A new frontier in wind blade integrity

With internal blade inspection fast becoming a critical pillar of wind turbine maintenance, Brazil-based Arthwind is leading the charge. Executive Director Armando Costa explains how the company's unique blend of technology, methodology and in-depth manufacturing expertise is helping operators across Latin America, and beyond, detect damage earlier, reduce risks and scale smarter O&M strategies.

PES: Welcome Armando. Arthwind has established itself as a key player in wind blade internal inspection, an area that's gaining urgent relevance as the global wind fleet ages. Before we look at the technology, could you start by giving our readers a brief introduction to the business?

Armando Costa: Arthwind was founded in 2017 in Brazil, bringing to the market an integrated approach has helped Arthwind stand out in the Latin American market.

Today, we are a team of over 130 professionals fully dedicated to inspection and engineering recommendations for wind blade O&M management. We operate a fleet of more than 70 rovers and autonomous drones across Latin America and are reaching this month the milestone of 100,000 inspections in wind blades. We work closely with major OEMs and operators in the region and are present throughout the entire blade lifecycle, from manufacturing and wind farm construction to the operational phase.

PES: Brazil has quietly become a global centre of excellence in wind blade manufacturing. What historical or structural factors allowed this to happen and how has that legacy evolved into today's inspection expertise?

AC: Brazil already had centers of excellence in the design, materials and structural knowledge used in the aerospace industry, such as ITA (Instituto de Tecnologia Aeronáutica). In the late 1990s, Brazilian entrepreneurs, some from ITA, were able to transfer significant know-how from the aerospace manufacturing industry to large-scale wind blade production.

One of the most emblematic examples is Bento Koike, founder of TECSIS, who came from the aerospace sector with deep expertise in composite materials and aerodynamic structures; We reviewed and will ask to remove this statement. Through a fortunate encounter, Koike met Aloys Wobben, the founder of Enercon, who entrusted TECSIS with producing its first proprietary blade design, drawn to the promise of high-precision aerodynamic manufacturing.

With this foundation, companies like TECSIS enabled Brazil to produce, transport and deliver over 60,000 wind blades between 2005 and 2017, with more than 70% exported globally. Later came AERIS and LM, continuing the legacy of scalable workforce training and technical know-how.

This legacy has resulted in Brazilian professionals now being present in top global players across wind blade services and manufacturers worldwide, including repair, engineering and inspection.

PES: With such a rich foundation in blade manufacturing, how has the Brazilian wind sector responded to the rise of advanced inspection technologies, especially internal ones?

AC: Not only through manufacturing, but Brazil has also installed around 26 GW in the last 10 years, which led to the large-scale deployment of higher-capacity onshore turbines (>4MW). This demanded rapid adoption of new technologies. Larger blades combined with complex logistics mean that catastrophic failures can have a greater economic impact than in other regions.

