THE PROS AND CONS OF BOAT LANDING-LESS

Whitepaper

SHAPING TOMORROW. PERFORMING TODAY.

ABSTRACT
In order to optimize WTG foundations for the offshore wind industry, omitting the boat landing can be a logical step tolower WTG foundation CAPEX. However, since there is more to wind turbines than foundations, over 15 inerviews with key stakeholders from the industry were held to investigate whether going boat landing-less is indeed a good idea or that certain disadvantages or restrictions are keeping this development from becoming the new standard.

Document title: The pros and cons of boat landing-less
Initiator: Sif Group
Execution: ROER renewables
Point of Contact: Michel Kurstjens / m.kurstjens@sif-group.com

EXECUTIVE SUMMARY

The high ambitions for the offshore wind market are challenging the overall supply chain. Standardisation and simplification of the WTG, foundation and wind farm concept could assist in relieving some of this pressure, allowing the supply chain to simplify and focus on their core activities. For a monopile foundation supplier one way of doing so would be to omit the boat landing on TP-less monopiles, since this would significantly simplify production and lower foundation related CAPEX. However, it is not the monopile supplier that determines whether omitting a boat landing is indeed a good idea.

To initiate discussion and to identify the pros and cons of going boat landing-less, this whitepaper was initiated by Sif. To that end, 16 key-stakeholders (design houses, manufacturers, (OEM) suppliers, installation contractors, wind farm developers, wind farm operators and government bodies) in the offshore wind industry were interviewed by ROER renewables, to acquire a balanced view on the pros and cons of going BL-less. As a start, the interviewees were asked, what they felt is really driving the boat landing-less discussion. The main consensus is that it is driven by both a possible reduction in cost, as well as a possible reduction in risk. Although discussion is ongoing in the industry, the urgency is still relatively low.

Conventional boat landing access was compared against two specific boat landing-less accessibility options in a direct qualitative comparison. Either an alternative secondary means of access (Pict Offshore Get Up Safe (GUS) system or Seasight Davits Spider system), or an (optimised) Walk to Work SOV-only scenario. The comparison criteria were safety, cost, legislation, access availability and reliability. Access availability, a key factor in guaranteeing general wind farm up-time, was split in three distinct topics: (A) workability (sea state), (B) flexibility (being able to access at anytime, anywhere, simultaneously and fast) and (C) reliability (does access system always work in a fail-safe manner).

The interviews have confirmed that omitting a boat landing has a clear potential to reduce the overall CAPEX of a wind farm. Also, alternative access systems in principle can improve safety by omitting the transfer from vessel to ladder and eliminating the need to perform the ever-increasing lengths of ladder climbing. From a legislative point of view, in general, no hard requirements that enforce the usage of a boat landing were identified. The pipeline of existing (UK) and future (US) projects (aiming at) implementing BL-less seem to indicate that the omission of a boat landing can be implemented in an acceptable manner.

With regards to access availability, when going boat landing-less:

- (A) The overall workability of the alternatives shows potential of being equal to or greater than the use of a boat landing;
- (B) The overall flexibility of the alternatives, using the established fleet infrastructure of CTVs and/or SOVs with daughter crafts, shows potential of being equal to the use of a boat landing, however very much dependent on the alternative access method used;
- (C) The risk increases of not being able to (timely) access the WTGs: Every mechanical and electrical system, in the end, will never be as reliable as a boat landing. It is hard to beat the up-time of a simple steel ladder.

Concluding: Boat landing-less is here to stay, driven by the potential of CAPEX reduction and safety improvement. Although the market might be moving towards boat landing-less in the (not immediate) future, in the short term there will be projects with and without boat landing. A near future revolution is not likely to take place, because the available alternatives do not meet all requirements of all interviewees yet.

1 INTRODUCTION

1.1 Offshore wind: Challenges and possible mitigations

Offshore wind is already growing rapidly, but is pushed even further by ambitions on the role that it could and should play in being a part of the energy transition. This is especially the case for the EU, where the need for more locally produced renewable energy is increasing due to geopolitical developments. Although positive from a future market perspective, this steep ambition is also leading to a gap between current capacity and capacity required. In Figure 1 the capacity needed to install up to 1300 WTGs per year for a number of main offshore wind components and tools are depicted as well as the required increase with respect to today's capacity.

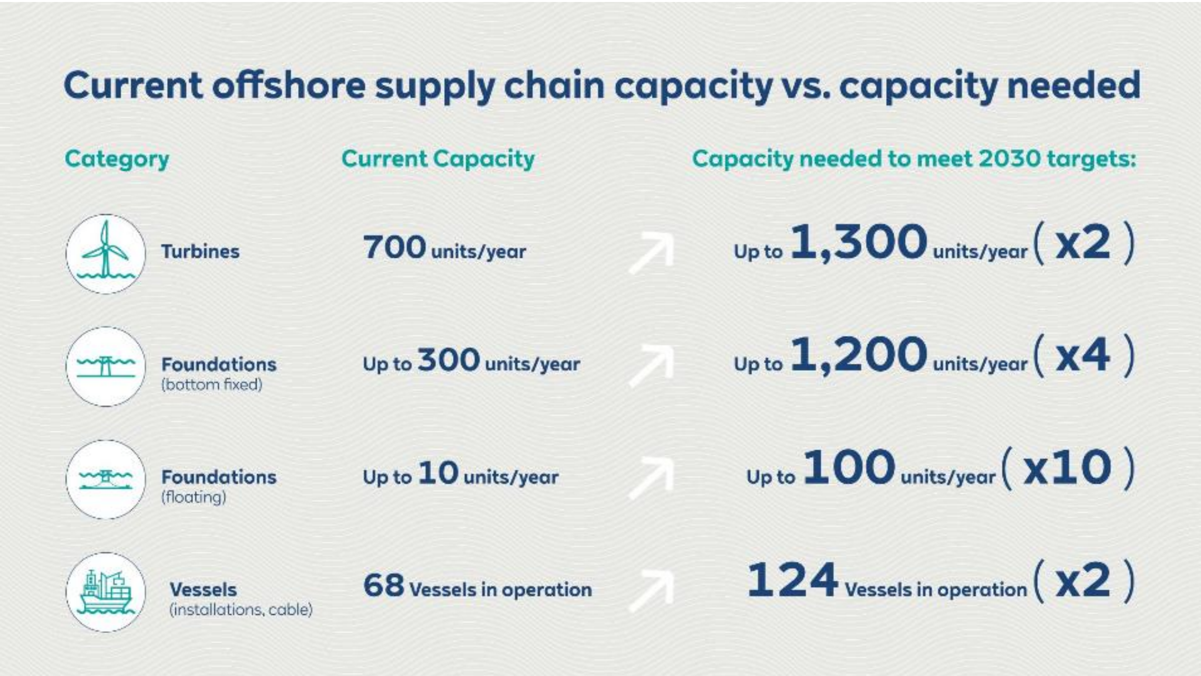

Figure 1: Current offshore supply chain capacity vs. capacity needed in Europe (source: RWE[1]).

Furthermore, the cost of offshore wind has significantly increased due to inflation (some material, labour and/or component related costs are higher by as much as 40%[2]), higher cost of capital (due to higher interest rates) and additional effects such as the cost for seabed lease. As a result, developers have raised warnings that projects could become uneconomic in the near future (e.g.: Vattenfall's *British Norfolk Boreas*[3] and Orsted's *Ocean Wind 1 & 2*[4]). The above-mentioned challenges and bottlenecks are hampering EU member states from reaching their individual offshore wind targets[5] and are therefore threatening a successful ramp-up of the energy transition.

'Only if everyone does the job they are best at, we can rise to this challenge of supplying large volumes in good quality, safely, economically and consistently.'

'Going for a basic Volkswagen instead of a customised Mercedes.'

[1] Perspectives on energy security and green transition in Europe - RWE 2023
[2] https://www.energymonitor.ai/renewables/data-insight-the-cost-of-a-wind-turbine-has-increased-by-38-in-two-years
[3] https://www.reuters.com/sustainability/vattenfall-says-it-is-stopping-british-norfolk-boreas-offshore-wind-farm-2023-07-20
[4] https://us.orsted.com/news-archive/2023/10/orsted-ceases-development-of-ocean-wind-1-and-ocean-wind-2
[5] The Bottlenecks Challenging Growth in the EU Offshore Wind Supply Chain - Rabobank 2023

A possible mitigation can be found in enabling each link in the supply chain to focus on what they do best. The (future) offshore wind market, in general, is so large that a smart way of scaling is required to overcome the overall increase in cost. Or in other words, make things as simple as possible. Simplifying scope allows the supply chain to ramp up volume while reducing cost.

Furthermore, the current project-based approach introduces inefficiencies in the market, also driving cost upwards. As a possible mitigation, a more holistic approach is advocated by the industry in which the 2050 EU ambitions are proposed to be treated more as a single objective instead of a large number of individual projects. To assist this, standardisation[6] & simplification of the WTG and wind farm should be considered, allowing the supply chain to simplify their key activities even further.

1.2 Supplying monopile foundations

For the monopile foundation market specifically, this market outlook implies that not only more monopiles are needed per year, but that these individual foundations will also be significantly larger, to be able to support future larger WTGs, installed in deeper waters. Sif, a current market leader in monopile foundations supply, understands the challenges that lie ahead.

> *'In the current market we, as a total and integrated supply chain, need to ramp-up both volume (number of units) and size (larger turbines, hence larger monopiles). This will have an effect on the challenges ahead.'*

To produce the volumes required, the total support structure will need to be innovated in a logical way. In that same line of reasoning, some general market trends are emerging, such as TP-less monopile design. The next step in TP-less design is making monopiles without secondary steel attached to it. A monopile without brackets required to connect the secondary steel offshore to the monopile foundation, is considerably easier to produce in large numbers compared to a monopile that requires brackets. Combining these two, Sif has developed the Skybox[7]. As a next logical step into going TP-less, the Skybox is connected to the MP using a slip joint connection only.

