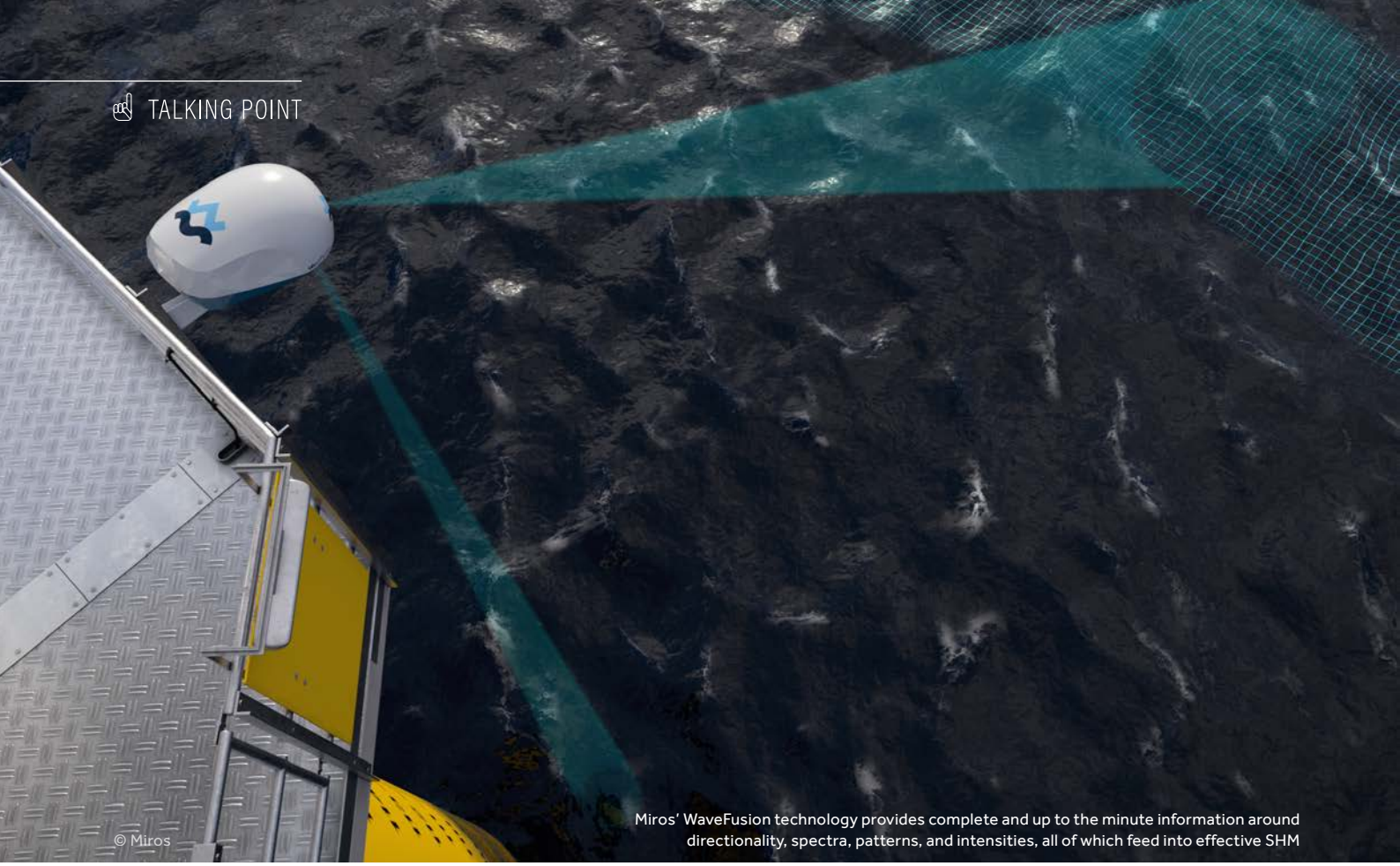

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Miros' WaveFusion technology provides complete and up to the minute information around directionality, spectra, patterns, and intensities, all of which feed into effective SHM

Safeguarding offshore wind structural health with round the clock monitoring

Words: Richard Chen, Technical Manager Offshore Wind
Lars Ivar Leivestad, Sales Manager Offshore Wind

Offshore wind farms are crucial to a sustainable energy future, harnessing powerful ocean winds to combat climate change. However, their success depends on overcoming the harsh marine environment. Continuous monitoring and advanced technologies are essential for maintaining efficiency, reducing costs, and ensuring these structures provide reliable, clean energy over the long term. Structural Health Monitoring (SHM) with advanced wave radar technology enables predictive maintenance and operational optimization. Miros' innovative solutions enhance safety, reliability, and sustainability in these challenging conditions.

