
At breaking point: Mooring line integrity for floating offshore assets

Mooring lines are essential for the safe and reliable operation of any floating offshore asset. They are designed to keep the asset in place for up to 30 years, even in harsh environments and extreme events. However, mooring lines are not immune to failure. They can suffer from various forms of damage, accidents and degradation, that can compromise their integrity and performance. In this article, we will explore the causes and consequences of mooring line failures, and what you can do to keep your mooring system safe.

Mooring line failure is more common than you might think. According to a study by [DNV](#), the average mooring line or anchor frequency of failure is reported as 1.23E-03 per year, while a [Granherne](#) study found that across 33 floating production storage and offloading (FPSO) vessels, 150 mooring lines had to be repaired or replaced over a ten-year period. The consequence is that for FPSOs with multiple mooring lines, between one and two mooring system failures have occurred per year since 2001. In reality, under-reporting means the situation may be even worse.

Mooring line failure can have serious consequences for offshore operations. It can lead to loss of station-keeping, damage to the asset and the environment, increased operational costs, and reduced production. For example when the [Gryphon Alpha FPSO](#) lost four of its ten mooring lines in 2011, line repair and replacement was reported to have cost around \$1.8 Bn.

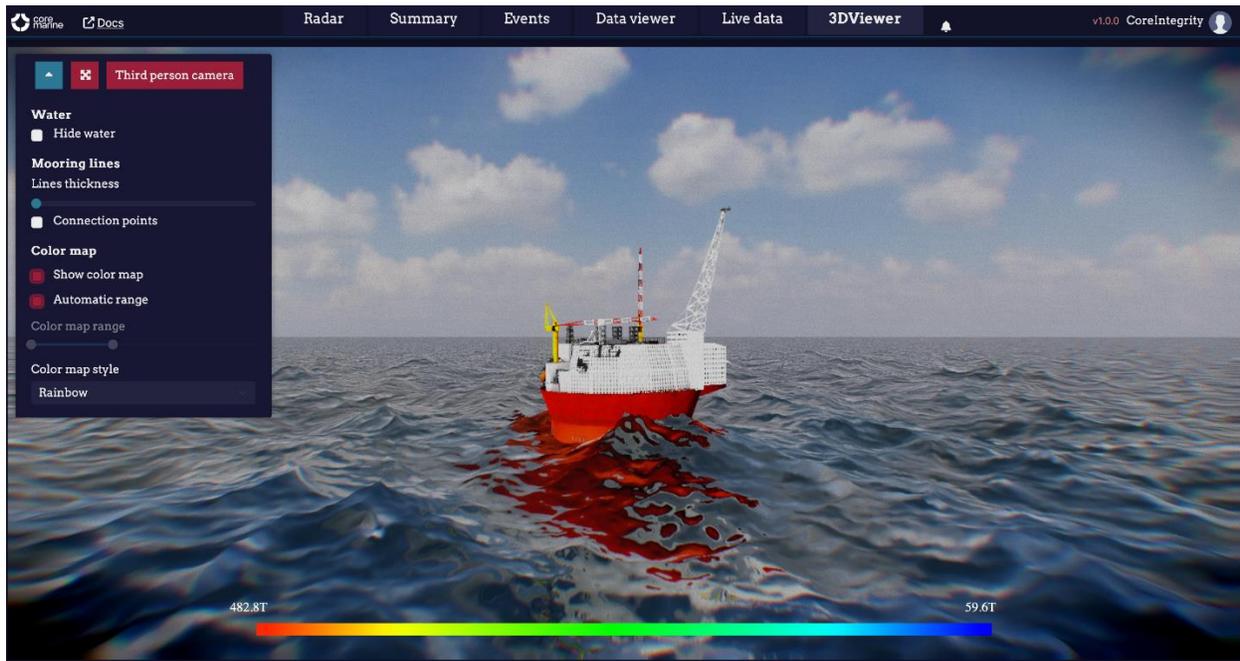


Fig 1: An asset's digital twin 3D-modelled in the CoreIntegrity dashboard

What causes mooring line failure?

