holm when the tides are northwesterly. When the flow is from the south-east, vessels keep a wide berth from the Fall of Warness. The tidal streams therefore do not alter the routes of vessels to the area surrounding the platforms.

During consultation it was revealed the during bad weather it was common for ferries to come into the Fall of Warness site. During a strong south-easterly wind, significant overfalls, wave heights and a race can be expected to the south of Eday. Ferries would therefore pass to the east of Muckle Green Holm, come into the EMEC site passing to the north of the SR2000, before turning to come in close to the headland to the south-west of Eday. This allows the

vessels some degree of shelter and means that they are not exposed beam on to the conditions

3.4 Under keel clearance

The radius of the blades is 11 metres max and the apex of the swept area is 4.4 metres below the surface. Given the width of the surface platforms (6 metres), there are potentially 9 metres of swept area either side of the platforms.

For a navigating vessel to collide with the blades, the vessel must be within 7 metres of the device and drawing at least 7 metres. It is therefore far more likely that the vessel would collide with a platform than damage the blades, and small vessels would be incapable of contacting the blades. The mooring arrangements are chain and, given the depth of water, will not compromise Under Keel Clearance (UKC) including when taking into account scouring.

3.5 Collision risk and visual navigation

The devices are less than five metres high and will therefore ensure that most vessels will be visible over the top when navigating in the area. The exception may be small craft such as open top RIBs or pleasure craft as well as maintenance vessels working on the device. Prudent mariners will provide sufficient clearance from the device when navigating and this will further reduce the chance of a hidden vessel emerging in a collision scenario.

The location is not on the leading line of any navigational aids nor will significantly alter the visibility of other lights or buoyage. It should be marked in accordance with the requirements of the Northern Lighthouse Board and could serve as an additional aid to navigation for navigating vessels.

As the turbines are subsurface, there would be minimal noise generated and so it would not interfere with sound signals used by vessels or aids to navigation.

3.6 Communication, radar and positioning system

The scale of the assets to be installed during this project are not likely to impact on electronic communication or positioning systems.

3.7 Moorings

The Fall of Warness mooring systems consists of 4 chain catenary legs, two north and two south, attached to the hull at attachments in the bow and stern of each platform. The mooring systems hold the platforms in line with the current flow.

The anchor size has been supported by a statistical assessment of simulated loads using Orcaflex software, namely that the peaks in anchor tensions are momentary spikes of a few seconds in simulated one in 10 year storms.

3.8 Station keeping

GPS Alerting for movement of the devices. Remote monitoring of the devices to detect any major movements that might indicate a breakout for immediate response.

3.9 Fishing activity

Relatively little fishing takes place in the study area and fishermen would generally be expected to take precautions in order to avoid any underwater assets that may be present across the test site.

3.10 Recreational activity

There is no racing or small boat sailing at the test site, most recreational vessels are yachts on passage.

3.11 Subsea cables

There is no evidence of anchoring or gear snagging at Fall of Warness historically.

3.12 Search and rescue

The devices will not alter the capability of search and rescue operations in the area, or interfere with neither RNLI or helicopter operations.

3.13 Cumulative and in-combination

The Fall of Warness site, as a device test centre, is home to other devices. Of these, most are well clear with the exception of the Orbital O2. For those deep draught vessels whose passage is through the Fall of Warness, it is likely that they would pass to the west of the ATIR platforms and Orbital O2 rather than in between the two arrays/devices due to the limited sea room.

4 Risk controls

4.1 Site-wide risk controls

A number of risk controls are embedded by the processes EMEC has implemented in order to operate the site and the layout of the Fall of Warness test site. The embedded risk control measures are detailed in Table 6, with any project-specific actions including any divergence from the specified control discussed.

ID	Embedded control risk	Description	Project-specific actions
1.	PPE Requirement	Maintenance teams to wear suitable PPE when working on the assets, including life jackets.	
2.	Training of staff	Staff to be trained to the required standards for their work and have suitable local knowledge of regulations and operations in the Orkney Islands.	
3.	Emergency Response and Cooperation Plan (ERCoP)	ERCoP for site developed and agreed with the MCA and SAR bodies to be consulted.	
4.	NtM and Promulgation	In addition to NtM, EMEC's Maritime Safety Information Standard Operating Procedures (SOP) ensures that all key navigational consultees are informed prior to any works. Distribution could include HMCG, Orkney Harbours (available via Orkney Islands Council Marine Services website), Orkney Marina noticeboards (as necessary), Orkney Fisheries Association, Scottish Fisheries Federation and UKHO. Stakeholders are targeted with information about relevant assets based on their activities and location.	
5.	Incident monitoring and reporting	EMEC to encourage incident/near miss reporting and monitor any safety issues at the test site. If necessary, risk control to be reviewed. Risk assessments to be reviewed following any incidents.	
6.	EMEC Procedures	EMEC has a number of SOPs and standards in place to reduce navigation risks, such as: <ul style="list-style-type: none"> • Task risk assessment; • Control of work (permit to access) • Hazard identification reporting; and • Maritime safety information. 	
7.	Hydrography	Contractual responsibility for developer to return the site to the original condition post-decommissioning.	
8.	Charting	Site is marked on nautical charts including a chart note.	