Offshore wind farms stand as shrines to the global energy industry's hunt for sustainable solutions to climate change. Turbines are already a common sight on the horizon for people worldwide, and their criticality will only grow as we harness the immense power of wind over open waters.

Maintaining these structures, many of which are located in harsh and challenging environments, presents unique challenges that must be overcome to help the sector minimize downtime and boost efficiency.

Continuous monitoring of dynamic forces, such as waves, on turbines is essential to ensuring the longevity of these massive structures. This guarantees that developers can maximize the return on their substantial investments.

Why monitor offshore assets round the clock?

SHM enables early detection of potential issues, allowing for predictive maintenance and reducing costly repairs. This extends the lifespan of turbines and sustainably boosts their overall energy yield, contributing to a reliable and clean energy supply for consumers. Regardless of location, there is a chance for project owners to slash their operating costs, while at the same time boosting the output of their assets. Although this seems like a no brainer to the industry, it requires the right technology to collect the right information.

Wave radars are one of the many sensors used in SHM systems to assess structural integrity. Among the vast array of technologies currently available on the market, dry mounted directional wave radars are fast becoming the solution of choice for wind farm operators. They are indispensable tools, offering a comprehensive view of the ocean's behavior and its impact on marine structures.

Avoid critical fatigue and structural degradation

Unlike their onshore counterparts, offshore wind farms face additional challenges due to the harsher and more variable conditions of the marine environment. Therefore, precise and reliable 24/7 monitoring is crucial for operators to get to grips with their sites, to detect anomalies early, and to prevent devastating failures.

Offshore wind farms endure relentless assaults from the marine environment and operators need to understand the specific challenges that their site presents. Waves, currents, and wind constantly exert forces on the turbines and support structures in the field. Over 25 years, the typical minimum life span for an offshore wind farm, this inevitably takes its toll. If left unchecked this can lead to critical fatigue and structural degradation conditions, factors that can jeopardize the integrity of the entire turbine.

An optimum monitoring solution

Directional wave radars, like Miros' WaveFusion, present a complete solution to the challenge of round the clock monitoring of offshore environments. Unlike other sensors, which only measure the height and period of waves, Miros' state-of-the-art technology provides complete and up to the minute information around directionality, spectra, patterns, and intensities, all of which feed into effective SHM.

By its very nature real-time wave data enhance offshore wind farm operators' ability to plan and execute their maintenance operations. Access to detailed wave characteristics, with higher spatial resolution, and greater accuracy in complex offshore environments, where wave conditions can vary significantly from one location to another, is invaluable.

It means operators can predict the load and stresses that wind turbines will endure, thereby enabling them to put proactive, robust, and efficient design and maintenance strategies in place. Detailed insights allow for precise structural analysis, supporting engineers to anticipate dynamic load variations, and by continuously monitoring wave parameters operators can identify potential areas of concern before they escalate into critical issues.

Floating structures have to grapple with six degrees of freedom

In the relatively new field of floating wind energy, the ability to measure structural loads is essential, because floating turbines encounter unique challenges from the motion caused by wind and waves. Understanding and measuring these structural loads accurately is essential for designing robust, efficient, and safe floating wind turbine systems.

Floating turbines must withstand simultaneous and often unpredictable natural forces, which can vary in intensity and direction, causing complex dynamic loads on the structure.

Moreover, floating structures have to grapple with six degrees of freedom: turbines can move in six different ways. They can heave in a vertical motion, sway in a horizontal side to side motion, surge in a horizontal forward-backward motion, roll by tilting side to side, pitch by tilting forward-backward, and yaw with rotational motion around the vertical axis. Operators must be aware of the potential impacts of all these movements.

