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Seeing through the composite

Visual inspection can reveal surface damage, but many serious structural defects develop within the blade. Subsurface inspection using ultrasonics can give operators earlier evidence of disbonds, delamination and other internal defects before repair options become more limited.

Drones and high-resolution cameras have changed how the wind industry inspects rotor blades. But looking at a blade is not the same as looking into one. As blades grow longer and root and spar-cap designs are subjected to greater loads, defects that can turn a repairable blade into a replacement may develop inside the laminate, out of sight and only reach the surface once repair options have become more limited.

The case for subsurface structural inspection is therefore to make it a routine part of blade operations & maintenance (O&M) rather than a step taken only after something has already gone wrong.

What the cameras can't see

Automated visual inspection is highly effective for surface condition assessment. A drone can image a full blade quickly and flag leading-edge erosion, coating breakdown, surface cracking and lightning damage without requiring a technician on ropes. For failure modes visible at the surface, it remains an important inspection tool.

The limitation is what visual inspection cannot see. A modern blade is a bonded composite structure comprising spar caps built up from carbon planks, shear webs and sandwich panels with a core between two skins. Internal defects can include adhesive disbonds in the shear webs and along the leading and trailing edges, spar-cap manufacturing flaws, interlaminar delaminations, porosity, resin pooling and ply wrinkles. In their early stages, these may produce no visible surface feature.

By the time an indication appears externally as a crack or deformation, the defect may have propagated far enough to make the repair more extensive. Whatever its resolution or the capability of the analysis behind it, a camera reads the outside of a structure whose integrity is also determined internally.

Visual inspection can tell you the blade looks fine. It cannot tell you the blade is sound.

Seeing through the layers with ultrasonics

Closing that blind spot means measuring the structure rather than photographing it, and in composite blades ultrasonic testing is a central method. Ultrasonics drives sound energy into the laminate and reads what returns. A disbond, delamination or void reflects that energy differently from sound material, allowing an internal flaw to become a measurable signal. It can assess critical structures including the root, bondlines, spar cap, shear web, leading and trailing edges and laminate over core, and identify defects ranging from delaminations and porosity to cracking, resin pooling and ply wrinkles.

Ultrasonics is the backbone, but not the whole toolkit. The appropriate inspection method depends on the failure mode. Thermography can provide a fast assessment of near-surface problems such as dry fibres, core damage and near-surface laminate defects. Shearography helps characterise ply wrinkles and near-surface delaminations.

Geometric scanning quantifies leading-edge degradation, checks root roundness before installation, confirms tower fitment and measures the blade's profile against the original design, helping verify build accuracy and aerodynamic profile. Internal visual inspection, including a crawler that travels inside the blade, can verify repair integrity, bondlines, core condition and bulkhead placement.

Ultrasonics paired with thermal correlation can also characterise lightning-strike damage, which may be more extensive inside the laminate than the entry mark suggests, while a lightning protection system check confirms whether the down conductor path remains intact. Each method answers a different question; together they can assess the blade from the surface down to the bondline.

Up tower and in the yard

Where the work gets done matters as much as how. On an installed blade, rope access teams can reach any portion of the blade up tower, drone-assisted inspection covers ground quickly and an internal crawler works from inside, so a suspect area can be confirmed, located and sized without automatically

pulling the blade down. In the laydown yard, and on returned or preinstallation blades, full access and controlled conditions allow deeper, more methodical characterisation.

The same methods run in-line during production for factory quality control and quality assurance, catching escapes before a blade ever ships. One caveat for the technically minded reader is that most thermography is a near-surface method. Through-transmission thermography can see deeper, though it is uncommon on wind blades, so the deepest structural questions are typically answered by ultrasonics rather than by a thermal camera.

This is why UT anchors the toolkit. Where a known indication needs watching between campaigns, installed root sensors can provide continuous monitoring, so growth is caught as it develops rather than at the next scheduled visit.

A scheduled repair versus a crane

For an asset manager, this ultimately becomes an argument about the cost of timing.

Identify a subsurface disbond early and the response can be planned: a scheduled composite repair carried out in a low-wind window, with the turbine returned to service in a controlled timeframe. If the same defect continues to propagate out of sight, the eventual intervention may involve crane mobilisation, an extended unplanned outage or, in the worst case, full blade replacement, together with the associated loss of generation. The financial difference between planned intervention and an unplanned failure can be substantial.

That difference illustrates the operational value of identifying subsurface defects early.

It is not only a repair-versus-replace question. Even when replacement is the right decision, a defect identified and tracked in advance can turn an emergency response into a planned intervention, reducing exposure to emergency crane mobilisation, collateral damage and unplanned generation losses. Run as a seasonal campaign ahead of the high-wind months, inspection can become part of planned asset management rather than a purely reactive expense.

What makes early action possible is the speed and clarity of the reporting behind it. CICNDT says analysis begins within 24 to 48 hours of inspection, with reports providing operational recommendations tied directly to the data rather than raw scans alone. These can include digital defect mapping, severity ranking, repair recommendations and warranty documentation where applicable.

The customer owns that data. That documented, owner-held record can also support an end-of-warranty claim or a life-extension assessment, where the question is not only whether a blade is sound today but whether it is likely to remain so.


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Independent inspection can also give the owner evidence that is separate from the party that built or will repair the blade.

From reactive to routine

In the end, the data is only as valuable as the decision it informs.

In one case, CICNDT says it tracked root debond indications on a monitored asset across successive inspections and flagged them for a planned blade replacement before the defect could progress to liberation. The intervention was still a replacement, but it was carried out as a controlled event rather than an emergency response.

The reverse is also instructive. A subsurface finding only protects an asset when it is acted on while there is still time. CICNDT reports that, in at least one instance, a flagged root indication progressed to blade liberation within days. The example underlines that detection and timely response are two parts of the same safeguard.

The wind industry already accepts that blades should be inspected on a schedule rather than only after failure. The next step is ensuring that inspection can reach the parts of the blade where internal defects may develop and that findings are acted on in time. That requires ultrasonics as a central method, supported by complementary inspection techniques and crews able to work from rope access, the laydown yard or the production line. It also requires appropriate expertise behind the data.

For any method in use, the inspection team should be backed by Level III expertise in that method and technicians with blade-specific knowledge, supported by the qualifications and safety certifications required for the work. The objective is to turn inspection data into evidence operators can use to protect both the blade and the energy it produces.

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