IMCA Lifting Technology in Offshore Renewables

Lifting & Rigging Seminar

27 October 2022

The International Marine Contractors Association (IMCA) is the international trade association representing offshore marine contractors, service companies, and the industry's supply chain.

IMCA's mission is to improve performance in the marine contracting industry. Our value proposition is to influence our industry in key technical, contractual, policy and regulatory matters that are in the collective best interest of the marine contracting industry.

For over 25 years, IMCA has maintained an important body of knowledge to assist our industry in the form of published guidance documents promoting good practice across a wide range of technical and professional disciplines. Documents have a self-explanatory title and are catalogued using a code containing letters and numbers. The letters indicate the discipline, and the number is simply sequential within that discipline.

Members are expected to adopt the contents of the IMCA technical library as a minimum standard in accordance with our document designation and grading system, see www.imca-int.com/publications

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Lifting & Rigging Seminar **– Version History**

Date	Reason	Revision
22 November 22	First draft	0

Foreword

IMCA's Lifting & Rigging Seminar is put together by a workgroup, comprising people involved in IMCA's Lifting and Rigging Committee work. They are IMCA members and have vast experience and in-depth knowledge of offshore lifting activities within our industry.

These events are primarily a discussion forum for members and non-members alike covering key technical and operational topics. Bringing a mix of presentations and workshops allows attendees to focus on the specific topics during the day, identifying the actual state of the industry and its future requirements.

Output from this seminar, the twelfth in the annual series, helps guide the IMCA Lifting and Rigging Management Committee in defining its future work scope on codes and guidance. The output from past seminars has influenced and shaped key areas of our industry and this one is set to perform just as useful a task.

This year's theme focused on the technical side of offshore lifting and on the challenges created in the renewable energy market.

Thank you to our sponsors

1 Session 1 – Background

1.1 Introduction & Welcome – Allen Leatt, IMCA and Laura Lombardi (Chair)

Allen Leatt, IMCA's Chief Executive Officer opened the 12th Lifting and Rigging Seminar and said that the focus for this year's seminar was on lifting technology and lifting in offshore wind. Allen mentioned that there were challenges in offshore wind of a technical nature and was looking forward to seeing some of the potential solutions on offer. He said that IMCA would work with all stakeholders in the industry to ensure that it becomes a sustainable and successful industry for all of us.

Allen stated that what was certain was that lifting and rigging is central to everything we do in offshore construction. He said that today we have a great line up of speakers and then introduced the Chair of the event who is also the Chair of IMCA's Lifting and Rigging Committee (LRMC), Laura Lombardi of Usha Martin Italia.

Laura said that this seminar was part of a series of events that started in 2012 and up to 2017 were focused on high value offshore ropes. The seminars have proven to be a great platform for the subsea contractors to discuss their issues and concerns with the various suppliers of equipment, for the suppliers to share their own developments and to ensure academia was involved in preparing solutions for the future. Over the years we have had great discussions and seen significant changes in the approach taken to the care and maintenance of high value ropes within the industry. This included preparing for high performance fibre rope operations.
In 2018 we took the decision to "Return to the Offshore Cranes". Looking wider at the full lifting systems utilised offshore. The workshops within the 2018 seminar were used to identify the industry needs and hot topics related to offshore cranes. From this we identified training of personnel, offshore lift planning, digitalisation of offshore cranes and general crane technology requirements.

In 2019 we covered Training & personnel competencies.

In 2020 we were hit by COVID. However, IMCA still ran a webinar equivalent – covering Crane Systems and Offshore Lifting.

Combining the ongoing and developing challenges of offshore renewables we have focused this seminar on Lifting Technology and Lifting in Offshore Renewables, touching on many of the sub-topics identified back in 2018. These included:

- Crane technology
- Offshore Personnel Transfer
- Lifting in the offshore wind environment
- Simulators and digital twins in offshore lifting and
- Reducing the human interface in offshore lifting

Laura presented the programme for the event and emphasised that engagement at the event was necessary to ensure that any concerns and solutions were captured.

Laura thanked the sponsors of the event and introduced the first Slido test session asking the following questions:

1. Say "hello" in your own language
2. Where are you from?

Figure 1 - It was nice to see such an international attendance including Europe, USA, Columbia, and South Africa.

3. What is your interest in offshore lifting?

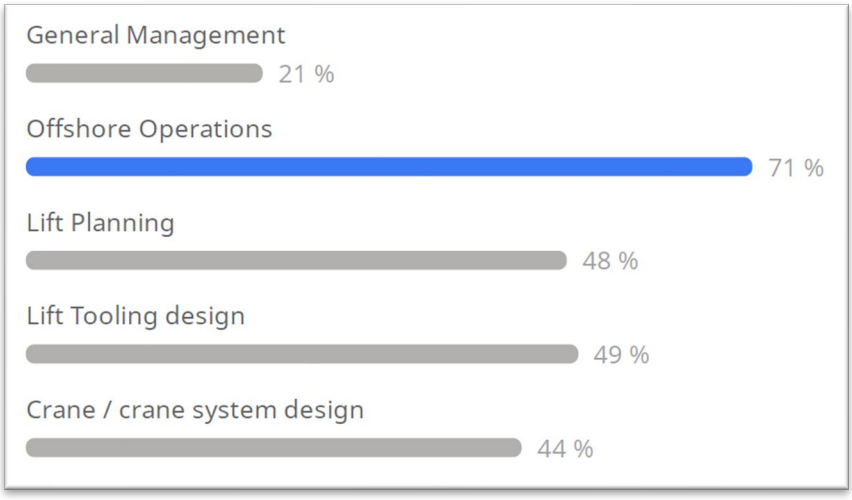

Figure 2 - All key subjects but Offshore Operations came out as the clear area of interest

4. How many relevant years' experience do you have?

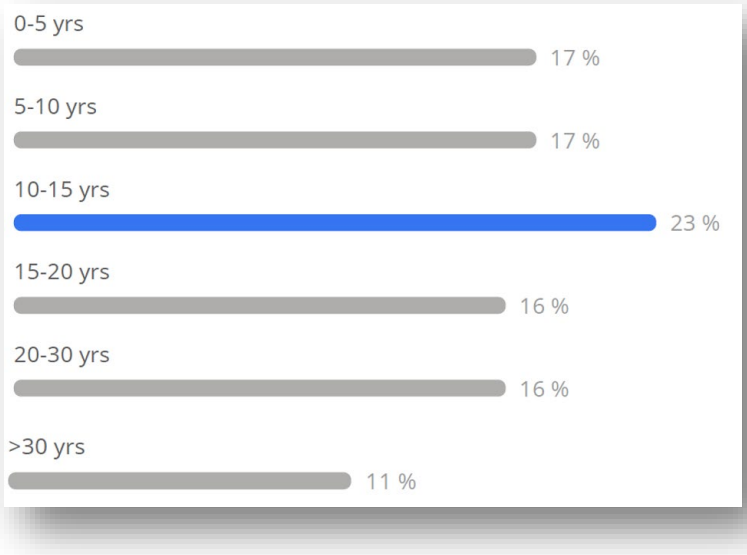

Figure 3 – 57% under 15 years' experience but overall, a good spread

Laura, thanked everyone for their participation in the Slido questions and introduced the next speaker, Mark Ford, Marine and Quality Manager of IMCA.