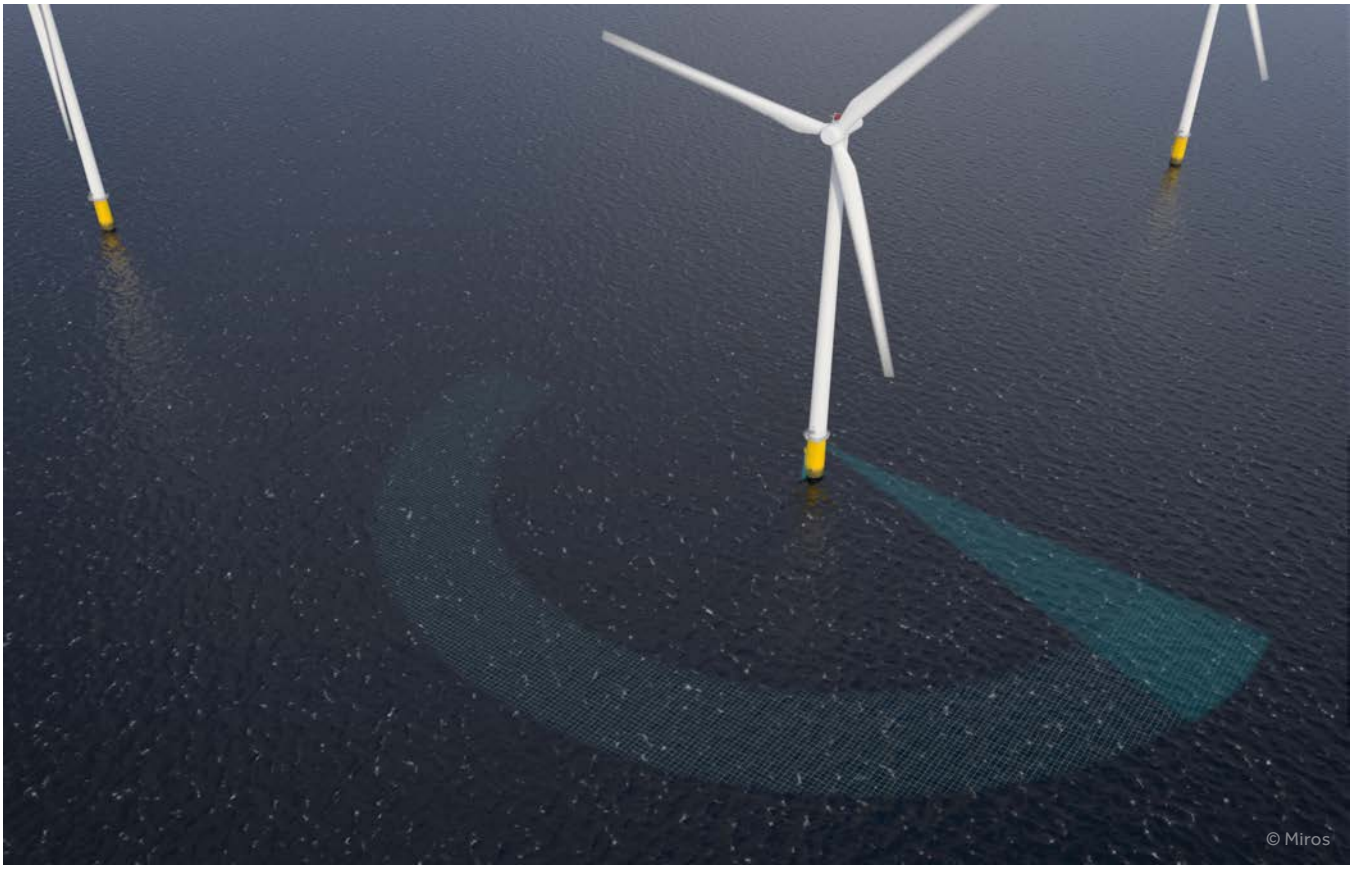
At the same time, mooring lines and anchors must be able to handle substantial and variable forces to keep the floating platform in place. These forces are influenced by the platform's motion and environmental conditions and can lead to significant stress being placed on the anchoring system.