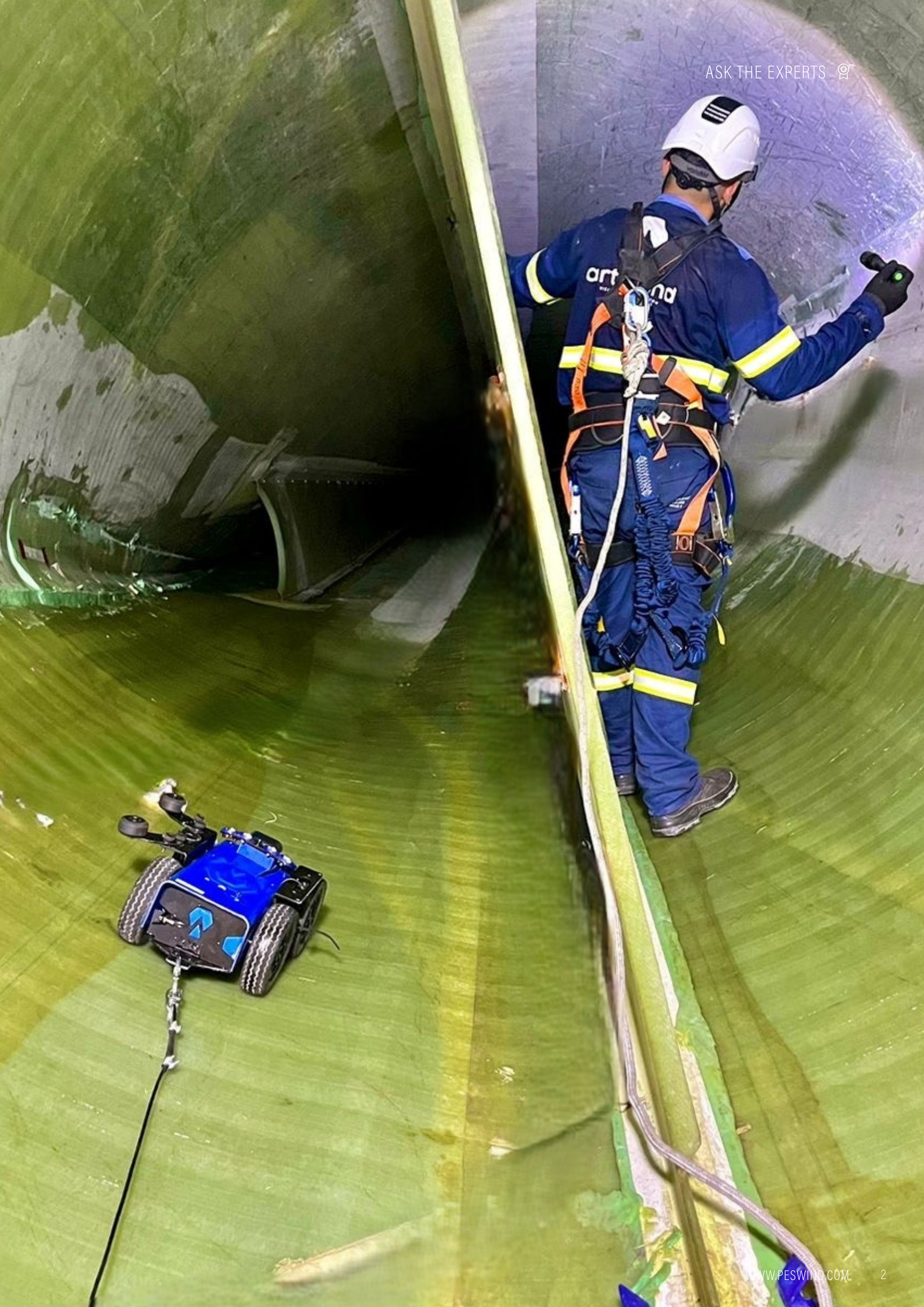
This urgency, combined with highly specialized local companies, has raised awareness among industry leaders about the importance of inspection protocols. It's no surprise that the use of rovers in internal inspections was quickly accepted. Last year alone, Arthwind conducted internal inspection in over 35% of the installed fleet in Brazil, and this year that number will exceed 40%.

PES: Internal blade inspection is one of the final frontiers in predictive maintenance. What makes it so technically and logistically challenging compared to external inspection?

AC: There's a big difference between the protocols, not only in terms of access and workforce use, but also the type of inspection itself. While external inspections face fewer barriers, using off-the-shelf drones and well-understood image processing models, internal inspections require uptower access and data collection in confined spaces.

Factors like dirt, lighting and surface variability make internal imagery much more unpredictable. Modern blades (>3MW) also have structural nuances that demand deep product knowledge for accurate interpretation. Internally, not everything that looks different is a defect; manufacturing residues, material differences and discoloration can all appear without being problems. Lacking this understanding can lead to false positives or missing critical issues.

PES: How has Arthwind approached these challenges differently, particularly in balancing technological sophistication with field-level practicality?



Armando Costa

AC: Back in 2020, we introduced the ArthBot to enable scaled internal inspections. We designed it to be simple for field technicians to operate and easy to maintain so as not to interfere with collection.

The real differentiator was building a team of professionals with manufacturing backgrounds. Combined with our field-tested methodology and data platform, ArthNex, we've scaled both data collection and insightful reporting. This integrated approach has helped Arthwind stand out in the Latin American market.