1.3 This whitepaper: Boat landing-less

Whilst Skybox omits the need for brackets to connect the access platform to the MP, it initially did not replace the functionality of the boat landing with its associated brackets. As a monopile supplier, Sif would therefore welcome leaving this item out, but it is not to the monopile supplier alone to determine whether omitting a boat landing is indeed a good idea. Therefore, to initiate discussion and to hear what the rest of the industry had to say, this whitepaper was initiated by Sif. To that end, 16 key-stakeholders in the offshore wind industry were interviewed, in order to acquire a balanced view on the pros and cons of going BL-less. The result is a qualitative summary of the received feedback regarding the pros and cons of omitting a boat landing (chapter 4). To include the necessary background information, a short summary of the current state of the art regarding monopile foundations is included (chapter 2) as well as a description of the proposed boat landing-less concept (chapter 3). In chapter 5, the overall conclusions are presented, while chapter 6 discusses a number of points that were mentioned that are looking at (possible) future developments. Lastly, it is noted that the main goal of this paper is to start-up an industry wide discussion on this specific topic. However, this paper does not aim, nor pretends, to be a fully comprehensive overview of all content related to the boat landing-less topic.

[6] https://www.nwea.nl/the-north-seas-standard-enable-growth-with-wind-turbine-standardization/
[7] https://sif-group.com/en/news/skybox-update-considerations-when-going-tp-less/

2 MONOPILE FOUNDATIONS; A BRIEF OVERVIEW

2.1 Market considerations and how this is affecting monopiles

The overall increase in numbers and sizes of required monopile foundations are leading to a number of market considerations. In the interviews with stakeholders a number of insights and considerations were discussed regarding their point of view with respect to the market in general and the monopile foundation market in particular. Together with available literature these insights were used to sketch a high level overview of the market including an outlook and (foreseen) challenges.

2.1.1 Future wind farm locations and outlook: Made in Europe

Both in terms of production location (made in EU), as well as in terms of actual future project locations (energy security) the EU is focussing more and more on domestic development. The Northern seas provide a relatively stable climate from a geopolitical point of view and the availability of (relatively) shallow waters with sandy soil provide a good local market outlook for monopiles. Although the US shows clear potential of a possible next very large market, implementations in other markets further abroad have not always turned out to be successful. Also, the projected domestic EU market alone already provides a large challenge for the supply chain to tackle. Furthermore, since near shore locations have to a large extend already been developed, future wind farms will be developed further away from shore, in deeper waters with harsher weather conditions. It is expected that monopile foundations will remain the go-to foundation type in the years to come. The market is stretching its existing, cost-effective, MP based solutions. In addition, larger wind turbines at deeper waters will result in an increase in required MP size, both in terms of diameter and length. Together with the increasing numbers of foundations, this significantly influences the future supply chain requirements, both from a fabrication and from an installation (vessel) capacity point of view.

2.1.2 Tools for the trade: Fabrication & installation trends

Fabrication of large numbers of 3000t, 125m, single piece MPs is a challenge, amongst others due to the required wall thickness and can-size, which poses specific requirements for production and port facilities. This will significantly affect the number of capable production facilities, especially since the lead-time available for production is also under pressure. The main identified risk is that monopile fabrication might become a bottleneck in the overall offshore wind market. Simplification and standardisation are earmarked as potential solutions to relieve this pressure on the MP supply chain.

With WTGs ever increasing in size and installation in deeper waters, MPs are becoming larger over time (both weight and length) leading to challenges in vessel (crane) capacity. The installation of XXL monopiles is therefore not only challenged by overall weight, but also by the length of the MPs, which is significantly influencing vessel onboard handling: Up/down-ending capabilities can become the limiting factor in certain cases. An option for mitigating these risks is by splitting the MP in two or more separate sections. Besides use of a MP/TP split, these developments could potentially be further enabled by future developments such as the C1[8] (enabling larger tower bottom and MP top diameters) and slip joint[9] (omitting flanges entirely) connections. This also provides the possibility for more flexible onshore versus offshore preparations but, in combination with increasing project size, does increase the complexity of overall logistics. An additional concern related to XXL monopiles are the increased sound emissions during installation. Especially when using an impact hammer, the noise levels increase with increasing component size and existing sound mitigation methods are having difficulties in reducing the sound levels sufficiently.

[8] https://c1connections.com/
[9] https://www.vanoord.com/en/updates/van-oord-installs-worlds-first-submerged-slip-joint-successfully/

2.2 Current State of the Art

Monopile foundations have been dominating the offshore wind industry since the start. To set a clear stage for the overall discussion later in this paper, a high-level overview of the current State of the Art will be presented here. In particular some considerations regarding MP/TP as well as overall accessibility will be addressed because of their relevance to the topic of going boat landing-less.

2.2.1 MP/TP considerations

The first wind farms were installed using MP/TP combinations. Having a separate TP facilitates a skirt that can be used to support anodes or ICCP as well as a boat landing. Further benefits are the possibility for onshore commissioning in combination with a single lift during offshore installation. The reason that the industry is using more and more TP-less designs is that the flange between MP and TP becomes critical due to the increased size of the components and related forces[10], whilst also reducing overall CAPEX.

A TP-less monopile solves this issue by removing this flange but introduces a number of challenges of its own. The first one being that it requires the MP supplier to weld brackets on to the MP that require tight positional tolerances, which introduces a fabrication step that is very different from that of the monopile fabrication itself. Therefore, often a separate supply chain member needs to be included, significantly impacting fabrication and logistical efforts, whilst reducing the overall MP output. Furthermore, offshore installation becomes more critical since onshore commissioning opportunities are reduced and multiple small lifts are required offshore to place all secondary steel components where they are needed. Lastly, the overall length of the MP increases, further challenging industry from a T&I perspective. The main viewpoint from industry is that TP-less designs are here to stay. However, the choice for MP/TP versus TP-less will strongly depend on specific site conditions and other (market / supply chain / project) conditions.

2.2.2 Foundation installation

The main steps in foundation installation are installation of primary and secondary steel, followed by cable pull-in and lastly WTG installation. Since both the complexity and size of offshore wind farms is increasing, the logistics/planning is becoming increasingly important. Significant benefits are identified when being able to complete works within 1 (summer) campaign. When considering an installation strategy, it is therefore interesting to investigate using 2 vessels (large for primary steel & small for secondary steel) instead of using only 1 large vessel due to the increased installation flexibility.

A MP/TP foundation can support a 2-step installation approach with the option to place all sensitive components on the TP allowing single lift installation and onshore commissioning. When looking at the TP-less option, the installation of the secondary steel poses a number of challenges on T&I in the form of additional lifts as well as the need for specialized tooling. Especially since components like the boat landing go through the waterline during installation, this equipment needs to be very precise and robust, increasing its complexity. Previous projects have shown that these challenges can be dealt with.

Within the offshore wind farm *Hollandse Kust Zuid*, Seaway7 deployed the Secondary Steel Installation Tool (SSIT) allowing simultaneous installation of the Boat Landing System (BLS) and Airtight Platform (ATP). However, weather can have a large influence on the installation process, specifically regarding the docking of the tool on the MP foundation. Besides the SSIT there are other similar tools developed (see Figure 2) and although complex, these tools can be economically viable if reusable.

[10] Considerations-when-moving-to-TP-less - Sif 2022

Source: https://twd.nl **Source**: https://tms.nl **Source**: https://twd.nl

Figure 2: Examples of installation tools for installing secondary steel.

2.3 A key function of the foundation: To provide accessibility

> *'Access is key.'*

One of the most important functions of a foundation is to provide access to the WTG. And this access is key during both the installation phase, as well as during operation and maintenance of the wind turbines in general to ensure the required wind farm availability. With WTG sizes ever increasing, the cost of not being in operation is becoming too high to allow for unnecessary standstill. Furthermore, the location of offshore wind farms further away from shore is challenging the overall O&M strategy to maintain OPEX costs at acceptable levels. This change in playing field has provided the industry an opening to re-assess the current WTG access methods and O&M strategies.

2.3.1 Hardware: Vessels and access systems

Access to a wind turbine entails that a maintenance crew can enter the wind turbine in a safe and reliable manner and to do so three things are required: A means to approach the WTG, a suitable landing point on the WTG and an access system.

At the moment, 2 types of vessels are commonly used for transporting technicians and goods to the individual wind turbines; Crew Transfer Vessels (CTVs) and Service Operation Vessels (SOVs). A third option, that is applied on a smaller scale, is the Service Accommodation Transfer Vessel (SATV), which operates somewhat in the middle between a CTV and a SOV.

Source: https://www.bmt.org/ **Source**: https://www.polandatsea.com/ **Source**: https://www.bmt.org

Figure 3: Examples of offshore wind vessels used for crew transport.

CTVs are medium sized vessels often used for daily transits between a nearby port and the wind turbines. Travelling longer distances with this type of vessel is unfavourable because of the relative long transit time (wasting workhours), but also because of the discomfort during transit, especially in more unfavourable weather conditions. Workability of CTVs is between 1.0m and 1.7m Hs but is also influenced by the vessels capacity to keep position at the MP while enduring (side) current effects. SOVs are stationed close by to the wind farm and normally operate in a two-week cycle. These vessels are 50m or longer, are operating with Dynamic Positioning systems to allow station keeping near WTGs and can house up to 75 technicians as well as spare parts and/or equipment. SOVs are significantly more expensive than CTVs (8-10 times) but do allow multiple work shifts (used during installation phase) as well as more effective workdays because of less transit time.

The increase required in the up-time of XXL wind turbines, as well as the increase of the elevation of the Main Access Platform (MAP), has resulted in the development of multiple (motion compensated) gangway systems. Combined with SOVs, these systems allow for a safe and reliable manner of transferring technicians as well as small goods onboard of the WTG. For these gangway systems a simple landing point on the MAP is sufficient which also allows for the option of including several of these landing points at different wind directions to accommodate optimal vessel heading at all times. Access by means of helicopter will not be covered in this document. In the interviews, a trend of increasingly not wanting to use this option was identified. Also, for the sake of comparison, this paper will focus on a specific base case transferring scenario, which is further detailed in section 2.4.