Ensuring stability through both active control systems, like blade pitch adjustment, and passive systems, such as ballast, is also more complex due to the dynamic environment, while waves can cause vibrations throughout the structure, which can interact with the turbine's operational vibrations, potentially leading to harmful oscillations and structural damage.

Integration with digital twin technology

'It is crucial that developers understand the unique characteristics of their site and the impact it will have on the floating turbines they intend to install. Digital twins, which provide a virtual replica of physical assets, processes, and systems, are key to achieving this. This technology leverages data from

Continuous monitoring of dynamic forces, such as waves, on turbines is essential to ensuring the longevity of these massive structures. In turn, this guarantees that developers can maximize the return on their substantial investments



Dry mounted directional wave radars, like Miros' WaveFusion, are fast becoming the solution of choice for wind farm operators. They are indispensable tools, offering a comprehensive view of the ocean's behavior and its impact on marine structures

sensors and advanced analytics to optimize the design, installation, and maintenance of offshore assets,' explains Richard Chen, Technical Manager at Miros.

'As digital twin technology becomes a norm for new floating offshore wind farms, Miros' wave monitoring solutions, which are already IoT and cloud based, are designed to integrate with any existing environment. There is no digital twin without the existence of IoT and cloud computing after all.'

Once the first foundation is installed and a sensor is placed on it, then wave data from Miros' systems can easily be accessed and used by multiple stakeholders as part of the SHM system. From there, the sensor can support all the vessels working on the rest of the wind farm, and data can then feed into O&M activities.

By adopting Miros' dry mounted, cloud-enabled sensor technology, customers gain access to the full range of services on the Miros Cloud platform. This includes the Sea-State-as-a-Service subscription and seamless integration with other offshore wind monitoring and control systems. This integration enables a comprehensive, centralized approach to managing sea state data. Live and historical data can be shared across multiple stakeholders, a critical feature given the numerous groups essential to the delivery and maintenance of an offshore wind project.

A route to effective scheduling

Precise wave data allows operators to schedule maintenance more efficiently. By aligning their work with forecasted ocean conditions and real-time sea state measurements, companies can minimize downtime and costs.

At the same time, directional wave measurements provide crucial insights into potential weather related safety risks, like rough seas and storms. Alerts become apparent earlier, and operators can then take informed measures, based on real-time information, around their maintenance strategies, thus protecting the safety of personnel and assets.

Intrinsically linked to this is compliance and regulations, and by continuously monitoring sea conditions, directional wave radars help ensure wind farms stay within the safety and environmental limits set by those overseeing the market.

Leveraging the aaS model to future-proof operations

Moreover, working with a supscription model provides users significant value by ensuring constant access to the latest technology and alleviating operational risks. Unlike traditional hardware purchases, where clients must handle maintenance, data quality, and operational risks, an aaS subscription shifts these responsibilities to the supplier. Customers profit from beneficial warranties, guaranteed uptime, proactive support, and the flexibility to scale. This model allows businesses to focus on their core activities without the burden of managing technology, ensuring they always operate with the most current and reliable systems.

Furthermore, a subscription model supports seamless data accessibility and sharing, essential for modern digital operations. Miros' Sea-State-as-a-Service solution, for example, uses Microsoft Azure to ensure data security and availability, allowing for easy and secure data sharing within the company and with external stakeholders. This approach not only improves operational efficiency but also enhances collaboration and continuous innovation. By leveraging the aaS model, businesses can future proof their operations, reduce costs and risks, and stay competitive with cutting edge technology and support.

Advocate foresighted and proactive operations offshore

As countries around the world set about decarbonizing their energy systems through renewables, offshore wind power is only going to become more prominent. Advances in sensor technology and data analysis are driving the adoption of wave radar technology, with artificial intelligence enhancing predictive maintenance capabilities.

WaveFusion offers users accurate real-time measurements and estimated wave data through intuitive and dynamic dashboards.

Traditional directional wave radars now face competition from innovative solutions like Miros' WaveFusion, which was specifically developed for the offshore wind market and is an indispensable tool for SHM. This advanced sensor provides comprehensive insights into the intricate dynamics of the marine environment, enabling operators to confidently navigate the challenges of offshore wind farms.