9.	Site Monitoring	EMEC's SCADA system provides real time status information, trends, alarms and remote-control access to facilitate a safe working environment, comprehensive assessment and safe operation of the sites.	
10.	CCTV	Fall of Warness test site is monitored by CCTV, located at Caldale, EMEC's onshore substation, to satisfy operational requirements for control and monitoring of test site activities, visual checks of the test site environment, monitoring of lone worker safety, effective plant operation and substation security.	
11.	Liaison with local stakeholders	EMEC regularly liaises with key local stakeholders to identify any potential issues as soon as possible. Regular updates include information regarding upcoming deployments and significant operations at the site.	
12.	500m advisory ATBA	A 500m advisory ATBA exists around all test devices located at EMEC test sites.	

Table 1| EMEC embedded risk controls for Fall of Warness test site

4.2 Project-specific risk controls

The following table provides a description of the risk controls that will be implemented during the project.

ID	Project-specific risk control	Description
1.	Radar reflectors	Use of radar reflectors to improve marking during times of poor visibility.
2.	AIS	Use of AtoN AIS (or virtual AIS if permitted) fitted to all surface piercing assets to improve visibility to passing vessels. AIS should be Category 3 with at least 97% up time and use Message 21, or as directed by the Northern Lighthouse Board (NLB).
3.	Heightened monitoring in adverse metocean conditions	During gale force winds, periodic monitoring of the assets is recommended to ensure excessive forces are not acting on the moorings which might cause a breakout.
4.	Inspection and maintenance programme	Regular maintenance regime by developer to check the asset, its fittings and any signs of wear and tear. This should identify any failings which might result in a mooring failure and breakout. Refer to the findings of your third party verification mitigation against device breakage.
5.	Remote shut down including feathering of blades	Devices to be fitted with ability to shut down in an emergency, such as feathering any blades or braking to allow access or prevent contact with a vessel.
6.	GPS alert system for asset moving	Remote monitoring of device to detect any major movements that might indicate a breakout for immediate response. Implement GPS excursion monitoring.

7.	Marking and Lighting	Assets to be lit to the requirements of NLB and marked in line with IALA guidance, IALA Recommendation O-139 (2013) ¹ . The following is typically requested by the NLB: <ul style="list-style-type: none"> • Yellow day marking/painting; • Flashing yellow special mark light (Category 1) (larger devices may require 2 lights at each end which are synchronised; light ranges should be at least 3 nautical miles); • Day top mark (if deemed necessary); • Radar reflector; and • AIS AtoN (mandatory for floating devices at EMEC). Appropriate statutory sanctions must be in place to exhibit, alter or discontinue lighting.
8.	Tow risk assessment and passage plan	As required under Orkney Harbours Pilotage Directions 4(3) ² , prior to conducting a towing operation, a risk assessment and passage plan for the move should be conducted. The plan should account for the size of the tow, maneuverability restrictions, tow arrangements and metocean conditions.
9.	Guard vessels	During major construction or maintenance activities, a guard vessel may be considered to assist in protecting the devices from contacts with passing vessel traffic. Due to the low density of traffic, this is not considered necessary except for extraordinary circumstances. If guard vessels are to be used onsite, it is important that such vessels employed to guard the site follow appropriate guidelines, with clear instructions on when to intervene in a potential incident.
10.	Liaison with local stakeholders	Consultation should be undertaken with Orkney Marine Services, the MCA and NLB prior to installation of device to confirm that adequate risk controls are in place. EMEC also conducts regular stakeholder consultation events to ensure that local marine users are aware of the pipeline of activity.
11.	Installation, maintenance and removal	All vessels undertaking activities on site should comply with EMEC standard operating procedures. Vessels should be mindful of other navigating vessels and avoid disrupting the activities of others.
12.	ERCoP	Project-specific annex to be incorporated into site-wide ERCoP.

Table 2| Project-specific risk controls

- Individual wave and tidal energy devices within a site that extend above the surface are painted yellow above the waterline;
- If marked, the individual devices should have flashing yellow lights. The flash character of such lights must be sufficiently different from those displaying on the boundary lights with a nominal range of not less than 2 nautical miles; and
- A single wave or tidal energy structure standing alone may be marked as either an isolated danger mark or a special mark.

It is also recommended that:

- Radar reflectors, retro-reflecting material, Racons and / or AIS transponders should be considered where the level of traffic and degree of risk requires it;
- The lit Aid to Navigation (AtoN) must be visible to the mariner from all relevant directions in the horizontal plane, by day and night;

¹ All surface piercing structures should be marked as:

² Orkney Islands Council Competent Harbour Authority (2016) The Orkney Pilotage Direction 1988 (as amended 2007, 2010 and 2016).

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- Any floating AtoNs should be located outside the moorings of the floating structures; and
 - AtoNs should comply with IALA Recommendations and have an appropriate availability, normally not less than 99% (IALA Category 2).

5 Summary and conclusion

This document has been prepared to support a marine licence application for the Magallanes ATIR platforms in Berth 1. This document is provided as an addendum to and should be read in conjunction with the document 'Fall of Warness Tidal Site Navigational Risk Assessment (NRA) – REP315 – version 6'.

In summary, the NRA has concluded that the deployment of the devices is low risk with suitable risk controls in place.

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