1.2 The Perils of the Mundane – Mark Ford, IMCA

Mark commenced by asking members of the IMCA's lifting and rigging committee to stand up so they could be identified by the audience. Mark said that some of the members of the committee were here to present but all could answer your questions today about IMCA's LRMC work programme. Some of the committee members also assisted in the workshop sessions.

A review of some of IMCA's key lifting documents were presented as follows:

IMCA LR 001 – This document includes guidance on the selection of wire ropes, storage, transport, maintenance, description of the causes of wire rope deterioration, thorough examination, inspection, testing, discard criteria and documentation for wire ropes used by vessels in the marine industry. It was mentioned that this was due for review in Q1 2023.

IMCA LR 002 - This document highlights the various aspects of crane design and performance in general terms only and intends to make the customer aware of the various options available for consideration. The intention was that the customer can approach the crane provider with a functional specification that contained the minimum of technical requirements. The crane provider can then respond describing how they intended to meet the functional requirements.

IMCA LR 004 - This document provides guidance on the use of non-destructive examination (NDE) by means of MRT for wire ropes, to assist with inspection and integrity management. It includes a section on rejection criteria.

IMCA LR 006 - This document describes the essential elements which should be included in company procedures for lifting operations and provides industry recommended practice on the steps within a lifting operation process that promote safety. This document has been reviewed and published in August 2022 and it has also been endorsed by the G+ for use in the offshore wind energy industry.

IMCA LR 008 – This Code of practice provides assistance to those concerned with the manufacture and use of cable-laid slings and grommets used in engineered lifts for offshore heavy lifting operations. It provides advice on the construction, rating, testing, certification, examination and use of these slings.

IMCA LR 009 - The purpose of this recommended practice is for the selection, safe use and inspection of fibre slings manufactured from high modulus synthetic fibres which are used for engineered lifts in an offshore environment, both in air and subsea. The document also contains inspection and discard criteria.

Mark then highlighted what can happen if guidance was not followed and things go wrong.

The focus then turned to the recent revision of IMCA's lifting recommend practice document LR 006 and the expert industry working group, identified below, were thanked for their valuable assistance and direction in the document.

Figure 4 – Working Group members for the revision of LR 006 – Guidelines for Lifting operations

Mark presented some of the changes that were made to the document during the revision process. It was welcome that the document had been endorsed by the G+ Health and Safety Organisation for use in the offshore wind energy industry.

A new section on complacency was introduced. Due to the repetitive nature of offshore lifts, all personnel involved with repetitive lifting operations, should ensure that complacency and a lowered awareness of risk was not allowed to develop. Every repetitive lift should be performed as if it were being carried out for the first time. For example, just before rigging attachment, the persons involved in the task should hold a toolbox talk to verify that all hazard mitigations had been implemented and that it was safe to proceed with the lift. Particular attention should be paid to Management of Change with the lift.

The biggest changes were stated to be in Appendix 4 – Lifting of offshore wind turbine components.

Safety considerations when lifting nacelles, blades, and towers - typical long load paths near other components and vessel structures (e.g., legs). Planning such a lift required particular attention to lines of sight for the crane operator as well as the lifting supervisor. In addition, collision checks need to be performed for the full load path of the lift not only for the load but also for the crane boom and its outfitting, tugger wires, tag lines, special lifting tools and any other structure in the vicinity of the lift path.

Spooling issues - Spooling issues can occur when a significant length of the wire rope has been spooled off the crane winch drum, then spooled back on with little or no tension. This situation can arise frequently when installing wind turbine components, although it can also happen during other types of lifting and subsea lifting operations.

When components or special tools (such as blade yokes) are lowered to the deck, raising the empty hook without load or tension can result in the crane wire on the winch drum becoming loose and the live line "ploughing" or "cutting in" to the lower wraps, which can damage the wire and cause jumping when spooling off again.

Wind speed - Wind speed and direction usually vary from sea-level to the working height. Typical components, e.g., blades, are relatively light and very susceptible to wind influence. During the lifting operation, real time wind data in addition to mean and gust values need to be available for the safety of the lift. Use of technology such as LiDAR[1] (Light Detection and Ranging) can be used to assist.

Dynamics - Lifting components at height usually involves high attachment points and significant changes in hoisting rope length during the lifting operation. The load may behave differently at different positions due to different natural frequencies at varying rope lengths. When planning a lift this should be considered.

The majority of special lifting tools have been developed for use by a jack-up installation vessel installing onto a fixed foundation. With the development of floating wind turbines and growth in the use of floating installation vessels, the increase in DAF and lateral motions must be assessed and addressed. Where the Lift Plan includes the use of these special tools, the operating and functional limits must be included to ensure they are not used beyond their design capabilities.

Mark summarised the event programme and stated that the workshop sessions were where we really needed audience engagement. He said that the expertise was in the room and feedback from the discussions would be collated and fed back to IMCA's LRMC to steer the future work programme.

[1] Doppler LiDAR systems are used to precisely measure air movements at higher elevations. The ground-based measurement devices shoot laser beams into the sky. These beams hit particles and aerosols in the air, a process that reflects the light. Measurement heights can be calculated from this duration period. The systems can determine wind speeds and direction with the help of the Doppler shift that causes the movement of the backscattering particles.

1.3 Lessons Learned – Maarten Loman, Van Oord

Maarten said that he had hoped to talk about the drop of the rotor star at Ormond where a three-blade rotor star was lost in the Irish Sea. However, after one year unfortunately the investigation was still ongoing, and Van Oord were awaiting the UK HSE to finalise their investigation before any lessons learnt could be shared.

Maarten mentioned that wire rope issues were being experienced and that due to the nature of the industry demands in lifting height and weight, their crane boom had to be exchanged twice in eight years.

Improvement topics presented included:

1.3.1 Implementation of controls and barriers.

- Snagged wires was something that had been experienced. Technology was stated to assist with that issue. Automated lift paths, the use of cameras were some of the solutions.
- Personnel flexibility and the shortage of skilled and competent personnel was a concern in a growing industry.
- Predictive maintenance to eliminate unplanned downtime. Working with the crane manufacturers was in progress.
- Client request/control – clients requesting more data – technology can assist with this.

1.3.2 What are the flavours in the offshore wind industry

Everything was growing in size and weight and having to exchange a crane on a vessel every four years just to keep up with the coming requirements was challenging.

Several markets were presented as follows;

- Cable laying – this does not involve much lifting, but it does involve a lot of wires
- WTG installation – lifting up to 150-200 meters with a vessel was a difficulty. Raising the block empty and lowering on a full load introduced issues such as knifing/ploughing. Operator experience assists with these issues.
- Foundation installation – everything was getting heavier. Floating installations were becoming more of a possibility in deeper water.
- O&M – Only minor lifts were being carried out – one or two per project. Speed of exchange of parts was required by the clients to continue to make money. This involved the use of old equipment, and 10–15-year-old method statements which were more than likely not relevant for today. It was stated that was one of the issues with the Ormond incident.
- Stakeholders – there are many stakeholders on a project which can make safety an issue as everyone has their own method – alignment was needed.

