Waygate Technologies

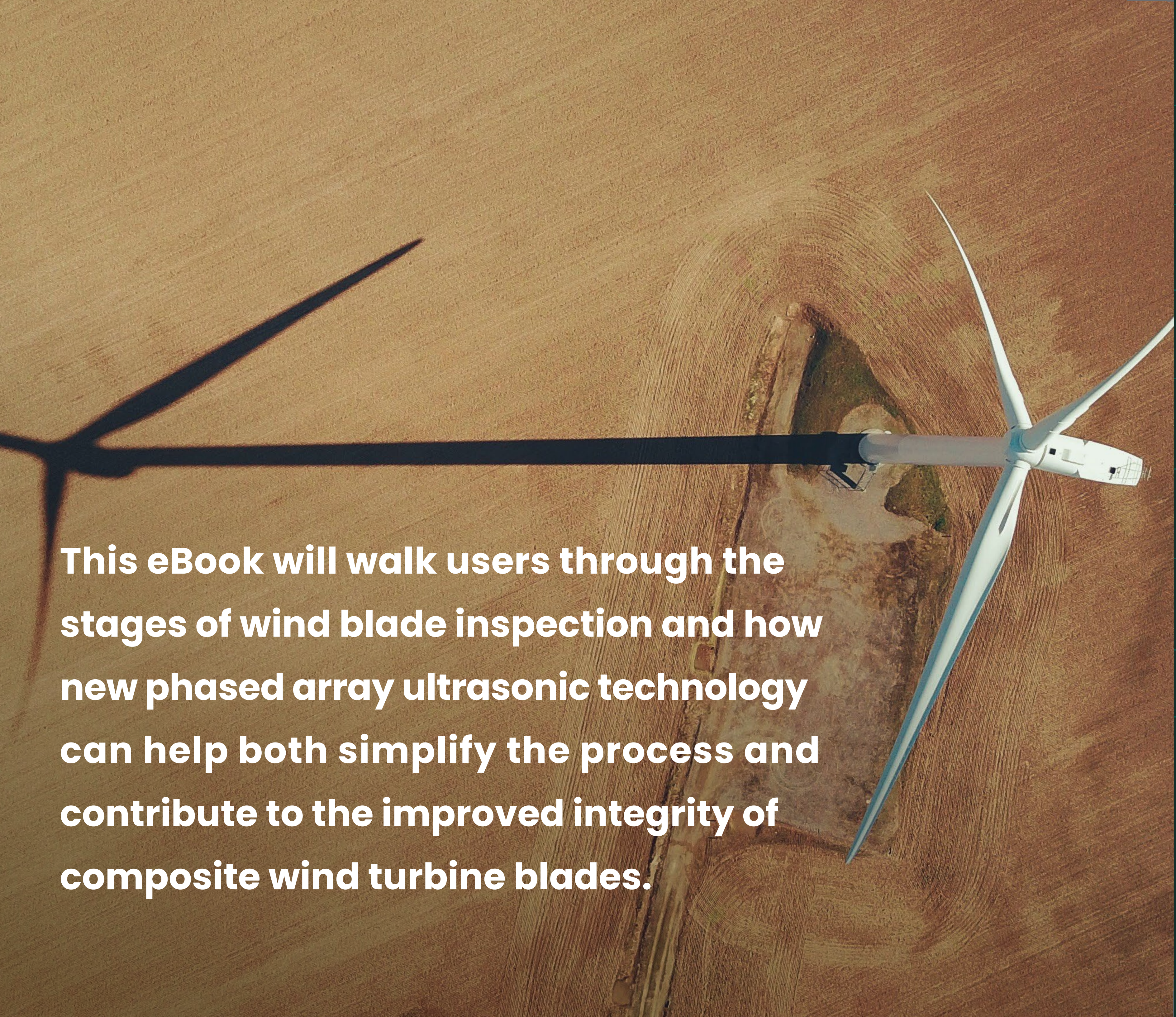
6 ways to simplify ultrasonic wind blade inspection