Source: https://www.ampelmann.nl/offshore-wind

Source: https://www.offshorewind.biz

Source: https://www.renewableenergyworld.com

Figure 4: Examples of offshore wind access systems.

2.3.2 Boat landing: Friend or foe?

'BL-less is not 'the new black'; BL is tested and tried.'	*'It is a relative risky procedure so good if this can be optimized.'*

The first wind farms were located within a relative short distance from shore, allowing a fast and relative comfortable transit between port and wind farm by CTVs. The logical option for accessing these first offshore wind turbines therefore was by using CTV in combination with a boat landing. Experience with this way of access was readily available both via the oil & gas industry as well as other offshore/maritime sectors. A boat landing consists of a ladder in combination with a fender. The latter can be used by the CTV for push-off as well to serve as a cage to protect a (climbing) person from vessel movements. Commonly used, a lot of experience was gained and a number of Standards and design guidelines were made available such as the ISO 14122-3 standard for ladders & stairs, IMCA's HSSE041 / M232, design guidelines by the Carbon Trust[11] and the G+ Good practice guideline Working at height in the offshore wind industry. The benefits of a boat landing are straightforward: It's passive, fail safe and therefore always 'works'. In the offshore energy business, a traditional industry, this goes a long way.

[11] Design_for_recommended_boat_landing_geometry

But the traditional boat landing also has some disadvantages. After these initial wind farms, WTGs were being installed in more severe metocean conditions, leading to higher free space between mean sea level and main access platform (if the MAP is at an elevation of 21m above SWL, this is quite a long distance to climb). Especially in combination with the use of a CTV in locations further away from shore, the transit becomes less comfortable for technicians (especially in harsher conditions).

Furthermore, the transfer from a CTV on to a boat landing introduces risks. The first is the risk for a technician standing on the boat landing to be hit by the CTV when the vessel is (unexpectedly) moving upward (for instance when slipping from boat landing). Furthermore, the standard operating procedure is that a technician is connected to a Self-Retracting Lanyard (SRL) via a harness, but when the vessel deck moves down faster than the SRL allows for, the person is hanging suspended in the air, with a risk of being hit by the deck when the vessel is moving up again. According to G+ 2022 data[12] transfer from/to vessel is in top 10 of incident reporting accounting for 12 registered high potential incidents (not all injuries; mainly near misses). The risk increases when sea states get higher.

2.3.3 O&M philosophy: Primary, secondary and emergency scenarios

To support the trade-off between costs and revenue, the O&M philosophy needs to balance a number of parameters and determines the optimal combination of vessels and access systems. TNO's report on accessibility[13] states that, in order to achieve an availability of the wind farm of over 90%, the percentage of time that an offshore wind turbine can be approached and accessed by technicians (accessibility) should be 80% or higher.

In this O&M trade-off a distinction is made between primary means (for planned maintenance) and secondary means of access (for unplanned maintenance). In some offshore wind farms that are further away from shore a combination of SOVs and CTVs is used, to combine access by means of SOV to perform planned maintenance, with the use of CTVs for flexible access and faster response time in case unplanned maintenance is required.

Another distinction to be considered, is access during the T&I phase and access for O&M during the remainder of the lifetime of the wind farm. Although the T&I phase is an intensive phase, requiring a relative high amount of (unplanned) foundation/WTG visits, it also is a relative short phase compared to the full wind farm lifetime. During the T&I phase, driven by a flexibility requirement, typically a Walk to Work type of access system is combined with the use of smaller CTVs and/or daughter crafts.

Prior to O&M optimisation, safety also needs to be ensured and to that end some SOVs include Fast Rescue Crafts (FRCs) that can be launched by the vessels and be used for emergency evacuations/procedures. These emergency scenarios include emergency (fire/evacuation) descend options, man-in-the-water scenario and re-accessing the WTG when descended into the water.

[12] gplus-2022-incident-report
[13] R12419 Offshore Wind Access Report - TNO 2022

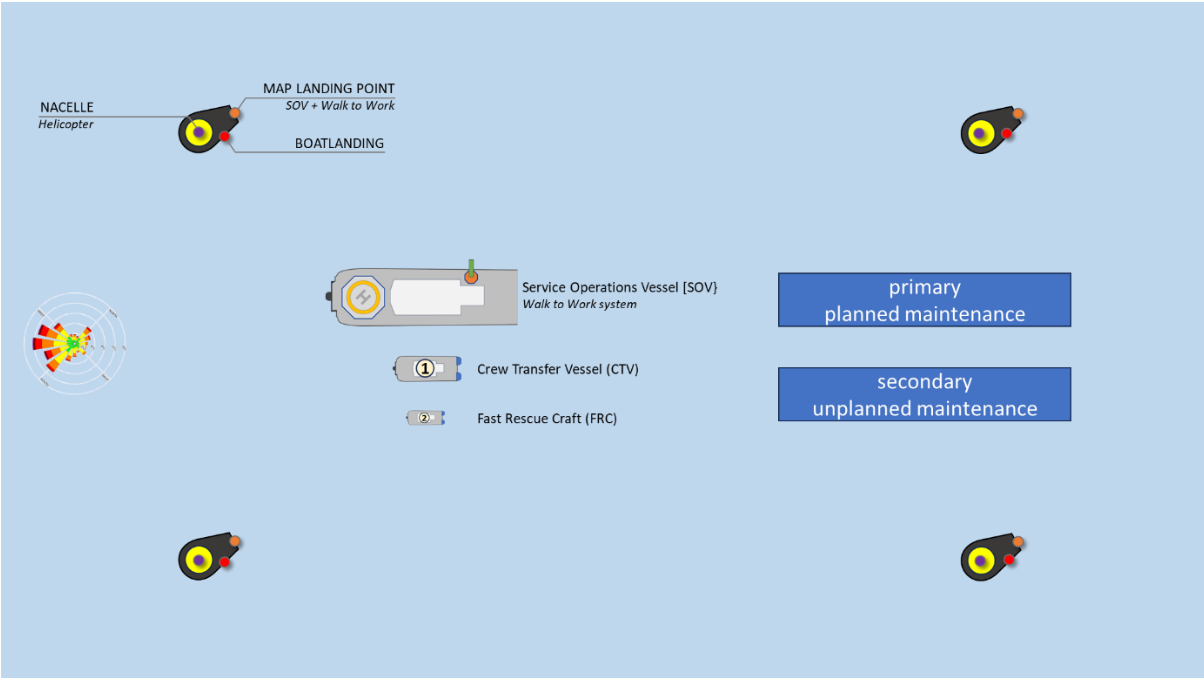

Figure 5: Artist impression of primary and secondary access options.

2.4 Most common means of access considered in this paper for comparison

The main trade-off between all access options is based on a number of parameters such as day-rates, weather restrictions, distance to shore, human comfort and the number of wind turbines. Any existing logistical infrastructure of existing adjacent wind farms can also play a role, especially if these farms share the same owner. As a result, many O&M and access strategies and combinations thereof are used in the field. This paper however will focus on a base case scenario where:

- Primary access (planned maintenance) is provided via a SOV in combination with a motion compensated gangway system;
- Secondary means of access (unplanned maintenance) via CTV & boat landing.

All accessibility options included in the qualitative comparison of this paper are further explained and detailed in subsection 4.1.2. Other wind farm specific parameters such as MP/TP, farm size, water depth and location are not fixed in the base case, to allow for investigating any effects of these on the concept of BL-less.

3 BOAT LANDING-LESS: CONCEPT AND CONSIDERATIONS

3.1 General remarks and concerns when the boat landing is omitted

'Not many specific concrete projects where clients were seriously interested or willing to decide for this so far.'

'BL-less is (often) pitched.'

'Some projects developers are not seriously considering it (yet).'

'Boat landing-less from design point of view logical and understandable.'

The debate on boat landing-less is not new, it existed prior to the start of this study. The interviewees were therefore asked, next to first impressions on the boat landing-less discussion, what they felt is really driving the discussion. The main consensus is that it is driven by both a possible reduction in cost, as well as a possible reduction in risk. Furthermore, wind farms are being developed further offshore and are ever increasing in size (higher sea states, increases in sailing time and project size), leading to an increased usage of SOVs which could also assist going BL-less. However, developers cannot be convinced with benefits in cost alone, safety and O&M are also key aspects that need to be carefully considered. Omitting the boat landing also introduces challenges, specifically regarding access: Access to the WTGs needs to be possible at any time, weather permitting.

From a business case point of view, omitting the boat landing seems an interesting option to investigate. During the design phase, excluding the boat landing is proposed in more and more projects. Omitting the boat landing leads to an overall simpler design, reducing CAPEX and OPEX of the foundation structure. In case of TP-less MPs, the brackets on the MP required for the BL are adding complexity. Also, additional wave loads are introduced on the MP due to the BL (although loads are relatively decreasing with increasing WTG size). Furthermore, when omitting the boat landing, the complex operation of installing the boat landing offshore is no longer required. However, the decision of going boat landing-less is very project specific. For some projects (large tidal range and challenging metocean conditions) it makes more sense than others to omit the BL. The larger the boat landing, the larger the cost saving. So, in principle, the design is simplified, but potentially, an alternative, technically more complex access system is required to provide equivalent accessibility. Also, since a CTV will now push on a specific area of the MP, an additional layer of coating or other protection will have to be applied on the MP.