1.3.3 Main topics

WTG installation

- Lifting at height – need to jack-up further with only centimetres to spare before topping out.
- Large wind areas – components built to catch the wind. Wind needs to be measured, use of LiDAR is helpful.
- Lifting needs to be very precise – there is close proximity of personnel working at 150m height that are receiving the blades in the nacelle.

Foundation installation

- Heavy lifts > 95% crane utilisation – some projects require 100% crane utilisation. This needed to be discussed with your crane OEMs regarding the crane limitations.
- Large auxiliary equipment – highly complex pieces of equipment with a lot of sensors that provide much data. We need to ensure that we read that information and use it.
- Environmental restrictions on sea state and wind strength
- Repetitive work – installing over one hundred monopiles. The first one will feel new but what will it feel like for the last one. Easy installations were coming to an end in some cases. Challenging soil conditions can present issues with punch through. How was that incorporated into your lift plan and method statement.

1.3.4 Different markets, different benefits

Planning, Design and Construction (PDC) contracts

These were contracts to be proud of. The installation of new systems. Positives were that this provides you with the flexibility to improve on your working methods and reduce installation time. However, it was pointed out that if anything goes wrong in the engineering phase you could be stuck with it for the entire project which can be quite costly. Experience in the design was key, Maarten stated that he felt that experience was being lost and not much being gained within the industry. Congested deck areas and poor line of sight can also be a challenge.

1.3.5 Technology Advantages – What do we use

- Lift re-enactment – Using 3D models to digitally simulate the lift and find any potential issues.
- Cameras – assists with crane operator vision, congested deck areas
- Feedback sensors – sensors in general provide a lot of data that we can use. We need to measure as much as possible and file it correctly and put it to good use.
- Cycle time optimizers – all the operations need to be correctly sequenced and optimised.
- Safe by design studies – Design using virtual reality to ensure that a design is safe for personnel.

1.3.6 Technology Advantages – What do we need

- Sensors, sensors, sensors – Bandwidth can be a limitation but will change soon.
- Predictive maintenance – used for crane wires and lifting gear.
- Lifecycle research – where are the limits for crane use. OEM's working on this using data analysis.

- Digital maintenance – very useful in order to detect anomalies and provide machine learning
- Increase available bandwidth onboard – with the amount of information/data being used we can provide shoreside assistance during critical lifts. The bandwidth onboard needs to be stable to ensure that reliability is maintained.

1.4 LR's Code for Offshore Personnel Transfer Systems – Maro Hartmann, Lloyd's Register

Maro presented an overview of Lloyds Register's new Code for Offshore Personnel Transfer Systems (COPTS).

The focus was on the document goals and structure and the Classification and certification requirements.

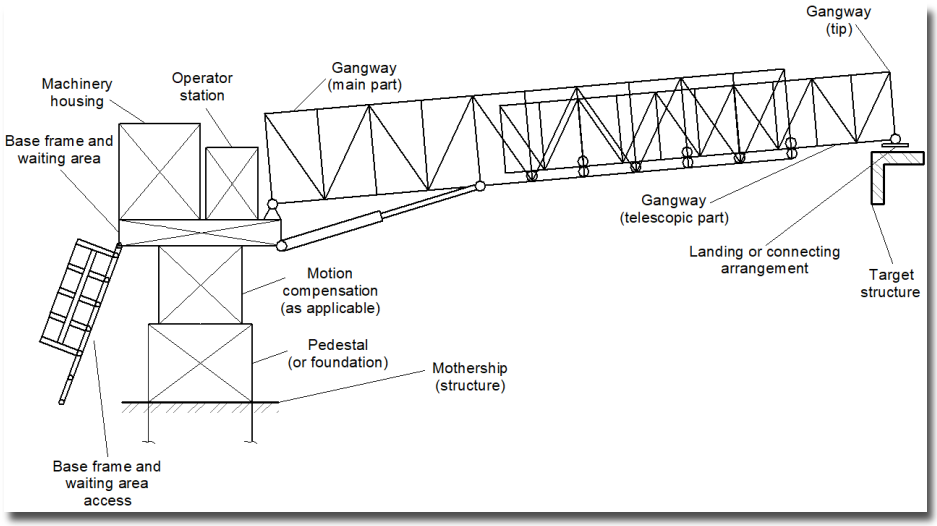

Figure 5 – Typical arrangement of an OPTS

The documents high level requirements were as follows:

- define the requirements:
    - which enable the design, manufacture and installation;
    - of safe offshore personnel transfer systems (OPTS); and

    - to minimise danger to personnel;
- to define the classification and certification framework.

The COPTS has two Chapters, where Chapter 1 defines the mandatory requirements for certification and classification. Chapter 2 was noted not to be mandatory, but it provides recommendations for the safe operation of OPTS.

Maro said that there were two class notations associated with classed OPTS:

1. A mandatory class notation: LA for cases where the OPTS is an essential feature of the vessel; and
2. An optional special feature class notation, W2W, where the OPTS is NOT an essential feature of the vessel.

It was mentioned that there were a large variety of types, features, and components of OPTS and Lloyds structured this by differentiating between:

- Systems Types
- Access Types
- Special features, such as cargo handling or winterization

and further highlighting the various components contributing to an OPTS, such as:

- Structural/Functional Systems
- Machinery components
- Electrical and Control Arrangements

An overview of the general loads an OPTS will see was presented and included personnel SWL and emergency loading.

The functional requirements were noted to cover aspects, such as:

- access and access control arrangements
- redundancy of components (e.g., the concept of risk coefficients).

The section covering electrotechnical systems was presented with the overall goal again being to minimise danger to personnel (operator and transferring).

- The relevant requirements of LR's Rules for Ship apply
- We require that an FMECA is carried for these systems
- Sensors, switches are required to be fail safe (See Pt 6, Ch 1, of the ship Rules)

Alarms and warnings were of particular importance as these systems come into contact with personnel.

Alarms were said to initiate in cases such as:

- Reaching geometrical limits and gangway angle limits (90% of maximum)
- DP system failure
- Overload detection

- Insufficient or loss of power
- Failure of control, safety or secondary power systems

The alarm system was to be designed to function independently of control and safety systems.

After priority 3 alerts (alarm) the OPTS was said that it must automatically progress to a pre-defined safe state.

Section 13 of the Code covered testing, Marking and Surveys. Maro presented the load testing criteria.

To close Maro said that the content shown in this presentation was a (not necessarily representative) selection focussing on some aspects of Lloyd's Register's Code for Offshore Personnel Transfer Systems (COPTS) (July 2022) considered relevant to this audience. The full code can be downloaded from the following location: https://www.lr.org/en/code-for-offshore-personnel-transfer-systems/

2 Session 2 - Offshore Contractors Experience

2.1 Reducing Manual Rigging Handling in Wind Turbine Generator Foundation Installation – Arnoud Bosch, Seaway 7

Arnoud commenced his presentation with a quote from HRH Edward, Prince of Wales that was made during his opening speech at the British Industries Fair in 1927.