Mooring lines have to put up with a lot:

- **Wear and abrasion:** This can occur when mooring line components rub against one another, against the vessel, or against the seabed. Wear will reduce the cross-sectional area and the strength of the line, as well as potentially increase drag and tension.
- **Corrosion and marine growth:** Mooring lines can degrade quickly depending on metocean conditions. Corrosion can both weaken lines and increase drag. Marine growth can accelerate corrosion and also increase mooring line drag and weight, which can affect a line's natural frequency and fatigue life.
- **Fatigue:** The fatigue analysis done at the design stage is a simplified version of what the lines actually experience in real life. Different load cycles, wave spectra, and environmental conditions can result in higher fatigue damage than expected. In addition, lines are often subject to out-of-plane bending at fairleads and chainstoppers, which can dramatically accelerate the time to failure, as famously happened on the [Girassol CALM buoy](#).
- **Faulty components and materials:** Mooring line materials, be they chain, wire, or rope, are subject to quality control and testing. However, even tiny imperfections can grow into large problems over the design life of the asset. For instance, cracks, pits, or fractures can initiate and propagate in the line, leading to sudden failure.
- **Manufacturing and installation errors:** Mooring lines often consist of multiple components, such as shackles, swivels, connectors, and clamps. Each additional component adds complexity and potential for things to go wrong. At one end of the scale, this may simply be bolts not being tightened adequately or anchors embedded with too much force. However, more extreme errors are possible, such as mooring lines being installed upside down when designer drawings are not properly followed by the installation contractor.
- **Damage and accidents:** With the best intention in the world, accidents still happen. Be it equipment dropped overboard, or fishing trawlers getting nets entangled, mooring lines can be exposed to unexpected and excessive loads that can cause them to break or snap.

How to Prevent Mooring Line Failure?

Mooring line failure is not inevitable. It can be avoided with proper mooring integrity management. This involves not only designing the mooring system according to the relevant standards and codes, but also monitoring and inspecting the mooring system throughout its operational life.

Monitoring and inspection are crucial for detecting and diagnosing any issues with the mooring system before they become critical. They can also help optimize the maintenance and repair strategies, as well as extend the service life of the mooring system.

However, traditional methods of monitoring and inspection are often costly, time-consuming, and unreliable. They rely on manual measurements, visual inspections, and periodic surveys that can miss important details or provide inaccurate data. They also require mobilizing vessels, divers, or ROVs, which can be challenging in remote or harsh locations.

That's why we developed CoreIntegrity, a digital platform for mooring integrity management that leverages the power of sensors, cloud computing, machine learning, and artificial intelligence.

What is CoreIntegrity?

CoreIntegrity is a software platform that creates a digital twin of a mooring system using onboard sensors and cloud computing. Machine learning and artificial intelligence provide real-time analytics and system status. It also enables proactive and preventive maintenance of the mooring system using predictive modelling and simulation.

CoreIntegrity works by collecting data from various sensors installed on the mooring lines, such as strain gauges, accelerometers, inclinometers, and load cells. These sensors measure the tension, position, orientation, and motion of the mooring lines, as well as the environmental conditions, such as wind, wave, and current.