As stated, potential cost savings alone will not suffice in this discussion. Safety, legislation, operational workability and flexibility & reliability and industry acceptance are all topics that came to mind when the interviewees were asked to share their first thoughts on the subject. A selection of various concerns and statements that were raised on these topics is presented below:

- Concerns (C) and statements (S) from a **safety perspective:**
  - C: How to mitigate the risk of someone falling in the water with no option of climbing back on the boat landing? The oil & gas industry has survival suits, life rafts and standby vessels. A WTG does not have life rafts and not always survival suits.
  - S: The Coastguard uses FRCs (Fast Rescue Crafts) that use the BL to access the WTG.
- Concerns (C) and statements (S) from a **legislative perspective:**
  - C: Law (might) require some of the structures in a wind farm to be accessible in case of an emergency (e.g.: sailors from a nearby boat accident); A safe haven in case something happens offshore.
  - S: In the US, whatever you build in sea becomes part of land (part of the US). It might be mandatory for a person to be able to safe him/herself, as oil & gas platforms typically require a way for a man overboard to climb back to a safe resting platform.
- Concerns and statements from an **operational workability and flexibility perspective:**

  - C: In general, many different O&M contractors are involved in offshore wind projects. You need to be flexible in getting people on the WTGs. Some only need 1 hour per WTG, others 2 weeks, only further stressing this flexibility requirement. 'Standard' WTG team is spending +/-3 days per WTG. 'Specialist' WTG teams however, can visit up to 8-10 WTGs per day. How to handle unplanned maintenance and quick dispatch of multiple O&M teams?
  - C: How do developers go about general WTG access strategy? What if secondary does not work? What if alternative system fails? SOV is back-up but will take time.
- Concerns and statements from a **reliability and industry acceptance perspective:**
  - C: OEM has to guarantee a certain up-time. What up-time guarantees will you get with alternative system(s)? What guarantees can you give on WTG availability if no certainty of accessibility can be provided?
  - C: If a new project site is next to an existing site that uses CTVs with boat landing, then the same infrastructure will likely be used. This poses an additional challenge to get innovation in.

3.2 Alternatives for boat landing

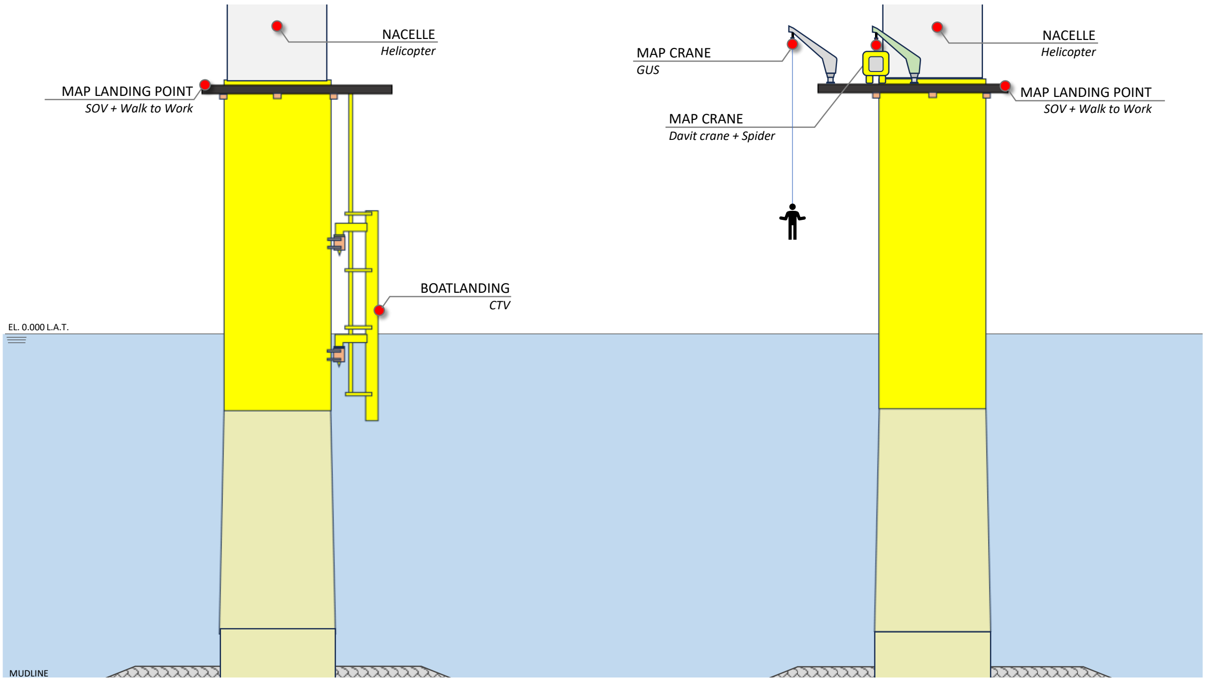

Figure 6: Overview of foundation with (left) and without (right) a boat landing, showing access points (capital letter writing above lines) and access means (writing below lines). Main Access Platform abbreviated as MAP.

Figure 6 displays an artist impression of the main (access) differences between a foundation with and without a boat landing. It also shows the two alternative means of access that were considered in this paper: The Pict Offshore Get Up Safe (GUS) system and the Seasight Davits Spider system. Both systems comprise of some form of, wireless remotely operated, man-riding access. Therefore, subsection 3.2.1 starts with some considerations regarding man-riding in general. Next, in subsections 3.2.2 and 3.2.3, both alternatives are introduced in more detail. Any observations regarding the performance of both systems are specifically omitted from these factual introductory sections and covered in chapter 4.

3.2.1 Man-riding general considerations

'Man riding, not in our time.'	*'If GUS/Spider would be the Industry Standard, no one would switch to boat landing if introduced.'*

Some say: Man riding has been standard practice in the oil & gas industry for decades ('*5M lifts per year in oil & gas*') and therefore only logical to implement in the offshore wind industry. Others say, use man-riding learnings of oil & gas industry and do not do it from an efficiency and safety point of view ('*it's slow and it's not safe*'). In various cases offshore, man-riding is only used in emergency situations and not as a base case. Another concern that was raised is that for some (offshore wind) developers, man-riding (basket) is a no-go, full stop. In the end it is about lifting of people offshore which will always be a topic of discussion. At the same time, during helicopter transfers, a more accepted means of transfer in the offshore wind industry, people are hoisted as well.

From a more technical point of view, (vessel) man-riding cranes have specific certification requirements. Standards for instance prescribe the ability to always be able to lower the basket in emergency situations. Man-riding (vessel) crane drivers require specific training ranging from: Sparrows 1 (only on deck), 2 (cargo from deck to quay) and 3 (cargo + persons from ship to ship). In Dutch law specifically (ARBO perspective), man-riding is not preferred, but also not forbidden. It needs to be safe. It has its own additional challenges and specific requirements to fulfil from a norm, technical and inspections perspective amongst others. For Dutch law the same holds true for remote operation. Next to allowable sea states, the wind speed is also a factor specifically not to overlook when lifting cargo or personnel offshore.

3.2.2 Pict Offshore Get Up Safe (GUS) system introduced

Figure 7: Picture of the GUS system in operation[14].

System intro and operational procedures
The Get Up Safe (GUS) system is a laser guided, heave compensated WTG mounted crane, wireless remotely controlled from the (CTV) vessel. The CTV pushes against the foundation, while integrated sensors track the vessels deck movement. Personnel are transferred by the software-controlled hoist to and from the WTG platform. The GUS system is used from a dedicated position and orientation relative to the MP (same as a boat landing), given the governing site wave direction. Depending on the exact location on the platform, the GUS system allows a person to transfer +3.0-3.5m away from the MP on to the vessel deck. Training centres have been established in the UK and USA in collaboration with Maersk Training.

System specs, performance and requirements
The GUS system is certified for use in up to 2.5m Hs with the hoist able to move the line at a maximum speed of 2.12m/s in automatic response to vessel movement. Normal line speed is 0.5m/s except when close to the platform, when speed drops to 0.25m/s. The GUS system has an integrated UPS to allow continuity of performance, including lifting, lowering and deck tracking, in the event of a power failure. The system also integrates a pull-down umbilical power cable, which is stored on a retractable reel on the platform, which enables the system to be powered from a CTV during the construction phase of the windfarm, or in the event of WTG power outage. The GUS systems supplied to Orsted's US projects have been equipped with the new 'Rope Transfer System', which is designed to act as means of back-up access from CTV if the GUS system cannot be used.

Commercial status and overall industry acceptance challenges (specifics in Chapter 4)
With regards to its commercial status, the first 165 commercial systems are installed and have been in use on the Hornsea 2 project since early 2022. Three projects in the US are currently under supply (South Fork, Revolution and Sunrise wind farms), with GUS systems at Southfork Wind in use at South Fork, which is – at the date of writing – under construction. All of these projects have removed boat landings from TP/ foundation design.

[14] http://www.pictoffshore.com/how-gus-works.html

3.2.3 Seasight Davits Spider system introduced

Figure 8: Overview picture of the Spider system[15].

System intro and operational procedures

The Spider system consists of a camera fitted, man-riding basket which is lifted from the (CTV) vessel by the WTG mounted Davit crane, which is wireless remotely controlled from the vessel. The basket remains on the vessel. Lifts are only performed above water, with the crane slewing out from deck prior to lifting. The crane if slewed back to the main access platform after lifting, implying that the basket always lands on the same point of the platform. If something fails, the basket will therefore fall in the water and is floating and self-righting. The Spider system lifts both goods and personnel and is certified for both. The system is developed according to crane standards (EN 13852-2), in an effort to repeat what has been done and used in the oil & gas industry in the previous decades. The crane has no heave compensation since this is not allowed according to these standards. Therefore, Seasight Davits's view is that man-riding as such is not new. What is new, is operating the Davit crane remotely from the (CTV) vessel and a camera system included in the basket.

System specs, performance and requirements

According to Seasight Davits, the workability of the Spider system is 1.5-2.0m Hs, but wind speeds are probably the limiting factor. However, during offshore trials, the basket was landed without any issues on a CTV deck up to wind speeds of 12-15m/s. The Spider basket has a 1.5x1.5m footprint (fitting 2 people), implying that no climbing harness is required during transfer and is outfitted with a redundant spring cushion system underneath the basket (up to 2-4m/s) to remedy any impact loads. The basket can be upgraded relatively easily to accommodate 3 or 4 persons. This will require an increase of the 'standard' crane SWL of 1000kg to 2000kg, which already is available in the product portfolio. A larger basket will require more space on the CTV deck. The basket size can also be decreased to fit 1 person if the CTV does not have space for a 2 seated basket. The system can be powered independently from the WTG. A pull-down wire design is work in progress, in combination with an Uninterrupted Power Supply (UPS) back-up battery package for slewing and lowering. In case of TP less foundations, Spider related installation and commissioning activities are pushed from onshore to offshore.