'*The young business and professional men of this country must get together round the table, adopt methods that have proved so sound in the past, adapt them to the changing needs of the time, and wherever possible, improve them*'

ADOPT, ADAPT & IMPROVE.

Arnoud presented on a decade's experience installing jacket and monopile foundations. Seaway 7's internal lifting tool for jacket installation which is remotely operated and can be used for load out as well as installation of jackets offshore.

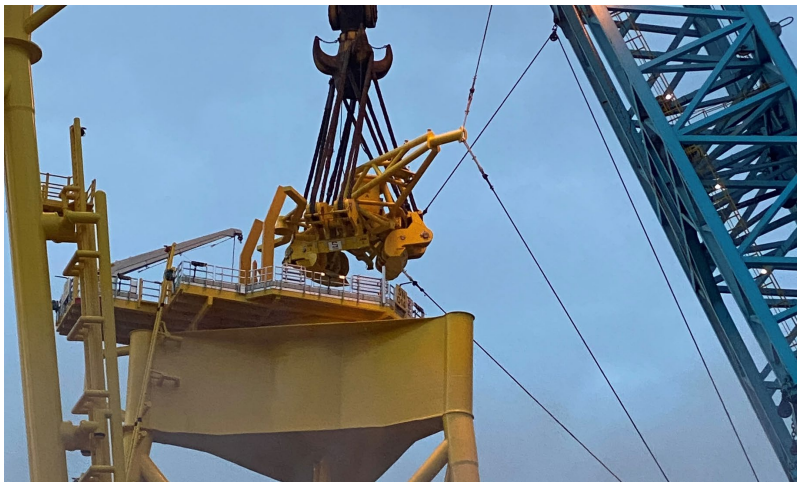

Figure 6 – Internal lifting tool

The challenges of deck layout for monopile foundation installations were shown, such as the vertical control and stability of monopile during pile driving. The use of a motion compensated gripper was shown which compensates for the vessel movements and keeps the monopile vertical. The use of virtual reality was utilised to support the offshore operations.

Figure 7 – Motion compensated on DP

Technology such as a 'Balltec' tool was presented. This tool is used to upend and position the monopile and to install the hydraulic hammer all using the same rigging configuration. This reduced human intervention in rigging operations. ADOPT, ADAPT & IMPROVE.

An overview of the new Seaway 7 vessel 'Alfa Lift' was shown, built to automate monopile installation, reduce human intervention in monopile handling therefore maximising safety and efficiency.

The challenges of things to come was well illustrated in Figure 8 and showed the Seaway 7 journey in monopile installation and the sheer size and weight of the near future XXL monopiles.

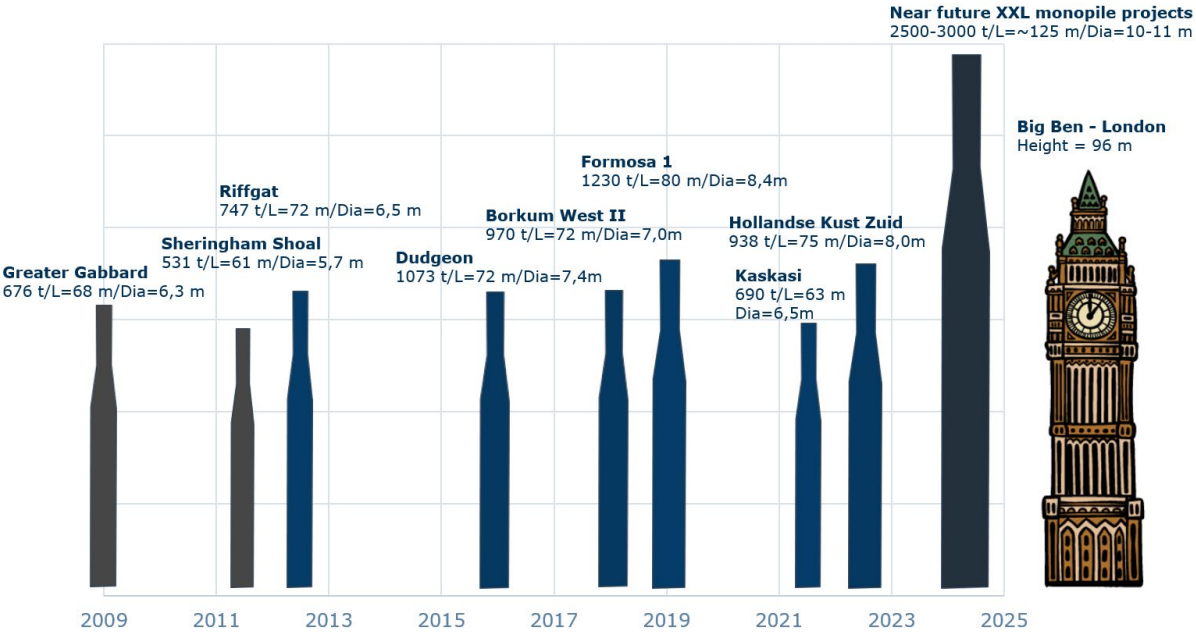

Figure 8 – Challenges of XXL monopile projects

2.2 Workshop

The first interactive workshop using Slido gauged the audience's opinion regarding their top three technical and operational issues. The table below clearly shows that the increasing size of components is challenging, closely followed by lift planning/competent lift planners and finally the increase in lift heights. Lift tooling designs and testing was also high on the table.

Issue	Percentage
Increasing component size	46%
Lift planning and forecasting	42%
Increasing lift heights	38%
Lift tooling designs / testing	32%
Competent lift planners / operators	30%
Vessel Supply / Demand	24%
Floating to floating	23%
Floating wind maintenance	11%
Mooring installation	10%
Lifting tools for maintenance	10%
Decommissioning	10%
Modularisation for lifts	7%

Figure 9 - Top technical and operational issues

IMCA's lifting and rigging committee will look at these issues to identify how they can be integrated into their work programme.

2.3 Outlook on OFW Lifting Requirements Effect on Existing and Newbuild Equipment and Systems – Jack Spaan, Boskalis

Jack commenced his presentation by providing an overview of incidents with offshore cranes that had occurred over the past three years. These incidents involved crane collapse, jack-up crane incidents, boom wire / rigging failures and hook failures. He followed this by presenting incidents on jack-up capsize caused by punch through and tropical storms.

Jack then presented on the renewable market developments and the number of offshore wind turbine generators (WTG) and offshore substations foundations. The data stemmed from the National Renewable Energy laboratory (NREL) of the US Department of Energy. The forecast was that annually 1,600 units need to be built, half of which were in 30 m water depth and the majority would be monopile based. Jack stated that the size of windfarms (in GW) was significantly increasing due to:

(1) increase in turbine sizes and

(2) larger lease/auction areas. In 2025 majority of offshore wind farms will be over 0.5GW.

• Growth regions were expanding to USA, Japan and South Korea; excluding China.