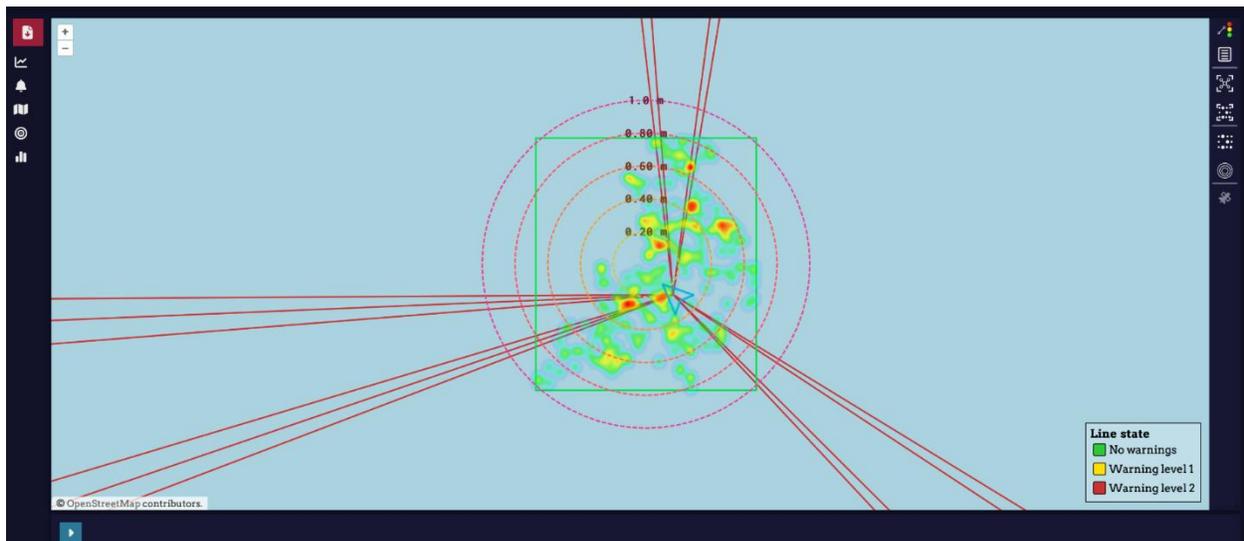


Fig 2: An asset's mooring line overview in the CoreIntegrity dashboard (NB - we've cropped this image to exclude proprietary data; please contact us for a complete system demo).

The data is then transmitted to the cloud, where it is processed and analyzed by our proprietary algorithms. These algorithms use advanced techniques, such as data fusion, signal processing, anomaly detection, and fault diagnosis to provide accurate and reliable information on the mooring system.

CoreIntegrity also uses historical data and numerical models to simulate mooring system behavior and performance under different scenarios and conditions. This means you can predict the system's future state and remaining life, as well as to optimize the maintenance and repair schedules.

CoreIntegrity provides a user-friendly interface that displays the results of data analysis and simulation in an intuitive and interactive way. The user can access the platform from any device, anywhere, anytime. The user can also receive alerts and alarms when the platform detects any issues or anomalies with the mooring system, as well as recommendations and guidance on how to resolve them.



Fig 3: An asset's events and alarms overview showing individual mooring line status in the CoreIntegrity dashboard (NB - we've cropped this image to exclude proprietary data; please contact us for a complete system demo).

Why Choose CoreIntegrity?

CoreIntegrity is more than just a software platform. It is a comprehensive solution for integrity management that offers multiple benefits and advantages, such as:

- **Enhanced safety and reliability:** CoreIntegrity helps you prevent mooring line failure by providing you with real-time and accurate information on your mooring system's condition and performance. It also helps you identify and address any potential risks or threats before they escalate into major problems. This way, you can ensure the safety and the reliability of your offshore operations and avoid any costly or catastrophic consequences.
- **Optimized performance and efficiency:** CoreIntegrity helps you optimize the performance and efficiency of your offshore assets by providing you with insights and feedback on how to improve your mooring system. It also provides you with optimal maintenance and repair strategies to reduce operational costs and downtime. This maximizes your offshore projects' productivity and profitability to achieve your business goals.
- **Sustainability and environmental goals:** CoreIntegrity reduces the environmental impact and carbon footprint of your offshore operations. Reliable remote monitoring reduces the need for manual surveys, minimizing the use of vessels, divers or ROVs.

How to Get Started with CoreIntegrity?

[Get in touch](#) if you are interested in learning more about how CoreIntegrity can help ensure mooring line integrity for your offshore construction. We will be happy to answer your questions and provide a free demo or quote. We look forward to working with you on your mooring integrity challenges!