The current state of wind blade inspection

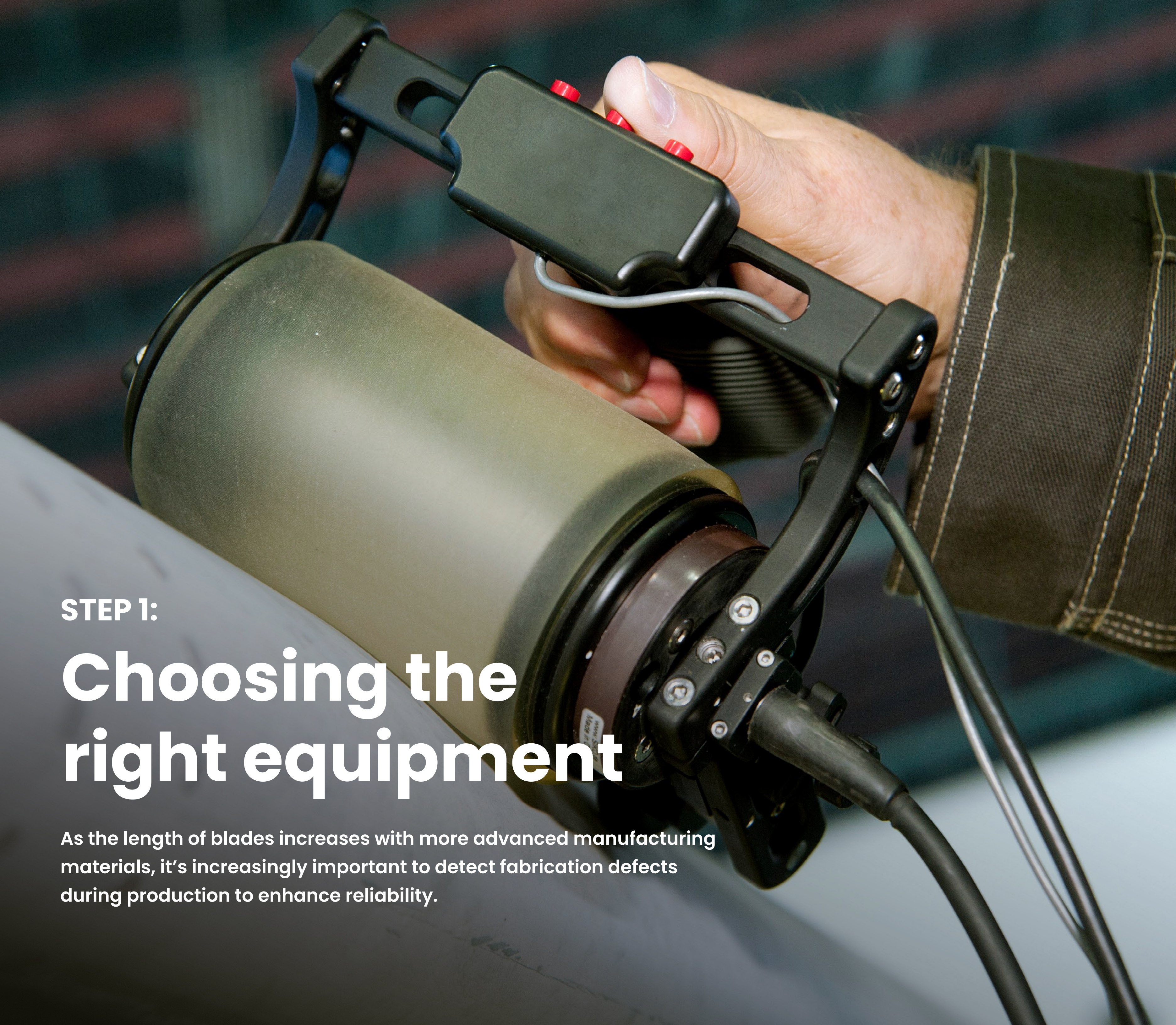
Wind energy may still be young, but the global wind turbine market is forecast to surpass $30 billion by 2025. The lightweight materials in wind blades harness wind energy with higher efficiency than conventional materials like aluminum and steel, and boast a longer life cycle, higher corrosion resistance, higher strength-to-weight ratio and lower maintenance. The rising demand for wind energy is leading to the construction of larger wind blades that offer higher power output, which is, in turn, resulting in the increased consumption of composite materials for blades.