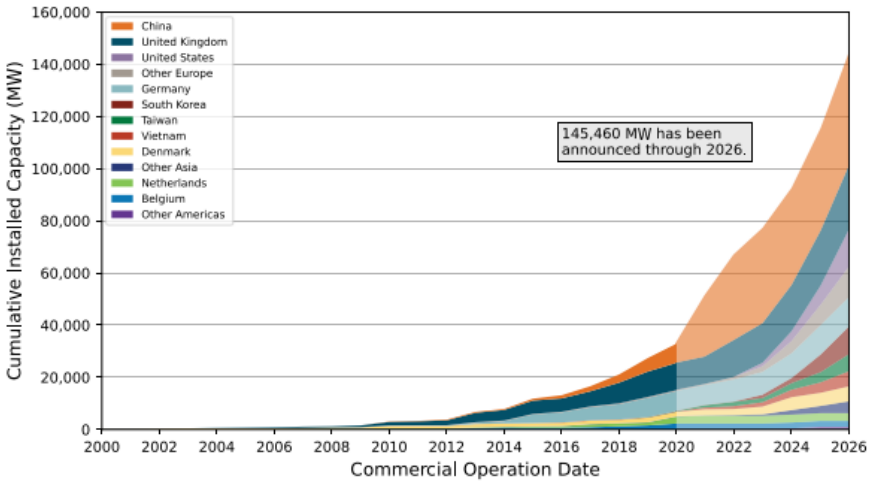

Figure 10 – NREL data 2021

Jack mentioned that the capacity of WTG was increasing from 8-12 MW from today till 2025, increasing further with the next generation units to 12-15+ MW. He said that the new XXL monopiles were over 100m in length, 13m diameter at a weight of 3,500t. Any jackets manufactured and installed were similar to the oil and gas structures as previously experienced.

Jack concluded his presentation by stating that the industry can expect an increased workload in the coming years with larger and heavier components. However, he stressed that accidents remain in offshore lifting and rigging. Performance improvements were required even with the larger components stretching current experience. There will also be a stretch on vessel capacity with respect to lifting capacity, high utilisation factors on the cranes, which will affect the economical lifespan of the equipment.

Jack said that engineers need to adhere to the codes and that installation techniques need to be fit for purpose. Vessel owners can expect an increase in equipment fatigue with 150 lifts per 2000t per year. Wire maintenance also needs to be an area of focus as increased wear was anticipated. Finally, the vessel crew needed to specifically trained by a simulator for new work using virtual reality. For companies, a feedback loop needs to be established to ensure that crew can report back in from the vessel.

2.4 Update from Contractor – Søren Møllgaard, Cadeler

Søren commence by presenting an introduction on Cadeler and their vessels. He mentioned that with the growing demand of installing large turbines they intend to enhance their fleet of vessels. He said that the 'F' class vessel can transport up to six XXL monopile foundations which will improve operational efficiency.

The project structure was presented. Utilisation of equipment was mentioned and optimising the lifting sequences. Communication lines were important and vessel to shore communication was key. Søren said that projects were mirrored from one project to the next with only slight adjustments to continually improve and that toolbox talks were very important.

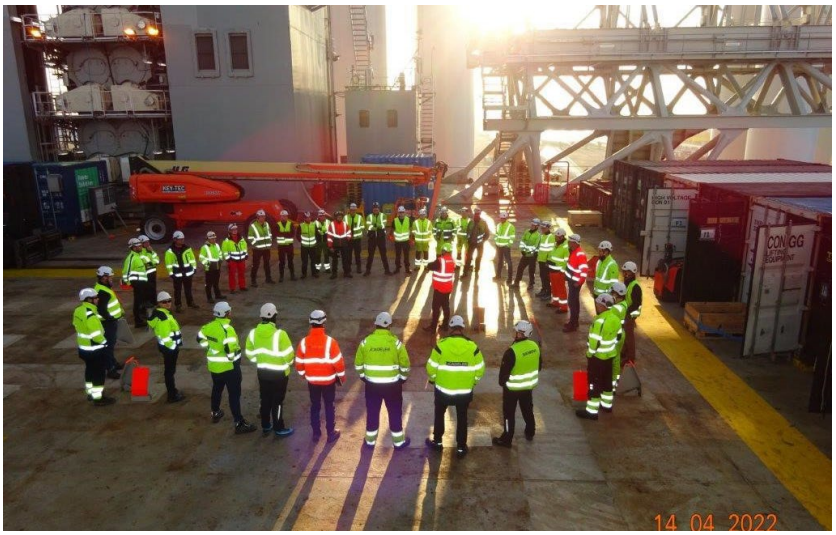

Figure 11 – Toolbox talk prior to work

Søren stressed that even though the turbine technicians were well experienced, when faced with a new project, invariably they were also faced with a new model/design and needed to refer to the installation manuals for guidance and information.

2.5 Blade Lifting/Installation – Vincent Shaw, Heerema

Vincent introduced floating WTG installations and why should we do this. He said that with increasing water depths, increasing WTG sizes and soft seabed conditions, floating was the future. There was no connection to the seabed and the installation speed was quicker with offshore feeder vessels utilised. However, monopiles presented challenges with deep water, harsh environments, large distance to shore, poor port infrastructure and Jones Act regulation challenges.

Blade installation was a challenge for floating wind and Vincent presented Heerema's solution to this challenge which was to lift a full Rotor Nacelle Assembly (RNA) in one lift.

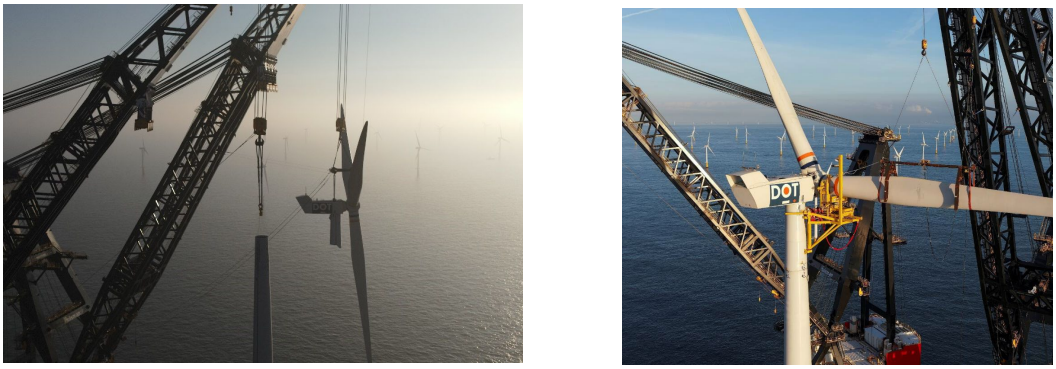

Figure 12 – Rotor Nacelle Assembly and Guided Root End Positioning tool

Blades were assembled on the vessel using a support tower and a Guided Root End Positioning (GREP) tool.

Figure 13 - GREP

He mentioned that at Heerema's simulation centre, a digital twin was established, and the lifting was carried out virtually prior to be being carried out on site.

The GREP was designed to stab the bolts of the blade with full XYZ motion control.
Vincent said that there were engineering challenges. A dedicated tugger system was installed on a crane for blade handling and the blade was lifted using the sling hoist.