Commercial status and overall industry acceptance challenges (specifics in CH4)

The Spider system has been sold to O&G companies, but it is new for the offshore wind market. No

[15] https://seasight-davits.com/spider/

commercial sales yet. The main concerns raised by the industry are reliability, safety and the importance of having a back-up option.

4 BOAT LANDING-LESS: PRO'S AND CON'S

4.1 Approach qualitative comparison of various access methods

4.1.1 Determination of qualitative criteria

In order to establish the offshore wind industry's take on the pros and cons of the boat landing-less topic, 16 interviews were conducted with a range of relevant stakeholders. Design houses, manufacturers, (WTG OEM) suppliers, installation contractors, wind farm developers, wind farm operators and government bodies were all included in the list. The interviews turned out to be an iterative process, using output from the executed interviews as input for the next sessions. Questions, concerns and statements (see section 3.1), led to an overall identification of challenges and opportunities. Furthermore, all interviewees were asked questions regarding the offshore wind market in general and first impressions of the boat landing-less discussion, before diving in more specific topic related criteria, which also evolved during the process; ultimately leading to the following set of qualitative criteria used in the comparison of different access methods:

- Safety
- Cost (business case)
- Legislation/Certification/Standards
- Operational workability & flexibility
- Reliability, industry acceptance and supply chain maturity

4.1.2 Boat landing-less accessibility options included in comparison

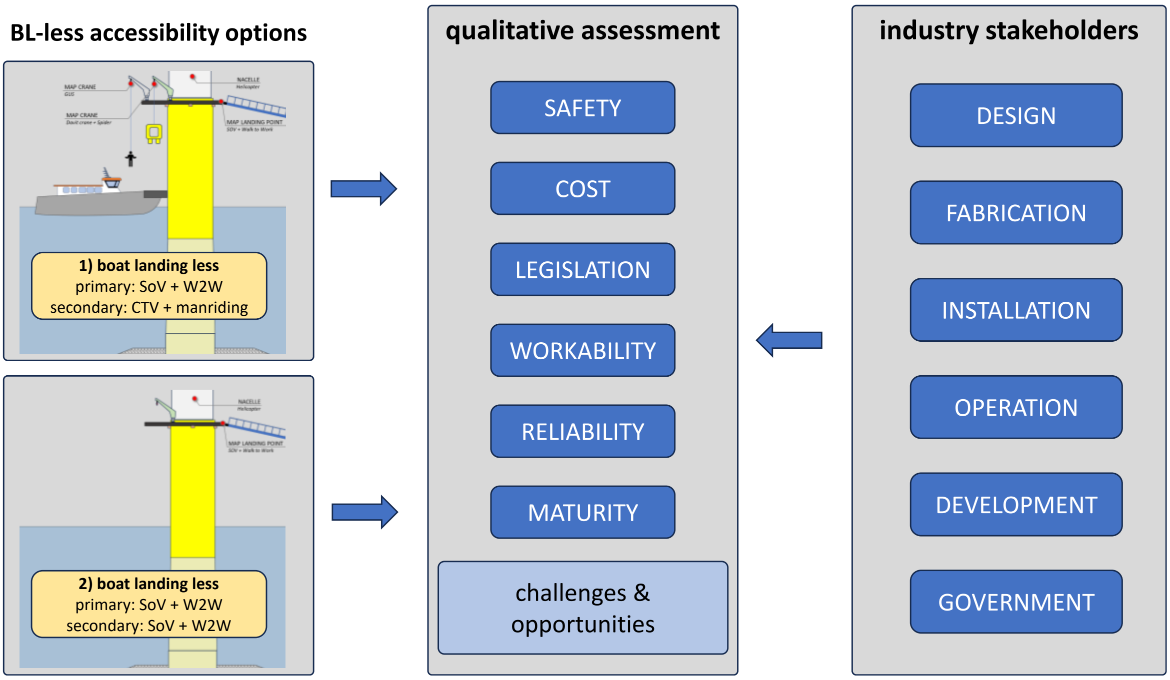

Figure 9: Schematic overview of the way of work of the qualitative assessment of the boat landing-less topic.

Figure 9 displays a schematic overview of the method for the qualitative assessment of the boat landing-less topic. The access method options that were considered in the comparison are as follows:

- Base case: **Boat landing access**
    - The base case against which the alternative means of access (replacing the boat landing) were compared. The primary means of access, for planned maintenance, consists of the use of a Walk to Work system. The secondary means of access, for unplanned maintenance, consists of a CTV in combination with the use of a boat landing. Since the boat landing is the main topic of this paper, it was mainly the secondary means of access that was considered in the comparison.
- Option 1: **Alternative secondary means**
    - The primary means of access, for planned maintenance, consists of the use of a Walk to Work system. The secondary means of access, for unplanned maintenance, consists of the use of an alternative man-riding access system; either the GUS system (3.2.2) or the Spider system (3.2.3). For the sake of comparison, it was mainly the secondary means of access that was considered.
- Option 2: **(Optimised) Walk to Work only**
    - Primary as well as secondary access via a full-size SOV in combination with a Walk to Work access system only. Potentially optimized on minimizing WTG to WTG transit time and already available during the wind farm construction phase. This set-up could simplify shore logistics, being a full-time offshore 'floating O&M office' and has the option to be down manned outside planned maintenance. To maximize the chances of a positive business case, it is important to fix the contract for a long period of time (estimate +/-10 years).

4.2 Results qualitative comparison access methods (outcome of interviews)

The results of the qualitative comparison are presented separately for each of the criteria in sections 4.2.1-4.2.5 in the form of a table. It is important to note that the tables are populated using the outcome of the various interviews. Which implies that this content contains a mix of opinions, statements, facts, concerns and questions. It also implies that the views of the different interviewees sometimes are in contradiction. With that in mind, overall conclusions were drawn (at the top of each table), in an effort to summarize the broadest shared view after combining the outcome of all interviews. The conclusions (part A in tables) on BL-less compared to use of a boat landing, have one of three different colours: Green indicates an improvement, yellow indicates a point of attention and red indicates a challenge to be overcome.

4.2.1 Safety perspective

Table 1: Feedback from interviews specifically related to the safety aspect of the BL-less topic. ***Disclaimer****: Content is based on the (sometimes contradicting) views of different interviewees (mix of opinions, statements, facts, concerns and questions).*

	Safety	
Topic	***Option 1:*** *Alternative secondary means*	***Option 2****: (Optimised) Walk to Work only*
A: Overall conclusion	Boat landing-less can be more safe as you do not have to transfer from vessel to ladder nor perform ladder climbing. Emergency evacuation point of attention.	

(distilled from content of all interviews)	In principle, alternatives can be as safe or more safe than boat landing access (if systems work properly and reliably). Man-riding in general is point of discussion.	Safer and more comfortable than boat landing transfer. Likely that importance of human comfort will only increase.

B: General considerations *(Overview of content/views/ feedback from all interviews)*	- In general, some say: BL is not safe so we need an alternative. Others say: BL has proven itself; let other systems prove themselves first. Preferred is Walk to Work. - Risk/concern is that focus is on cost optimization instead of safety. If fully reasoned from safety, combining boat landing and alternative means could be optimal (value of safety complex topic). - From a safety point of view, the more options for access the better. Especially in emergency situations such as person in water, which is always a point of attention. In that regard, boat landing-less probably not safer because you remove an option. Davit crane evacuation was already an option for evacuation. - In the UK, with regards to person in water scenario, it was assumed that should a windfarm technician end up in the water, they would have correct PPE and an emergency response system to come and rescue them in a timely manner, without the need to climb back onto a structure. Also, while there is a potential risk that someone may be in the water and without BL unable to cling on to a ladder and/or climb up it, the chances of that happening successfully were deemed as quite low. - Person in water scenario potentially not relevant/problematic. Likelihood is low and currents very high around MP. Plus, vessels (CTV and/or FRC) will be near. Depending on the scenario: During transfer, vessel in the vicinity. In case fire/emergency and somebody jumps in the water, vessel(s) will move to WTG asap. Although not allowed by standards, it is possible to lower Davit crane hook. - Person in water scenario probably not governing. It is not sure if BL will help (high currents around MP). Mostly people fall from vessel (due to the platform elevation survival chances are low). - The use of boat landing to climb back on to WTG could potentially even worsen person in water situation due impact of person on to boat landing fenders and/or ladder steel structure. Also, if person would be holding on to boat landing, they would need to let go when rescued by vessel, to prevent getting stuck between vessel and BL due to currents and/or waves. - A consideration could be to put to other grab rails on the turbines but there could be a maintenance question with this and potentially, such a rail could become more of a hazard. - If there is something that you can grab, it will help. However, chance that you can is not very large and therefore probably this will not be showstopper. - Having no ladders also increases the security element of a wind farm: because harder to tie off any packages to WTGs and unauthorised access to the turbine is likely to be (nearly) impossible. - Boat landing ladder now always up to and including -1m LAT. Maybe option to only add ladder and no boat landing if this proves to be a governing scenario (some WTG towers require an elevator and a back-up ladder). Sometimes WTG elevator goes into foundation and certain WTG suppliers specifically ask for back-up ladder. What would this imply for alternatives? - Going forward, human comfort is likely to become more and more important.