While ultrasonic inspections of high-strength metal materials focus on detecting discontinuities such as internal inclusions, materials used to construct wind blades, such as fiberglass and carbon reinforced plastics (CRP), pose a unique set of inspection challenges that span from very thick and attenuative spar cap structures to porous bond lines. Due to the high levels of strain endured by active wind turbine blades, the most integral point of inspection occurs at the bond between the blade's structural beams and shell, which ensures the blades are clear of defects such as delamination and wrinkles.

Although it's absolutely crucial to have inspection procedures in place in order to maintain the integrity of each wind blade, your inspection data is only as reliable as the quality of your equipment and the accuracy of its data. Blade failure can cause extensive downtime and lead to expensive repairs, and the industry has been searching for a simple and reliable solution.



This eBook will walk users through the stages of wind blade inspection and how new phased array ultrasonic technology can help both simplify the process and contribute to the improved integrity of composite wind turbine blades.



STEP 1:

Choosing the right equipment

As the length of blades increases with more advanced manufacturing materials, it's increasingly important to detect fabrication defects during production to enhance reliability.

Most inspectors have switched from conventional ultrasonic technology to the more accurate and precise phased array system because of time savings.

Toggle to learn more

The device: The advanced, computer-based device—capable of driving the multi-element probe, receiving and digitizing the returning echoes—can plot that echo information in various easy-to-interpret formats. Unlike conventional flaw detectors, phased array systems can sweep a sound beam through a range of refracted angles or along a linear path, or dynamically focus at a number of different depths, thus increasing both flexibility and capability in inspection setups.

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Calibration block: When it comes to composite wind blade inspection, the materials used for wind turbines vary, not only from traditional metals, but from manufacturer to manufacturer as well. This can pose risks to inspection reliability. The best calibration block for ultrasonic testing equipment is one in the same form and shape as the material being inspected, as well as the same grade of material and heat treatment condition as the manufactured items. Additionally, the artificially induced flaw should mirror the actual flaw of concern, with a weld containing genuine flaws such as porosity, debonding, or delaminations.

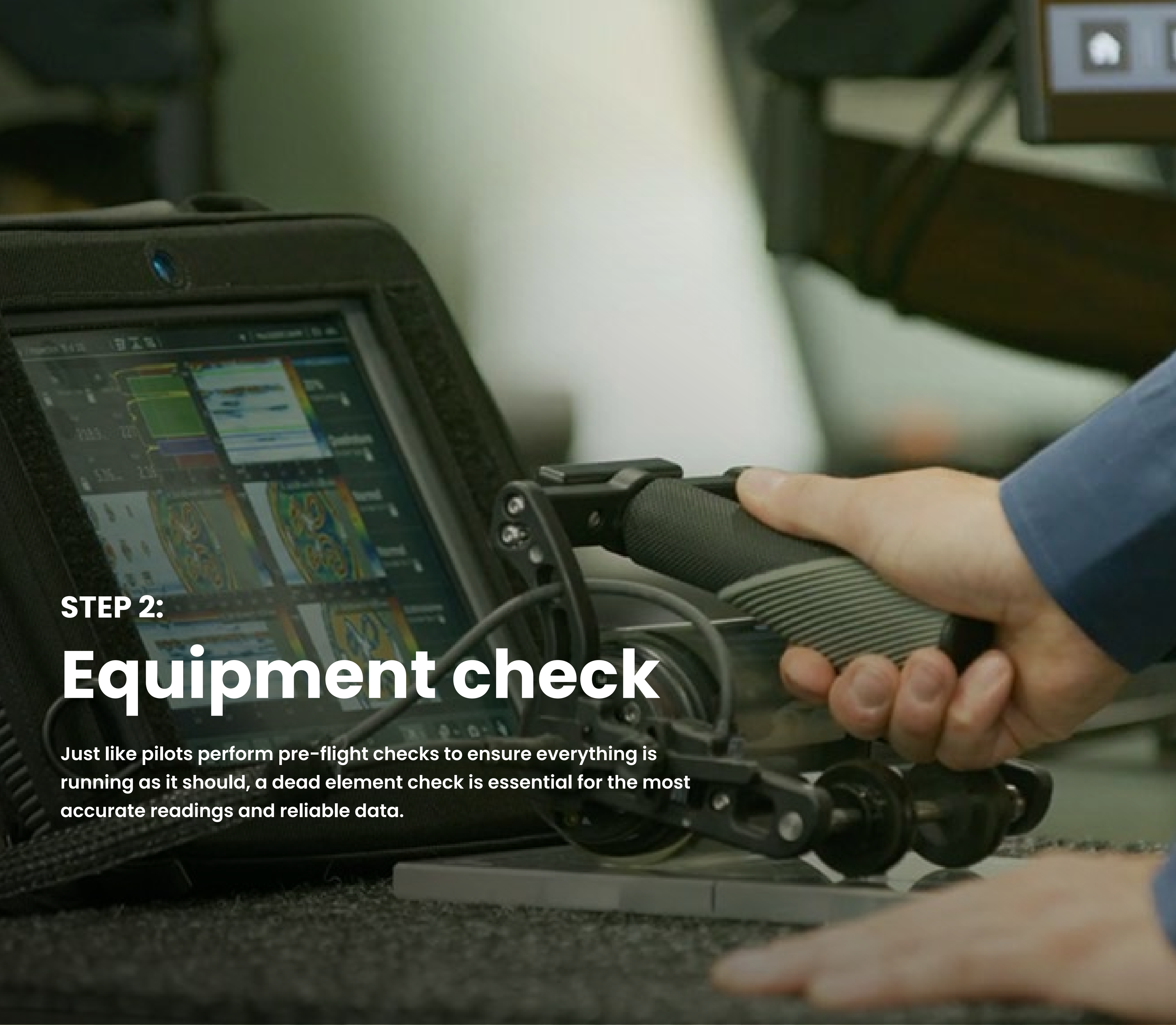
We know equipment is not only crucial, but comes with a vast amount of complicated options to choose from.