Figure 14 – Tugger system

The next step in Heerema's project was to install 27 WTG using this method in the Baltic Sea using a scaled-up GREP which had been designed, fabricated and tested.

Vincent mentioned that this method was planned to be used for floating installations where soil conditions were not favourable for monopile installation.

2.6 Workshop Issues and Technology Needs using flip charts and groups

The following questions were asked:

1. What are the offshore renewables lifting challenges
    - E.g. component size, height of lift, dynamics

Feedback from the groups were as follows:

Complacency
Environmental challenges
Water depth – deeper water
Deck space – lack of
Control of loads at deck level – light and heavy items
Skills/competence gaps, training, shortage
Fatigue of equipment (cranes)
Growing vessel size - port interfaces
Crane capacity keeps growing
Strategy and cost of new installations
Topology - Soil, environment, location
Guidance on jack-up operations
Offshore feedering operations (Jones Act)
Vessel downtime due to high utilisation
Detailed feedback on crane utilisation to crane OEM's
Automation - less human intervention
Dynamics in a floating installation
Certification of lifting slings
Short lifecycle of lifting equipment
Vessel availability

2. What are the limits on vessel / crane capacity and operating modes
    - Can we categorise them?
    - What is needed going forward?

Feedback from the groups were as follows:

Limits on vessel and crane capacity and operating modes
Lifting height, weight, clearance
Design and lifecycle
Stability, deck space/strength, jacking capacity/leg strength
DP limitations - environment
Slew bearing capacity
Boom tip position accuracy
Rigging accessories
Is going bigger actually better?

3. Lift tooling systems for renewables
    - What is available?
    - What is missing?

Feedback from the groups were as follows:

AVAILABLE
Floating repair tools
Height - self erecting WT
GREP
Blade handling
Pile lifting
Nacelle lifting
Vibro hammers
Drilling piles
NEEDED
Tools for floating - motion compensation
Real time AI
More automated systems
Use of simulators
More standardisation with tools
Load testing of tools

4. Do we need to improve the competence and training of associated lift planners / lifting teams

Feedback from the groups were as follows:

No training standards
Shortage of experience
Sharing of training knowledge - lots of simulator training available - is this shared?
Training academy for lifting - IMCA?
Competence needs improving - lift planners & teams
Global accreditation system - CPD?? IMCA?
Better comms between onshore engineering and vessel team
In house training - knowledge management?

There was overwhelming feedback regarding training, competence, and suitably qualified and experienced personnel.

Each group said that training was either not adequate or just not available. It was suggested by a few of the breakout groups that IMCA develop a global accreditation system for lifting which includes lift planning. This suggestion will be taken back to the lifting and rigging management committee and IMCA's competence and training committee for assessment.

3 Session 3 - Supplier Sessions

3.1 Universal Quick Connector: Improving Safety and Efficiency in Heavy Lifting – Cees van Veluw, Huisman

Cees introduced Huisman and shared some images and statistics. It was noted that the theme was continuing regarding the growing length and weight of monopiles.

Cees looked at the advantages and disadvantages of using a jack up vessel or a floating vessel. It was presented that any installation from a jack up vessel is utilising a stable platform, however there was limited workability because of the jacking procedure and crane capacity is limited due to leg capacity. A floating vessel is suitable for heavy lifts with the new XXL monopiles and has increased workability. However, vessel motions present a challenge.

With the long monopiles there were challenges to meet the vertical requirements. An example was shown that at a water depth of 40m equates to a 0.17m maximum offset for 0.25 degrees verticality.

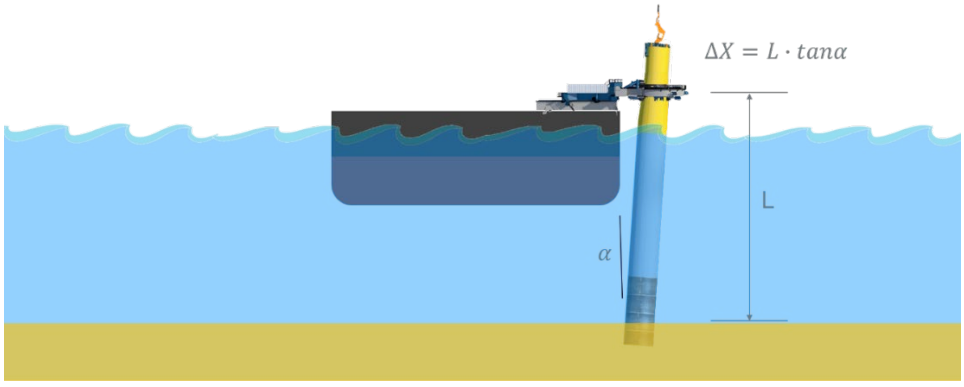

Figure 15 – Challenges with monopile verticality

Cees presented a motion compensated solution which kept the monopile in the vertical position irrespective of vessel motion.

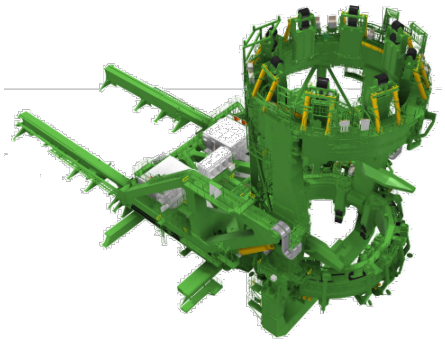

Figure 16 – Motion compensated pile gripper

Cees then presented Huisman's universal quick connector which allows the user to change the hook and tooling very easily. There is a selection of different tools that could be adapted to fit the quick connector as shown:

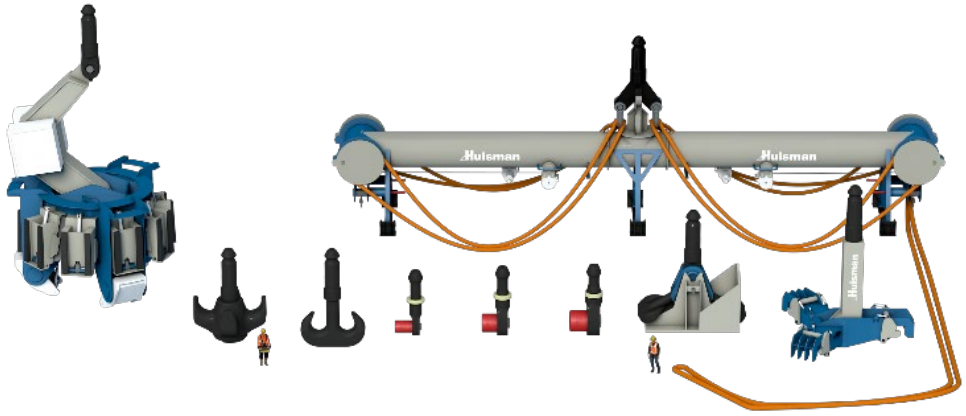

Figure 17 – Quick connector tools

Another tool presented was a monopile lifting spreader that can be landed on top of a horizontal monopile and has automatic sling connection by remote control.