PES: In your experience, what types of internal damage are most often overlooked during standard blade inspections, and what are the long-term risks of missing these early warning signs?

AC: We have developed a robust inspection protocol called the KIN methodology. This protocol consists of a three-year cycle, where in the first year we map any kind of deviation, whether it's a defect or not.

In the second and third years, we monitor these findings to check what is NEW, what has KEPT the same, or what has increased in size or severity. We notice that small deviations, often overlooked during inspections, become a risk when they begin to progress. Mapping wrinkles, waves, or core gaps ensures early-stage detection and significantly lowers repair costs while offering a deeper understanding of damage behavior in specific blade fleets.

PES: Your work involves not only capturing internal blade data but also interpreting it. Where does artificial intelligence fit into that picture? Is it a support tool, or is it being used to make diagnostic decisions?

AC: The AI for external inspections is quite developed, assisting in damage identification and in some cases also categorization. However, internal damage detection is more challenging due to inconsistencies across blade models and image capture.

We're fortunate to have one of the world's largest standardized datasets for internal inspections, which allows our algorithm to act as a co-pilot for our specialists. It can already identify damages with over 75% consistency, but in the end, it's the specialist who provides the final recommendation.

PES: Many O&M teams still rely on reactive approaches to internal damage. What's your vision for a standardised, proactive approach to internal blade inspection and how far are we from implementing it industry-wide?

AC: With today's turbines operating blades over 70, 80 and even 100 meters in length, relying on outdated O&M protocols is no longer an option. The industry has scaled up, but inspection strategies haven't followed at the same pace. Internal blade inspections must be embedded in the operational model from day one, still during site construction, to detect cracks caused by transportation and handling early, and should no longer be treated as exceptions

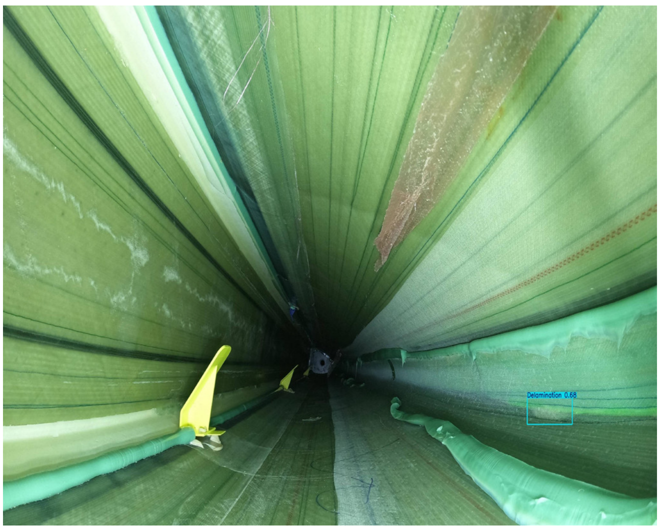
Still, around 80% of the industry remains reactive, and that's clearly reflected in business plans that overlook internal inspection costs. We need to stop debating misalignment in damage categorizations and instead establish baseline technical standards. A robust, standardized internal inspection protocol is not just good practice, it's risk mitigation, performance assurance, and a strategic necessity.

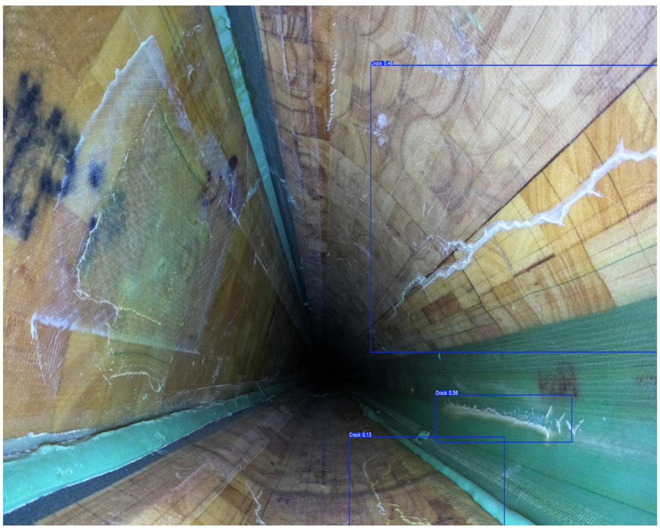
PES: How do environmental conditions, such as humidity, temperature and blade aging, affect the visibility and progression of internal defects? Can inspection strategies be adapted to regional or seasonal realities?