Conventional ultrasonic probes typically contain one element, or sometimes two arranged as a pulse-receiving pair. These probes are capable of providing one sound beam along an angle to a focal point determined by the probe's construction. Phased array probes contain many elements, and these can be fired individually and in groups. This allows steering and focusing of the sound beam electronically, providing inspection of larger areas in less time.

A phased array instrument can more easily adapt to varying conditions, such as moving from blade skin to spar cap and bond lines, combining ultrasonic data with positional encoding to produce easy-to-interpret images.

For improved productivity, the latest equipment utilizes phased array technology to provide:

- **Improved scan speed**
- **Increased data point density**
- **Stronger depth of penetration**
- **Reliable data**
- **Comprehensive, intuitive imaging**



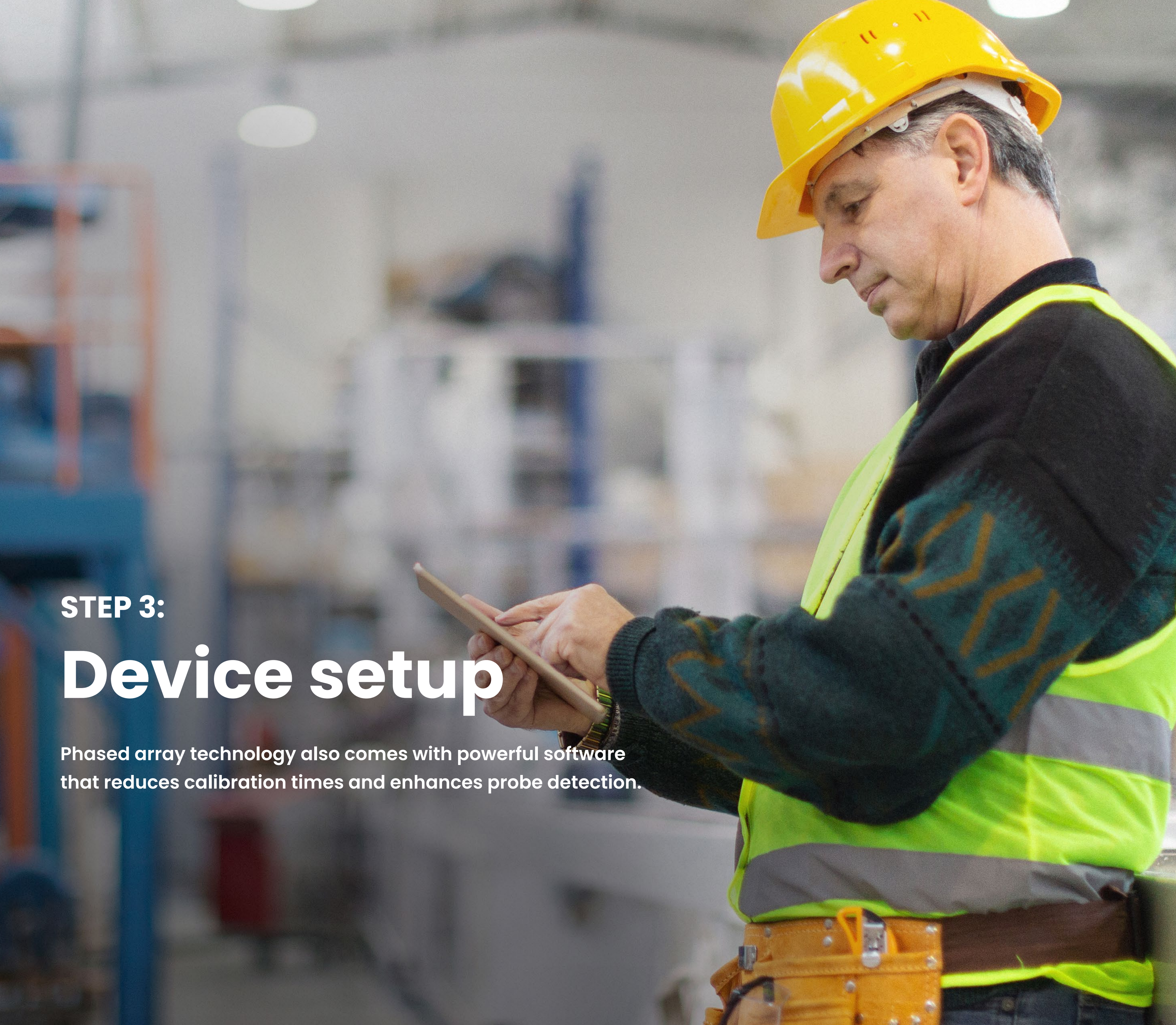
STEP 2:

Equipment check

Just like pilots perform pre-flight checks to ensure everything is running as it should, a dead element check is essential for the most accurate readings and reliable data.

Confirming proper operation of equipment is an important aspect of setting up for inspection, and checking the probe for proper sensitivity of all elements is an essential step in that process. While this can be a cumbersome process on some instruments, the most efficient ones provide a one-button solution allowing the probe to be validated in seconds.

The latest technology can automatically know which application you're using it for — providing more precise readings while saving you valuable time.



STEP 3:

Device setup

Phased array technology also comes with powerful software that reduces calibration times and enhances probe detection.

Most phased array instrumentation has overly sophisticated interfaces that are difficult to navigate, forcing you to waste valuable time familiarizing yourself with its features. When operators have access to more information, more views and more settings, it is of utmost importance to keep the user interface simple and easy to use.