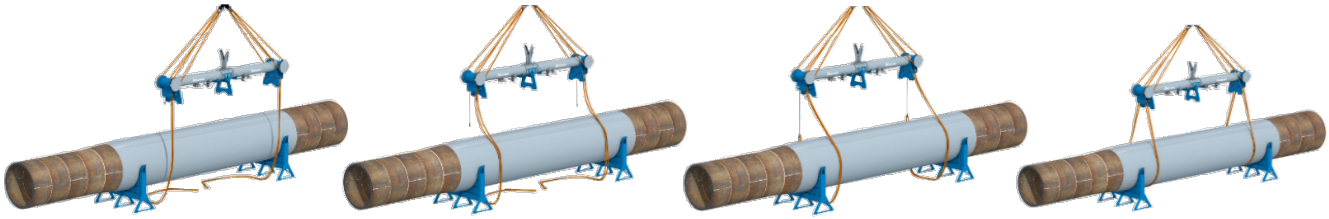

Figure 18 – Monopile lifting spreader

Cees also shared a concept for a floating windfarm installation vessel which fastens itself to the floating structure and allows a more stable assembly to take place.

Figure 19 – Floating WIV installing on a floating site with motion compensation

3.2 Lifting Meets Digitalization – Peter Wolf and Mark Jaxion, Siemens Gamesa

Peter provided an overview of the number of wind turbines installed by Siemens Gamesa and the number of lifts involved as follows:

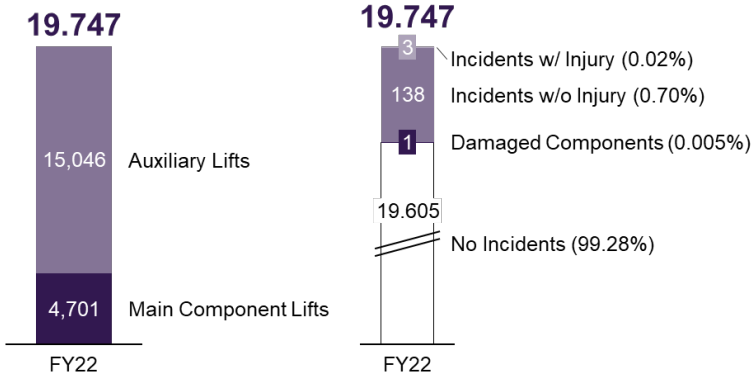

Figure 20 – Number of lifts Vs incidents

The forecast for the number of turbines to be installed was presented to be 223 for 2022 growing to ~1500 in 2030. A massive increase in turbines and the number of lifts follows at 19,747 in 2022 to ~110,000 in 2030.

Peter also presented how the lifts were fully optimised over time which is heading towards a near 100% utilisation factor for the crane.

The use of deck cameras and digitalisation allows each lift to be monitored to maximise the efficiency of the operation in addition to the safety of personnel.

3.3 Handling of XXL Monopiles – Alberto Pegurri, Remazel

Alberto commenced by looking at the challenges in handling XXL monopiles.

Alberto defined an XXL monopile as shown below:

Length	*> 90m*
Mass	*> 2000mT*
Dtop	*> 6m*
Dbottom	*> 10m*
D/t	*up to 160*

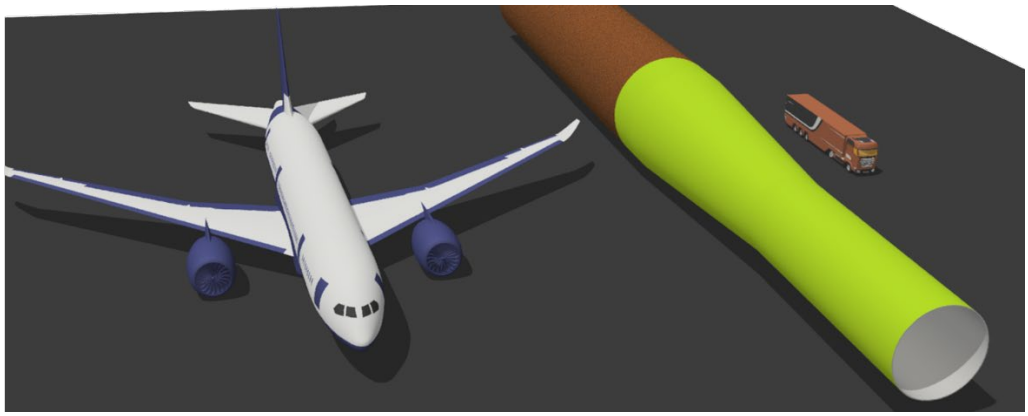

Figure 21 – Illustration of an XXL monopile

Alberto then looked at the challenges a floating vessel may encounter when installing these XXL monopiles in a dynamic environment.

He presented Remazel's solution to these challenges which included an upending hinge system skidding system for the pile positioning on deck and the sea fastening arrangements for transit.

He said that the main issues with the sea fastening were as follows:

- MP sea fastened transverse to vessel axis, so subject to high vessel roll (sway loads) which need to be sustained by friction
- High contact pressures affecting friction performances of most pads' compounds
- Different frictional behaviour on coated parts, including different coatings performances, and non-coated ones
- Friction coefficients may be affected by wet/dry and icy conditions
- Large diameters involve higher centre of gravity (CoG) elevation respect to saddle position with associated risks of overturning due to side accelerations

Remazel's upending hinge is illustrated below:

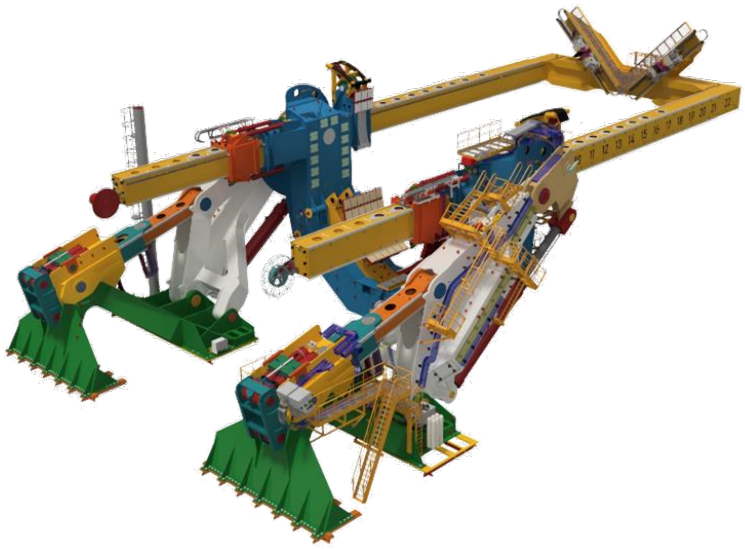

Figure 22 – Upending hinge

Alberto then presented Remazel's cradle and saddle solution using a design that accommodated different diameters of monopile from 6m to 12m. The system can also be incorporated into the skidding system.

To close, a brief look at the other installation tools was provided such as tools for internal and external platforms, anode cages and boat landing installation.

3.4 Offshore Lifting Tools in the New (Wind) World: Full Motion Control for In-Air Heavy Lifting – Gjalt Lindeboom, Seaqualize

Gjalt presented the next generation in offshore lifting equipment regarding in-hook active compensation.