WaveFusion offers users accurate real-time measurements and estimated wave data through intuitive and dynamic dashboards, making it far easier to achieve safer, more resilient, and sustainable operations. Continuous monitoring of offshore wind structures yields substantial benefits, allowing operators to perform predictive maintenance and proactively address structural issues, thereby ensuring safety and sustainability throughout the lifespan of their fixed or floating offshore wind farms.

Promoting sustainability and environmental stewardship

'Dedicated to improving maritime decision-making, our goal is to provide the most accurate and reliable real-time ocean surface measurements to raise situational awareness and strengthen operational efficiency and safety at sea,' explains Lars Ivar Leivestad, Sales Manager at Miros.

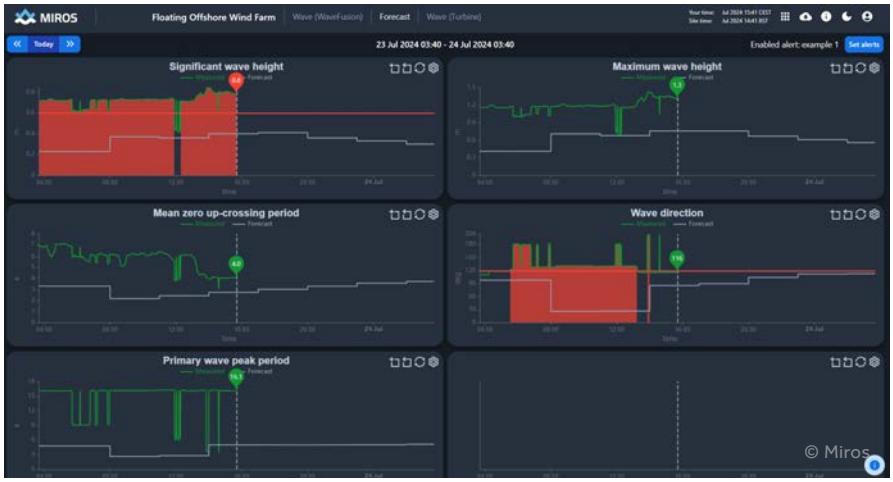
'Supporting offshore wind and other maritime industries by consistently delivering high quality, dependable solutions tailored to client needs is Miros' contribution to promoting sustainability and environmental stewardship in marine environments.'

Miros is dedicated to driving innovation in sensor technology and application development, addressing the unique challenges of the offshore wind sector through collaborative research and industry partnerships. Implementing artificial intelligence and machine learning, this ongoing innovation is crucial for advancing the efficiency and reliability of offshore wind power, cementing its role as a cornerstone of the global renewable energy landscape.

In what is Miros' 40th anniversary year, the company continues to look to the future by developing solutions designed to help the offshore sector operate efficiently and safely for decades to come.

www.miros-group.com

Miros WaveFusion provides real-time directional wave data for structural response analysis. Detailed insights into wave direction, intensity, frequency, and directional wave measurements enable engineers to anticipate dynamic load variations, leading to more robust and efficient design and maintenance strategies for offshore wind installations



The Miros Forecast application provides users with forecasted ocean state data together with real-time measured data integrated into an intuitive and dynamic dashboard. The application offers personalized alerts for each chart, enabling a proactive response when specific wave conditions surpass predefined limits to ensure the safety of offshore assets and personnel

About the authors

Richard Chen, Technical Manager Offshore Wind

With a career spanning both the wind industry and information technology, Richard brings a wealth of experience and expertise and seamlessly merges his knowledge of wind farms and cloud computing to provide invaluable support to customers.

His unwavering commitment to staying at the cutting edge of new technologies and exploring potential integrations underscores his passion for innovation and driving progress in the industry.

Lars Ivar Leivestad, Sales Manager Offshore Wind

Lars Ivar is a seasoned Sales Manager for Offshore Wind at Miros, with a comprehensive operational, technical, and commercial background within the energy sector.

He brings a unique blend of technical prowess and strategic management skills to his role, making significant contributions to bringing real-time ocean insights to the forefront of the offshore wind sector.