BladeDAS–Distributed Acoustic Sensing for Offshore Wind Blade Health Monitoring

Publieke samenvatting / Public summary

Aanleiding

Offshore wind is the cornerstone of the Dutch electricity transition: capacity must grow from 4.7 GW today to 21 GW by 2032 and 50 GW by 2050, implying over 4,500 blades operating in harsh offshore conditions. Operations and maintenance accounts for 34% of offshorewind Levelized Cost of Energy, and blade inspection alone for 29% of O&M. Inspections today are manual, weather-dependent, and reactive: damage is detected only after vibration or performance loss has occurred, when cracks and delamination are already advanced. No commercial SHM solution combines the spatial coverage and acoustic sensitivity required for early-stage blade damage detection. Piezoelectric arrays and strain gauges provide only single-point coverage, and their cabling and bonding degrade rapidly under offshore vibration and humidity; current fibre-optic DAS lacks the bandwidth to capture the high-frequency acoustic emissions of crack initiation. SignoPhoton, with industrial partner Wattrogen and knowledge partner TU Delft, will develop an advanced FO-DAS platform with 1–5 cm spatial and 300–400 kHz temporal resolution, enabling real-time blade SHM and a 4–6% reduction in O&M cost.

Doelstelling

The project aims to develop and validate an advanced fibre-optic distributed acoustic sensing (FO-DAS) platform for continuous, real-time structural health monitoring (SHM) of offshore wind turbine blades. Four quantified targets are pursued:

Projectinformatie / Project information

Projectnummer / Project number
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Algemene informatie / General information

Penvoerder / Secretariat
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spatial resolution improved from 1–10 m to 1–5 cm; temporal resolution from 1–20 kHz to 300–400 kHz; signal-to-noise ratio (SNR) lifted by 6–10 dB through coded pulses, multi-heterodyne detection, and gauge-length optimisation. Over 36 months and four work packages coordinated by SignoPhoton, with Wattrogen leading FPGA/SoC signal processing and TU Delft leading composite-specimen validation, the consortium will deliver a TRL 5 prototype with route toward TRL 6 that detects 4 of 4 damage classes (matrix cracking, delamination, debonding, fibre breakage) with localisation accuracy = ±5 cm and low processing latency. The validated platform underpins MMIP 1 — Wind op Zee, unlocking a 4–6% reduction in offshore O&M cost and an estimated €220–330M/yr saving across the 21 GW Dutch fleet by 2032.

Korte omschrijving

Activities are organised across four work packages over 36 months. WP1 (M1–M36) ensures coordination, reporting, dissemination and IP filing, led by SignoPhoton. WP2 (M1–M14) designs, builds and benchtests the f-OTDR-based FO-DAS interrogator by integrating a tunable laser, modulator, coherent frontend, high-speed ADC and optical assembly delivering an interrogator at Gate G1. WP3 (M10–M26) develops the high speed data transfer module integrated with a high speed parallel signal-processing unit by Wattrogen, phase demodulation, coded-pulse decoding, multi-heterodyne filtering and damagelocalisation algorithms validated against synthetic and laboratory data low latency at Gate G2. WP4 (M22–M36) integrates the full FO-DAS prototype and validates it at TU Delft's Aerospace Structures and Materials laboratory facilities (Aircraft Hall) on composite specimens under impact fatigue test which induce four damage cases (matrix cracking, debonding, fibre breakage, and delamination) benchmarked against piezoelectric AE arrays and post-test CT/Visual scans. This delivers a validated BladeDAS system at G3 under laboratory conditions representative of offshore wind blade damage scenarios.

Resultaat

The project delivers a validated TRL 5 FO-DAS prototype with route toward TRL 6 for early-stage damage detection on offshore wind turbine blades, with documented performance against impact fatigue damage test representative of four generated damage (matrix cracking, debonding, fibre breakage, and delamination) in wind turbine blade. Supporting deliverables include the high-bandwidth f-OTDR interrogator hardware, high speed data transfer module integrated with a high-speed parallel signalprocessing firmware with damage-localisation algorithms, an experimental dataset benchmarked against piezoelectric AE arrays and post-test CT/Visual scans, a CERTIFICATION pre-assessment and IEC 61400-5 compliance evidence pack, and two patent applications (High-Bandwidth FO-DAS Interrogator and data acquisition architecture at M18, DSP pipeline at M30). The validated platform enables a 2029 pilot at TUDelft, and commercial rollout from 2032 under DNV-ST-0376 type approval. At Dutch fleet scale this translates to a 4–6% offshore O&M cost reduction, €220–330M/yr savings on the 21 GW fleet by 2032, +10–15% blade lifetime and 0.6–0.9 Mton avoided CO2 over 2030–2040.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.
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