He said that the push for offshore wind required new lifting methods due to the following challenges:

- A 5-to-10-fold year-on-year faster installation time
- Deeper waters were not suitable for jacking or fixed bottom installations
- Lifting heavier and more delicate components
- Jones-Act restricted areas for installation vessels
- The constant push for cost reduction

Gjalt said that heave compensation was something that would have to be used to lift from feeding vessels, back loading to vessels and installations for floating to floating (floating wind). Existing active heave compensations (AHC) systems were integral to the crane and were challenged with component weights and sizes, and the anticipated duty cycles. He said that floating lifts were not new (think Oil and Gas), however the frequency, time constraints and delicacy required new, better tooling. The requirement for offshore wind components were that they need to:

- Prevent damage to components
- Prevent damage to crane
- Minimize manual handling (See earlier)
- Reduce cycle times, while keeping highest level of safety
- Not wait for weather, also outside of the 'season'
- Be without modifications to the turbine components

Seaqualize presented their crane hook fixed AHC system that has been used for the US feedering vessel operations and were now looking at being able to lift ~2000mT compensated lifts. Gjalt also said that Sequalize were also developing their concept for XY motion compensation using smart controlled tugger line systems.

3.5 Panel Session – Suppliers Q&A

The Q&A session commenced for all the suppliers.

The first question was for **Remazel**:

Q – Have you experience any breakdown or cracking in the coating on the monopiles in way of the high hoop stress areas when lifting?

A – As far as experience Remazel have a limit on the pressure applied to the coating and stay well within the limits of the coating.

Question for **Siemens Gamesa**:

Q - Have Siemens considered wearable technology to alert the person of the danger?

A – Peter explained that the idea was to initially identify the areas of danger then in the future progress to alerting the person that they are potentially in a danger area.

Question for **Huisman**:

Q - How do you compensate for vessel motion when installing the fully assembled turbine?

A – Most of the turbine installation is carried out by Jack-up vessels, so at present there is no compensation used. However, for floating installations there is compensation in the crane in multiple directions.

Question for **Seaqualize**:

Q - How is ballasting time taken into account while lifting with a floating vessel?

A – The ballasting time is left to the vessel owner. They inform how much time is required for ballasting. The system is flexible in respect of being able to adjust the lifting times to ensure that the lift remains in the ballasting limits.

Questions for **Huisman:**

Q - Can your Universal Quick Connector also be retrofitted to existing cranes? And;

Do you do load testing of your quick connector?

A – Yes, the Quick Connector can be retro-fitted to existing crane and we have a few projects ongoing. One of the challenges is that the unit has certain dimensions so you have to make sure it can fit in between sheave block or it can consume lifting height.

A – Yes the Quick Connector is load tested.

Question for **Siemens Gamesa**:

Q - How is the data gathered being used to alter training or its frequency, "preventive maintenance" on safety awareness?

A – The intention is that in the future all the data will be used for training purposes.

Questions for **Seaqualize**:

Q - For how long can the system compensate with one battery charge? And; what limits do you foresee for active heave compensation in terms of max weight and max stroke?

A – The limits for AHC is 3.5m stroke and the battery lasts for approximately 12 hours.

The Chair thanked the suppliers for their presentations and for their time in the Q&A session.

4 Session 4 - Current & Future Challenges

4.1 Non-Contact Motion Compensation for Floating Installation of Offshore Wind Turbines – Peter Meijers, Technical University Delft (TUD)

Peter said that he was to speak on floating installations and the TUD work with Heerema (HMC) and Delft Offshore Turbine (DOT).

Peter mentioned the GREP on-deck assembly that had been presented earlier by HMC and then moved on to presenting the slip joint connection. This was a simple taper connection that uses the taper lock principle to fix the monopile to the tower.

Figure 23 – Slip-joint connection

Peter then looked at non-contact motion compensations using a magnetic field. Why non-contact?

- No need to attach tuggers/sensors on the pile
- Ease of control

With magnetic interaction there was the potential to pull and push the load. This was achieved by using an electromagnet that was controlled to react to the vessel and load motions and remain within a controllable distance from the load.

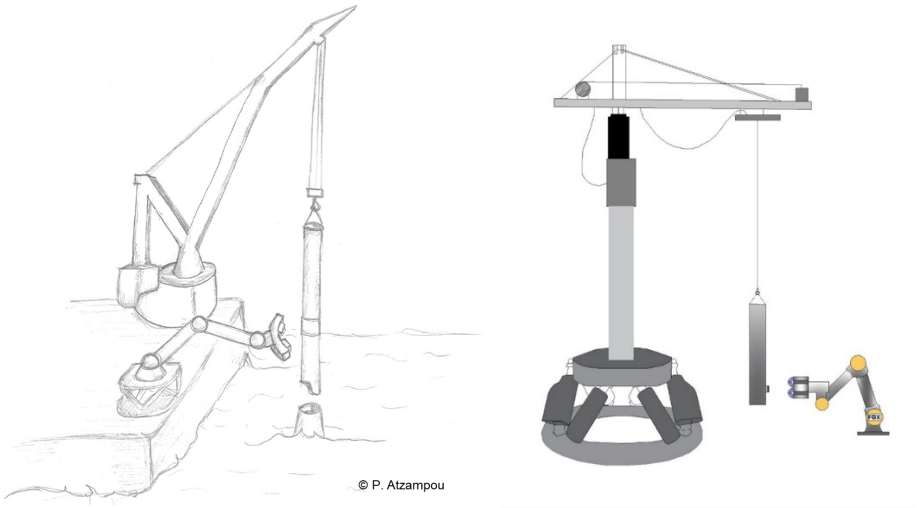

Figure 24 – Drawing of the concept.

Peter stated that TUD anticipated the following developments:

In one year:

- Scaled proof of concept with a robotic arm
- Scaled 3D prototype

In two years:

- Scaled 3D prototype with vessel motions
- Determine requirements for upscaling

5 Session 5 - Review of the Day

5.1 Review of the Day and Final Comments/Questions – Laura Lombardi, Chair

The Chair, Laura Lombardi presented a brief review of the day covering some comments and quotes of the day, as follows:

Comments	Quotes of the day
Everything is getting bigger, overturing moment, resonance with waves and pile integrity to be considered	XXL monopiles – Big Ben and Aircrafts…
Continuous stretch of capability, experience, vessel capacity	Adopt, adapt and improve
Availability and competence of the personnel is a concern	Continuous commitment for safety
Communication and feedback are the key	The first is new, what about the 99th? Complacency is a risk
We should adhere to the Codes	What can happen to them can happen to you, take the lesson
Accidents remain running in offshore lifting	

The Chair then thanked IMCA for hosting the event and thanked the speakers and the sponsors. Finally, all attendees were thanked for their participation and input into the event.

Laura reminder everyone that the next IMCA lifting and rigging seminar would take place in October 2023 in Amsterdam and hoped to see everyone again. With that the event was closed.

Stand-out quotes

"Availability and competence of the personnel is a concern"
"Crane capacity keeps growing"
"Automation - less human intervention"
"Lifting height, weight, clearance"

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