<table>
<tr>
<td rowspan="8">C: Pros & Cons
(Overview of content/views/ feedback from all interviews)</td>
<td rowspan="4">+</td>
<td colspan="2">+ The assumption is that BL-less is more safe as you do not have to transfer from vessel to ladder nor perform ladder climbing.
+ Comparing to BL, fabrication should also be taken into account; more fabrication is more risk.</td>
</tr>
<tr>
<td>Alternative secondary means:
+ If GUS/Spider would be Industry Standard, no one would switch to boat landing if introduced.
+ Increase in comfort due to no climbing.</td>
<td rowspan="3">+ Boat landing-less more safe in case of a Walk to Work system. If boat landing is replaced with SOV + W2W safety is improved.
+ SOV + W2W very interesting from a human comfort point of view.</td>
</tr>
<tr>
<td>Pict Offshore Get Up Safe (GUS) system:
+ Hornsea 2: Good results so far safety wise; no safety incidents (assumption transfers safer). Statistics not in place yet to validate assumptions</td>
</tr>
<tr>
<td>Seasight Davits Spider system:
+ Since 2 people fit basket, less hoisting operations required.
+ Stretcher fits in Spider basket.</td>
</tr>
<tr>
<td rowspan="4">-</td>
<td colspan="2">- Getting up is one thing, but getting off is maybe even more important (also OEM demand). Solutions are imaginable (such as: Ladder backup and raft backup). Note that Davit crane always has hook-on point for emergency lowering device.
- Evacuation during T&I phase: If something happens on foundation (and SOV not available) BL now is secondary means of escape.
- Concern that people need to wait when emergency descending from platform in BL-less case. Boat landing potentially goes faster.</td>
</tr>
<tr>
<td>Alternative secondary means:
- Everyone can climb; man-riding more complex.
- Alternative systems require power. If not available, or power via CTV, how to act (fast) in case of evacuation?</td>
<td rowspan="3">- Walk to Work systems do also have risks in usage.</td>
</tr>
<tr>
<td>Pict Offshore Get Up Safe (GUS) system:
- Not very enthusiastic: Lifting someone on a wire and concern on secondary support. However, a secondary support i.e. back up fall arrest system is now available for integration into the GUS system on request
- System could be positioned above boat landing fenders, but if BL-less no protection by fenders.</td>
</tr>
<tr>
<td>Seasight Davits Spider system:
- Not very enthusiastic. Should be fail-safe. Davit crane needs to be controlled from CTV.
- Impact forces during landing concern heard from industry.</td>
</tr>
</table>

		- No commercial implementation in offshore wind market as of yet.	

4.2.2 Cost (business case) perspective

*Table 2: Feedback from interviews specifically related to the cost (business case) aspect of the BL-less topic. **Disclaimer**: Content is based on the (sometimes contradicting) views of different interviewees (mix of opinions, statements, facts, concerns and questions).*

		Cost (business case)	
Topic		***Option 1**: Alternative secondary means*	***Option 2**: (Optimised) Walk to Work only*
A: Overall conclusion *(distilled from content of all interviews)*		Omitting the boat landing has a clear potential to reduce overall cost of a wind farm, but will remain project specific.	
		Very likely to reduce cost, additional MP coating protection point of attention.	Will reduce overall CAPEX, but OPEX depends on farm size and contract.
B: General considerations *(Overview of content/views/ feedback from all interviews)*		- BL-less leads to CAPEX cost saving. But OPEX (O&M) is more complex. Accessibility to the WTG is key. - Business case varies per project and region because it depends on local steel price and cost for personnel and transport. - Coating MP impacted where CTV pushes-off in case BL-less. Difficult to predict in design. Additional challenge in maintaining additional protection (coating) system MP (no boat landing). - Lifetime requirements of offshore wind farms going toward 35yr (and potentially above), but coating suppliers only guarantee to +/-20-25 years lifetime. No track-record yet on coating performance. - Design challenge introduced if free corrosion requirement is imposed on design due to additional protection / coating requirement on MP (will have an effect on MP steel usage).	
C: Pros & Cons *(Overview of content/views/ feedback from all interviews)*	+	+ MP primary steel saving: Loads are reduced, no BL buckets/brackets leading to SCFs. + MP secondary steel saving: No boat landing, no ladder, no (intermediate) platforms. + Corrosion less likely to initiate on a smooth surface than at or around welded attachments. + MP output from each fabricator would go up (estimated from +/-5 to +/-6-7 per week). + Secondary steel installation saving (specifically installation of boat landing). + O&M saving (no boat landing/ladder maintenance). + In case of MP/TP design: Potentially shorter grouting skirt (skirt supports lower BL bracket).	

		Alternative secondary means: '+ Void.	
		Pict Offshore Get Up Safe (GUS) system: + Implemented at Hornsea 2 (UK) and Southfork, Revolution and Sunrise Wind (USA) implying positive business case calculation.	
		Seasight Davits Spider system: + Void.	
	-	- Cost additional ICCP anode cages: Not possible to mount on boat landing (for larger MPs other locations needed in any case so less of a disadvantage).	
		Alternative secondary means: - Cost alternative access system. - Cost of training personnel (incl. OEM and all stakeholders requiring access to the WTGs). - Cost additional protection (coating) system MP. - Additional protection required over large part of MP (depending on local tide + wave conditions). - Protection (coating) system MP can influence MP output.	- Cost larger (SOV) vessel. Long term contract probably a must have (estimate +/-10 years).
		Pict Offshore Get Up Safe (GUS) system: - GUS (crane) in addition to Davit crane. - Different, potentially more complex platform if GUS & Davit crane - GUS (crane) maintenance cost.	
		Seasight Davits Spider system: - Additional price crane for man riding (a.o.: Safety system, additional brakes, UPS, ...). - Cost for Spider basket(s) (1-2 per wind farm) and remote control(s) (1-2 per wind farm).	

4.2.3 Legislation/Certification/Standards perspective

Table 3: Feedback from interviews specifically related to the legislation/certification/standards aspect of the BL-less topic. ***Disclaimer****: Content is based on the (sometimes contradicting) views of different interviewees (mix of opinions, statements, facts, concerns and questions).*

		Legislation/Certification/Standards	
Topic		***Option 1****: Alternative secondary means*	***Option 2****: (Optimised) Walk to Work only*

<table>
<tr><td rowspan="2">A: Overall conclusion
(distilled from content of all interviews)</td><td colspan="2">For NL waters, no hard requirements for a boat landing were identified. In the UK, the industry was able to demonstrate that they had robust alternative arrangements for transferring personnel including multiple evacuation methods in place. Both NL and UK bodies were not aware of any legislation and/or guidance on the requirement of WTG grab points anywhere around the world. For US waters, the pipeline of projects aiming at implementing BL-less seem to indicate that the omission of a boat landing can be implemented in an acceptable manner. For wind farms close to shore or in a high traffic density area, the BL-less topic might be reconsidered. To be checked for each case, also since legislation requirements might differ from country to country.</td></tr>
<tr><td>Alternatives must be shown to be sufficiently safe in all scenarios. Clear standards not always available given innovative nature.</td><td>W2W generally seen as an improvement compared to boat landing access.</td></tr>
</table>

<table>
<tr><td>B: General considerations
(Overview of content/views/ feedback from all interviews)</td><td>- The Netherlands specifically implements ‘goal-setting legislation’ instead of ‘prescriptive legislation’. Therefore, in principle, legislation will never prescribe something in a hard fashion. However, you have to prove you can work safely. Specifically taking into account emergency situations.
- Alternative needs to be safe in all (emergency) scenarios, which need to be backed-up by extensive (internal) risk assessments. Whether alternative(s) will be allowed will to a large extend be determined by safety performance (must be deemed sufficiently safe).
- In the UK, for the first BL-less implementation, the industry was able to demonstrate that they had robust alternative arrangements for transferring personnel including multiple evacuation methods.
- Note that, also in the UK, the windfarm (Hornsea 2) is situated in an area which is generally less populated in terms of vessel traffic and less likelihood of leisure activity around it. Should the wind farm be developed within a few miles of the coast or in a high traffic density area, the BL-less topic should be carefully reconsidered.
- Both NL and UK bodies were not aware of any legislation and/or guidance on this anywhere around the world. Therefore, no proof was found to back-up the concern that legislation requires some of the structures in a wind farm to be accessible in case of an (vessel/sailor) emergency nearby (grab points on WTG).
- No proof was found to back-up the concern that the Coastguard, using their FRCs (Fast Rescue Crafts), need a boat landing to access the WTG. In the Netherlands, the Coastguard in principle does not enter the construction. Also, its FRCs are not designed for BL access. It is the responsibility of the asset operator that someone can be evacuated by Coastguard vessel (from water) and/or via helicopter (from nacelle).
- Standards take some time to catch up with innovations (same was the case for Walk to Work concepts).
- Simplification of designs is important and can be beneficial; generally speaking the more simple the better. The more activities are added, the more risk is introduced. However, when a means of access is removed, probably, it needs to be replaced.
- Some countries have national rules that go beyond norms (more strict than norms).</td></tr>
</table>

<table>
<tr><td>C: Pros & Cons
(Overview of</td><td>+</td><td>+ No hard demand for boat landing in legislation. Design is checked using standards for steel design; If BL excluded, less checks on steel are required.</td></tr>
</table>

content/views/ feedback from all interviews)		***Alternative secondary means***: + Void.	
		Pict Offshore Get Up Safe (GUS) system: + Void.	
		Seasight Davits Spider system: + Designed according to existing EN 13852-2 norm.	
	-	***Alternative secondary means***: - If no boat landing, also inspection requires (access) training.	- W2W landing points not standardized yet, although notified bodies are moving in right direction.
		Pict Offshore Get Up Safe (GUS) system: - GUS, being an innovative device, falls within the 'cracks' of existing standards. - Gap analysis performed by certification bodies but not one very clear standard to refer to.	
		Seasight Davits Spider system: - All cranes to be certified for man-riding.	

4.2.4 Operational workability & flexibility perspective

Table 4: Feedback from interviews specifically related to the operational workability & flexibility aspect of the BL-less topic. ***Disclaimer****: Content is based on the (sometimes contradicting) views of different interviewees (mix of opinions, statements, facts, concerns and questions).*

	Operational workability & flexibility	
Topic	***Option 1****: Alternative secondary means*	***Option 2****: (Optimised) Walk to Work only*
A: Overall conclusion *(distilled from content of all interviews)*	The overall workability shows potential of improving when going BL-less. Depending on the access method, serious concerns on overall operational flexibility.	
	Sea state (Hs): Equal or improved. WTG-WTG time: Equal. Harbour-WTG time: Equal. Allowable wind speed point of attention. Largest concern how to get on to WTG when alternative system not working.	Sea state (Hs): Improved. WTG-WTG time: Slower. Harbour-WTG time: n.a. / faster. Largest concern is potential reduced flexibility due to increased in-field WTG transit time and no CTVs.