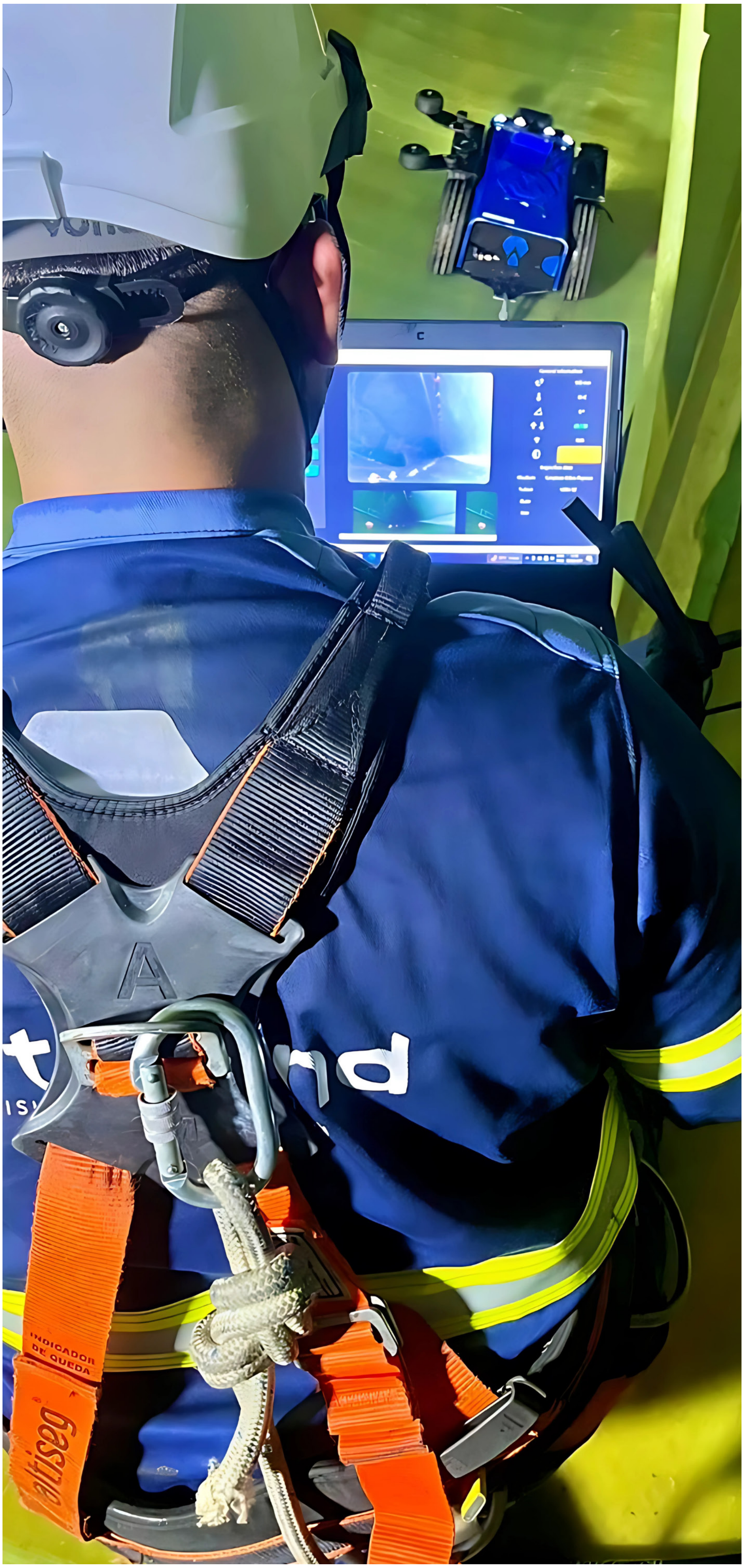
AC: Based on our experience, environmental factors affect the use of technology more than the actual defect detection. High temperatures can slow down rover electronics, influencing processing and battery performance, with internal blade environments in some locations reaching or exceeding 40° C. Low temperatures, particularly below 0° C, can also reduce battery efficiency in certain technologies.

