MOOR-LIFE: Predictive Health Monitoring and Failure Estimation for Mooring Lines

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Floating wind turbines can be installed in deep water where fixed foundations are not possible, which opens some of the strongest and steadiest wind resources in the world. What keeps each turbine in place is its mooring system: steel chains several hundred meters long, anchored to the seabed. Those chains wear out. Every wave pulls on them, seawater corrodes them, and over the years that repeated loading grows small cracks that can end in a broken line. When one line fails, the others take its load, and the repair bill can run into millions.

Today, operators know surprisingly little about how much life a chain has left. Inspections follow a fixed calendar, so some lines are replaced while they are still healthy and others degrade unnoticed between visits. Measuring the load on the chain directly would help, but sensors mounted on the line rarely survive long at sea.

MOOR-LIFE asks a different question: can we work out the condition of a mooring line from something the platform already measures reliably? Every floating turbine records its own movement with positioning and motion sensors that sit safely on board. MOOR-LIFE uses that movement to estimate the tension in each line, turns the tension history into accumulated fatigue damage while accounting for corrosion, and projects it forward into a remaining-life estimate with its uncertainty stated openly.

The framework was built and tested in OpenFAST, an open-source simulation tool for wind turbines, on a widely used floating reference platform under waves, current and turbulent wind. Three findings stand out. First, chains wear out from how much the load swings, not from how high it is on average: lines carrying almost the same average load had predicted lives up to ten times apart. Second, which line wears out first depends on the turbine's wind thrust as well as the waves, so an assessment that leaves out the rotor can send the inspection vessel to the wrong line. Third, the two ways of calculating fatigue did not agree on how long a chain would last. The faster, frequency-domain method predicted a longer life than the time-domain method in every case tested.

The project also delivered a streaming version that updates damage and remaining life every ten minutes as new data arrives, and a review of all 106 modelling assumptions against the Det Norske Veritas (DNV) standards for floating wind. That review is candid about where the framework stands today, a working demonstrator rather than a certified design tool, and sets out the steps to close the gap, ending with validation on a real, instrumented turbine.

MOOR-LIFE is built entirely on open-source software so that Tarucca can carry it forward. The longer-term goal is to inspect the right line at the right time, extend the life of mooring systems where it is safe to do so, and avoid the steel, vessel trips and emissions spent on replacing chain that still had years to give.

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