<table>
<tr>
<td>B: General considerations
(Overview of content/views/ feedback from all interviews)</td>
<td>- Workability of alternative system should be the same (or more) when using same CTV to be a viable alternative. If reliability is equal to or larger than CTV and boat landing, than overall workability can go up.
- A boat landing with a 'simple' steel ladder always works. How do you get to the WTG for unplanned maintenance when alternative secondary means does not work?
- An option could be to train service engineers in a more all-round fashion, so more people can do more things. However, challenging since a lot of different specialist are required. Also challenging due to potential over-qualified personnel.
- When BL-less, no option to access WTG via BL during T&I. Access required for small activities (such as paint repairs), prep and pull actions for cable works and various punch items. A question sometimes raised is how alternative systems are (externally) powered (especially during T&I phase)? Specifically, the GUS system integrates a pull-down umbilical power cable, which is stored on a retractable reel on the platform, which enables the system to be powered from a CTV during the construction phase of the windfarm, or in the event of WTG power outage. The Spider system has a pull-down wire design as a work in progress. Power to alternative systems could also be delivered via switchgear in foundation, but requires OHVS and cables operational. However, transformer usually in lower part WTG tower.</td>
</tr>
</table>

<table>
<tr>
<td rowspan="8">C: Pros & Cons
(Overview of content/views/ feedback from all interviews)</td>
<td rowspan="4">+</td>
<td colspan="2">+ Boat landing in principle has a lower workability (Hs) than alternatives.
+ Boat landing requires periodic inspection. When inspection fails, WTG becomes no-go area, leading to a logistical challenge.</td>
</tr>
<tr>
<td>Alternative secondary means:
+ CTVs are here to stay.</td>
<td rowspan="3">+ SOV has high workability.
+ Depending on vessel spread: (slightly) more expensive vessel with increased workability.
+ If Hs is too high for CTVs in any case than SOVs are the way to go.
+ No daily transit time to and from farm.
+ Continues in-field operation.</td>
</tr>
<tr>
<td>Pict Offshore Get Up Safe (GUS) system:
+ In principle, more or less same workability.
+ Hornsea 2: Experience easier transfer of people at higher states (Hs 1.5-1.7m). Statistics not in place yet to validate assumptions.</td>
</tr>
<tr>
<td>Seasight Davits Spider system:
+ Void.</td>
</tr>
<tr>
<td rowspan="4">-</td>
<td colspan="2"></td>
</tr>
<tr>
<td>Alternative secondary means:
- How to get to WTG if SOV not available and secondary alternative system not working?
- Maximum allowable wind speed is a factor not to be overlooked when lifting people offshore (next to sea state).</td>
<td rowspan="3">- SOVs often supported by CTVs (in summer) because O&M with SOV goes relatively slow (WTG positioning takes time).
- if SOV only, flexibility decreases. Option for use of multiple SOVs, but still concerns regarding access speed.</td>
</tr>
<tr>
<td>Pict Offshore Get Up Safe (GUS) system:
- Void.</td>
</tr>
<tr>
<td>Seasight Davits Spider system:
- Vessel needs space for landing basket; some (daughter) crafts are relatively small.</td>
</tr>
</table>

4.2.5 Reliability, industry acceptance and supply chain maturity

*Table 5: Feedback from interviews specifically related to the reliability, industry acceptance and supply chain maturity aspect of the BL-less topic. **Disclaimer**: Content is based on the (sometimes contradicting) views of different interviewees (mix of opinions, statements, facts, concerns and questions).*

Topic		Reliability, industry acceptance and supply chain maturity	
Topic		***Option 1**: Alternative secondary means*	***Option 2**: (Optimised) Walk to Work only*
A: Overall conclusion *(distilled from content of all interviews)*		Every mechanical and electrical system, in the end, never as reliable as simple steel ladder, significantly increasing risk of not being able to (timely) access WTG.	
		Challenging due to the relative added complexity of innovative, unmanned systems, operating in remote locations. Combined with a limited (offshore wind) track record and supplier competition.	Systems proven and accepted by industry with a mature (growing) supply chain. Technically more complex, but easily reachable.
B: General considerations *(Overview of content/views/ feedback from all interviews)*		- Given the (ever increasing) importance of WTG up-time (cost of lost production), having a reliable and flexible access method (and in various cases, therefore having a secondary means of access) is of vital importance. - New alternative access systems have a very high burden of proof posing a large challenge. HSE teams are involved at early stage to cover all scenarios. Almost 'unfair' comparison with current practice, because it needs to be better than BL instead of as good. Access is key to O&M and eventually availability and therefore very little concessions and unknowns accepted. - The boat landing-less discussion complicates when O&M and QHSE are introduced. Specifically, in case alternative is defect, and SOV is not available, how to access the WTG? - The industry is curious to BL-less since potential benefits are there, but main question is whether alternatives are safe and reliable. Industry awaiting track record from Hornsea 2 to make up their mind. BL-less discussion is stalling due to current lack of track record. - CTVs and daughter crafts are flexible but require a reliable method of WTG access, which BL provides: Low tech alternatives not there yet. - Challenging to manage pilot issues from a reputation point of view (negative publicity travels fast).	
C: Pros & Cons *(Overview of content/views/ feedback from all interviews)*	+	+ The offshore wind industry is looking for ways to improve itself.	
		Alternative secondary means: + Some developers no strict regulations against man-riding. ***Pict Offshore Get Up Safe (GUS) system***: + Hornsea 2 numbers and learning curve look promising. Statistics not in place yet to validate assumptions. + Alternative systems, fitted to GUS, are	+ Multiple (mature) suppliers and market and supply is growing rapidly.

		a work in progress, as a back-up for failure of GUS.	
		Seasight Davits Spider system: + Designed according to existing EN 13852-2 norm (existing norm well known in industry). + Dedicated ongoing test site in Belgium. + System has been sold and used in oil & gas industry.	
		- Every mechanical and electrical system, in the end, never as reliable as simple steel ladder (in spite of reliability as a design); hardware requiring power and maintenance.	
		Alternative secondary means: - Unmanned systems (no personnel on WTG) in remote location. - Platform cranes are not often used and require (periodic) maintenance. - All WTG systems experience vibrations. - Remote control required (adding complexity). - Only few suppliers and not all mature yet.	- Technically more complex than BL, but system well reachable on-board of vessel.
	-	***Pict Offshore Get Up Safe (GUS) system***: - Challenges at Hornsea 2 (as expected this being first large-scale commercial pilot/application). Specifically, regarding commissioning of system, leading to availability issues. However, challenges reported as largely resolved. - Less mature, innovative, solution with no competition yet.	
		Seasight Davits Spider system: - Offshore trials completed, but no commercial implementation in offshore wind market yet. - Little competition.	

5 CONCLUSION: IS BOAT LANDING-LESS HERE TO STAY?

'Current feeling is it will be difficult to fully omit BL. Fail safe and reliable alternatives not there yet.'	*'In the UK, we do now have turbines installed without any ladders and will likely see more in future.'*
'If alternatives available with use of CTV we are open for it, but I do not see that as of yet.'	*'Market moving toward boat landing-less in the long term.'*

Boat landing-less is here to stay. The interviews seem to have confirmed that what was already driving the BL-less discussion: Omitting a boat landing can reduce cost, and alternatives in principle improve safety by removing risk related to CTV boat landing transfers. The further offshore, the more logical this option becomes. Overall, the offshore wind industry is looking for ways to improve itself. At the same time, the offshore wind market has a relative conservative nature. When something works and has been used in the past, it is a challenge to switch to innovative alternatives. Especially since these alternatives need time to build-up (positive) track record. Access to a WTG needs to be possible at any time, weather permitting, in an acceptably flexible manner. Furthermore, the alternative needs to be safe and needs to be reliable. Above all, the decision of going BL-less is very much project specific (depending on local site and project conditions), country based and developer mindset driven.

From a safety perspective, BL-less seems an interesting option to further develop, as you do not have to transfer from vessel to ladder nor perform the ever-increasing lengths of ladder climbing, although emergency evacuation was identified as a point of attention. Cost wise, omitting the boat landing has a clear potential to reduce overall cost of a wind farm. For Dutch waters, no hard requirements for a boat landing were identified in legislation. Both NL and UK bodies were not aware of any legislation and/or guidance on the requirement of WTG grab points (allowing man overboard to cling on to and/or climb up) anywhere around the world. The first operational BL-less wind farm has been approved in the UK. However, for wind farms close to shore (more leisure activity) or in a high traffic density area, with an increased likelihood of someone in the water and without BL unable to cling on to a ladder and/or climb up it, the BL-less topic might be reconsidered. Ongoing BL-less wind farm developments in the US indicate that BL-less can be implemented in an acceptable manner there as well. The overall workability shows potential of improving when going BL-less, but, depending on the alternative access method that replaces the boat landing, there are serious concerns on overall operational flexibility. The largest challenge for BL-less, especially for innovative alternatives, seems to be reliability and industry acceptance. Every mechanical and electrical system, in the end, will never be as reliable as a simple steel ladder, significantly increasing risk of not being able to (timely) access the WTGs.

Although the market might be moving towards boat landing-less in the (not immediate) future, in the short term there will be projects with and without boat landing. A near future revolution is not likely to take place. As with MP/TP versus TP-less, the WTG design will remain a mix of various solutions. No one size fits all. Note that in the offshore industry, this usually implies an introduction period of many years. Introducing TP-less designs also took +/-20 years to mature. At the same time, it should be possible to make the alternative concepts work in an acceptable reliable manner ('*we also can get people to the moon*'). This remains one of the main challenges for an innovative alternative secondary means of access: How to get it to always work? In the (very) long term, drones will play a larger and larger role; the market is developing rapidly for both cargo and people. Human comfort specifically, is likely to become increasingly important going forward. Some say it is not taken into account sufficiently yet: The technician's perspective should be the starting point, not cost. Being able to work in the best possible conditions. Human capital was, is and will become more scarce in the future. Labor conditions related legislation will only become stricter. Technicians used to climb >50m inside WTGs, this also is no longer acceptable. The offshore wind industry should be careful with its people.