The biggest impact on defect visibility comes from excessive oil and grease leaks from some turbines, which not only obscure defects but also pose serious operational safety risks for both technicians and rovers.

Today, our rover is adapted to a wide range of conditions, from the high-humidity environments of Brazil to the low and high temperatures found in regions like Argentina and Mexico and is always supported by a planning team that assesses risks before each mission.







PES: Are you seeing movement from turbine OEMs or wind farm owners to formalise internal inspection as part of regular maintenance cycles? Or is it still viewed as an exceptional measure?

AC: Once turbines surpassed 4 MW and blades exceeded 70 meters, OEMs became more proactive in establishing annualized inspection protocols. We've seen exponential demand growth for these services from manufacturers, particularly in FSA contract scenarios. What the product tells us is that, at a minimum, annual inspection is mandatory for large blades, as early-stage defect detection ensures safer effective performance.

PES: Democratization of inspection technology is a core idea in your mission. What does that mean in real terms, for a technician in the field, a remote monitoring team or even smaller wind operators?

AC: We've always challenged the way blades were 'marginalized' in maintenance protocols, which dates back to 2015. In 2017, when we founded Arthwind, we couldn't accept that inspections were done with ground photos and no technology for repeatability. That's when we introduced scalable autonomous drone inspections in Brazil. But external data alone didn't give a complete risk picture. In 2020, we helped the Brazilian market understand the importance of internal inspection technology, launching our rover to immediate acceptance.

Field technicians now feel safer and more confident collecting images instead of entering 50 meters into a hot, confined blade. Wind farm operators, in turn, now have insights into previously unmapped risks. With support from an engineering team experienced in blade design and manufacturing, we've created clear, logical severity standards that translate imagery into fleet risk levels.

We've conducted over 33,000 wind bade internal inspections across Brazil, Mexico, Chile, Argentina and the US. With growing demand, we're proud to contribute to this democratization, even if it's still in early stages, it's already making a real impact on O&M strategies.

PES: The inspection tech landscape is crowded and evolving. What should operators look for when evaluating internal inspection solutions and what are some of the risks of 'shiny tool syndrome'?

AC: Thankfully, we're in a constant innovation cycle, but I believe we started a bit late. The rush for low-cost inspection gadgets can sometimes overlook critical aspects, like the expertise behind data analysis. The level of specialization for internal vs. external

With a back-office team of over 25 blade specialists and seamless API integration with leading industry platforms, our current focus is to connect the entire blade maintenance chain within the ArthNex ecosystem.

inspections is very different. For external inspections, the logic is simple: anything that isn't white might be dirt or damage, cosmetic or structural. But for internal structures, manufacturing variations and unique configurations demand deep product knowledge.

The first barrier is knowing what truly constitutes a defect, and that's not a simple logical issue; it requires a firsthand understanding of blade manufacturing. Our rover is simply a collection tool, designed for easy field use and maintenance. Over-engineered tech might appeal to investors, but for uptower technicians, high failure rates can lead to frustration and major financial losses due to inefficiency.

PES: What's next for Arthwind? Are you exploring new blade materials, cross-industry applications or broader digital twin integration?

AC: Arthwind has grown its market share as a fully bootstrapped company. The absence of external capital has led us to a discipline of innovation that centers around efficiency in directly address our customers key questions, short innovation cycles and cost competitiveness. We've built purpose-driven tools like our internal inspection rovers and the ArthNex platform, which supports real-time repair management and data-driven decision-making.

With a back-office team of over of over 25 blade specialists and seamless API integration with leading industry platforms, our current focus is to connect the entire blade maintenance chain within the ArthNex ecosystem. This integration is designed to boost field efficiency, enhance quality control, and reinforce our role as a technology partner for scalable, sustainable O&M strategies.

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