6 DISCUSSION

During the course of the research, but specifically when talking to the interviewees, a number of topics were identified that are of interest to the overall discussion but did not entirely fit in one of the qualitative criteria 'boxes'. In this chapter, two of these topics are discussed in more detail.

6.1 Decision making process when going for BL-less

The decision for boat landing-less is driven by many factors and there is not one 'global' solution. Cost is a main driver (after safety and legislation), but it is very project specific and complex to fully predict. Balancing CAPEX & OPEX as well as predicting revenue for omitting a boat landing are depending on many factors such as: Monopile design & fabrication, local site conditions, O&M strategy (vessels), relation to existing projects and distance to shore.

The question asked was: '*Who makes this choice?*'. What party but also which department and what persons are included in this decision-making process? Especially since offshore wind is a conservative industry, choosing something 'new' can be a challenge since there always is a relatively large chance that someone in the decision-making tree chooses for something they know (and understand the risks) instead of something new (even if potentially better).

The decision whether or not to include a boat landing lays ultimately, similar to other design decisions, with the developer. This decision is made based on all earlier mentioned criteria with CAPEX (a saving compared to BL design) and safety considerations often being dominant and is mainly project specific with input from important stakeholders such as the WTG OEM and T&I contractor. The WTG OEM has a large role, also because first +/-5 years O&M is usually performed by the WTG OEM. Input from the T&I contractor is important, but it must be noted that the O&M phase of the wind farm is much more significant (30-35 years access) compared to the relatively short time the T&I contractor requires access (T&I works temporary by nature). At the developer, the final foundation concept selection is based on all previous points (criteria), and therefore, the product development / technical (foundation) departments in principle are in the lead. However, the (foundation) design team needs to work in close collaboration with the O&M department.

The option for omitting the boat landing is quite often included in the option list during development but until now almost always dismissed. Exception to this was Ørsted with the Hornsea 2 project (followed by its US projects), where a SOV combined with a GUS system was introduced. A key differentiator for Orsted, is that they can rely on a large in-house (foundation) engineering team.

6.2 Standardization & holistic approach

As mentioned before, the planned roll-out for offshore wind in the EU alone will already significantly challenge its domestic supply chain. Combined with the need to drive down cost, overall industry standardisation and a more holistic approach is advocated by multiple players in the industry.

> *'Treat the EU 2050 300GW offshore wind ambition as a single goal instead of a combination of a large number of individual projects'*

A simplification of the concept of a wind farm could help in concept and design optimizations. With the ever-increasing size of WTGs, in short, too soon, too new (WTG) prototypes keep entering the market, often resulting in project disruptions and/or delays. The offshore wind industry specifically, a highly repetitive industry with a strong focus on efficient logistics, could benefit from a high degree of standardisation. Given this specific logistical challenge, another focus should be on scaling: Determining what scales properly (in terms of safety and efficiency). The market is looking for and is open to having these discussions, but for now, generally speaking, decisions will remain highly project, site and supply chain specific. Standardisation also poses its own challenges. It is not always beneficial for engineering companies, but mostly very beneficial for both fabricators and T&I contractors. When the industry manages to successfully introduce a (North Sea) standard, standardisations can be applied throughout the entire value chain (re-use of installation tooling, seafastening, ...). And one step further, with a well-defined WTG interface, it will ultimately be possible to design the entire Balance of Plant (foundation, cables and substation) with a design lifetime in excess of 80 yrs.

> *'Offshore wind; a military logistical operation.'*

Simplification of the foundation (fabrication) process (by omitting the boat landing and therefore removing the need for placing cumbersome brackets on the MP) can/should be seen as part of this philosophy. A boat landing is mostly only logical when the market is approached on a project-by-project basis (as it is now), rather than a more holistic approach as advocated above. A high degree of standardization (such as a maximum WTG tip height) potentially enables, amongst others, timely and in a profitable manner, the required investments in infrastructure (ports, vessels), enables lifetime extensions (with a minimal increase in steel), reduces risk and helps unlock continues fabrication of all required wind farm components.

Within O&M, focus should be on getting the right person as safely and fast as possible on the right location with the right equipment. There are many different visions on WTG access in the market, leading to different access alternatives between wind farms, which ultimately complicate the transfer for someone accessing the WTG. Making a transfer should not be something you have doubts on. Doubts introduce risk. You should be able to transfer blindfolded using a coherent, well-known and trusted access method. A point of attention is the height of the MAP, which can be(come) problematic, adding steel and complexity on the vessel side. However, considering the scalability point of view, it is the WTG design that should be kept as simple as possible. Therefore, some added complexity on vessel side may be acceptable. Standardizing of SOV landing points and swing gates is also a must: Implementing standardised safe design as well as standardized procedures.

When moving towards SOV type of vessels, a must have boundary condition to drive down cost is fixed, longer term maintenance contracts. Current project-based contracting can prevent fully exploiting potential cross project synergies. The same goes for the T&I contractor, where framework agreements for multiple projects can allow for more economical development of specific tooling.

POSTSCRIPT: GUS SYSTEM (PICT OFFSHORE CONTRIBUTION)

At the time of writing, Get Up Safe (GUS) systems are in use on two commercial offshore wind projects; Hornsea 2 in the UK and Southfork Wind in the USA, and boat landings and access ladders have been entirely removed from the foundations across all WTG, numbering 165 at Hornsea 2 and 12 at Southfork. Consequently, during transfer of personnel from CTV, vessels push onto the monopile directly underneath the GUS system, with lifting/ lowering taking place from a point on the deck roughly 3.5 metres back from the push-on point. Taking the transfer zone away from the hazardous interface between the CTV and the foundation is a large part of what makes transfers via GUS systems safer than step-across ladder transfers, with the active heave function ensuring that even fast, sudden vessel deck movements are instantly accommodated.

Between January 2022 and now (April 2024), GUS systems at Hornsea 2 performed roughly 10,000 personnel transfers with no incidents of any kind. Technicians working there particularly appreciate its use for egress back to the CTV in heavy sea state conditions. The installed base of foundations without boat landings and with GUS systems will expand dramatically as Orsted's Revolution (65 WTG) and Sunrise (84 WTG) begin their offshore construction programmes.

Of course, things were not always straightforward. The GUS systems in-use at Hornsea 2 were the first ever to be deployed at scale and there was a steep learning curve. As was expected by Pict and by Orsted, the product can be further matured. One only discovers all unknowns when going offshore in a serial production run. Various aspects of the design have meanwhile been improved, to enhance serviceability, usability, and robustness in the upcoming GUS-equipped windfarms. For example, an adjustment to the design of the pull-down umbilical power connector - that allows the GUS system to be powered from CTV – will further mitigate the likelihood of damage because of wind loading.

At the end of Q1 2024, GUS system availability at Hornsea 2 is running above 96%, but we expect this will rise. Systems are connected into the SCADA network, allowing a range of diagnostic information to be accessed remotely, as well as sea state information underneath each position, as a by-product of the deck tracking sensors picking up wave heights, when the GUS is not in use. Ever since the Company was founded in 2019, we have been in discussion with a wide range of developers and other stakeholders about the GUS system and the advantages of using it to replace boat landings. We therefore have good insight into this topic and confirm that this report accurately represents the opinions we have heard.

However, with four commercial scale windfarms having made the leap to boat-landing-less design, there is a real basis against which the pros and cons may be considered, and a growing body of evidence from the field. Some of the concerns expressed by interviewees for this report can be dispelled while others are still work in progress. With GUS systems in operation at Hornsea 2 since early-2022 and at Southfork Wind since mid-2023, we would make the following comments:

1. Offshore technicians do not miss climbing ladders much. After some initial skepticism, technicians at Hornsea 2 largely prefer using the GUS system for transfers from CTV. The view that technicians will not take to alternative methods of transfer can be dismissed. The benefits in terms of reduction of physical exertion and musculo-skeletal health risks are self-evident and this is enhanced as boat landing ladder climbs become longer.
2. Safety can never be taken for granted. But, on the basis of 10,000 safe transfers at Hornsea 2 and no safety incidents, the benefits are increasingly tangible. This is particularly evident in the all-too common scenario, when the weather has come in faster than predicted, requiring technicians to egress back to the CTV in heavy sea state conditions. Heave compensation can really come into its own to get the team back down safely.
3. Availability is probably the number one concern that we hear. Boat landings may be a deeply flawed and imperfect personnel transfer solution, but their lack of complexity ensures that they can (almost) always be used. Keeping turbines turning and power flowing is what windfarms are all about. To ensure WTG availability, highly reliable and/ or redundant forms of access are needed. As noted, GUS system reliability at Hornsea 2 is good for a first-generation system and will continue to improve. Given the other benefits that the GUS system can deliver and the back-up access measures that can now be applied to further mitigate commercial risk, there is a growing appetite to look again at the issue. However, uncertainty around these points, risk aversion and the need to get agreement from multiple internal and external stakeholders - including WTG OEM's who are contracted to ensure availability during warranty - can act as a brake on the move away from boat landings.
4. For new systems such as the GUS, with a limited track record, the reassurance of a back-up access system is a likely requirement for deployment. Sites with SOV walk-to-work or helicopter winch access baked into their strategy already have some redundancy. But for CTV only sites to commit to replace boat landings with new lifting systems, another form of back-up access will likely be needed. As noted in this Report, Pict has worked with Orsted and Skylotec on the development of a back-up; a low-cost, Rope Transfer System (RTS) to allow technicians to safely access a foundation platform from CTV even if there is no boat landing and if the GUS system is unavailable. We hope this will encourage projects that the perceived risks of moving away from boat landings can be mitigated. More information about this can be provided on request.

In conclusion, we think that it's positive to have a report such as this, to provide an independent review of current industry opinion around boat landing removal. We hope that an open discussion of the issues and points of concern can help move the debate forward faster.