Due to the high attenuation of ultrasound in wind blade materials, an operation frequency of 500 kHz is optimal for achieving a good depth penetration while still having a reasonable spatial resolution. At this point, setting the data-acquisition gates (e.g., type, position, threshold) is all manual and depends on a wide range of bond thicknesses within the blade.

New technology has features that adapt to unconventional geometries without requiring frequent changes in setup. Less tweaking in the field means more time focusing on inspections. With reliable information and easier-to-use devices, inspectors can make better decisions.

STEP 4:

Calibration

Since most ultrasonic equipment can be reconfigured for use in a large variety of applications, calibration is necessary to validate that the desired level of precision and accuracy are achieved.

There are four steps to calibrating your device. It's absolutely critical that this gets done correctly, which, given the state of equipment out there, isn't always easy or time-efficient.

Toggle to learn more

Part velocity and delay: The instrument must be programmed with the speed of sound in the test material as well as any necessary zero offset. It should always be calibrated with a sample of exactly the same material as the one to be tested, using as large a thickness as possible.

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Time corrected gain : Like any ultrasonic technique, a Time Corrected Gain (TCG) calibration is required to ensure that indications have uniform amplitude with depth and position.

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Sensitivity setup: This calibration will provide the required gain adjustment for each beam and sound path used.

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Encoder setup: This calibration will ensure the device is accurately reading the distance travelled with each roll of the probe.

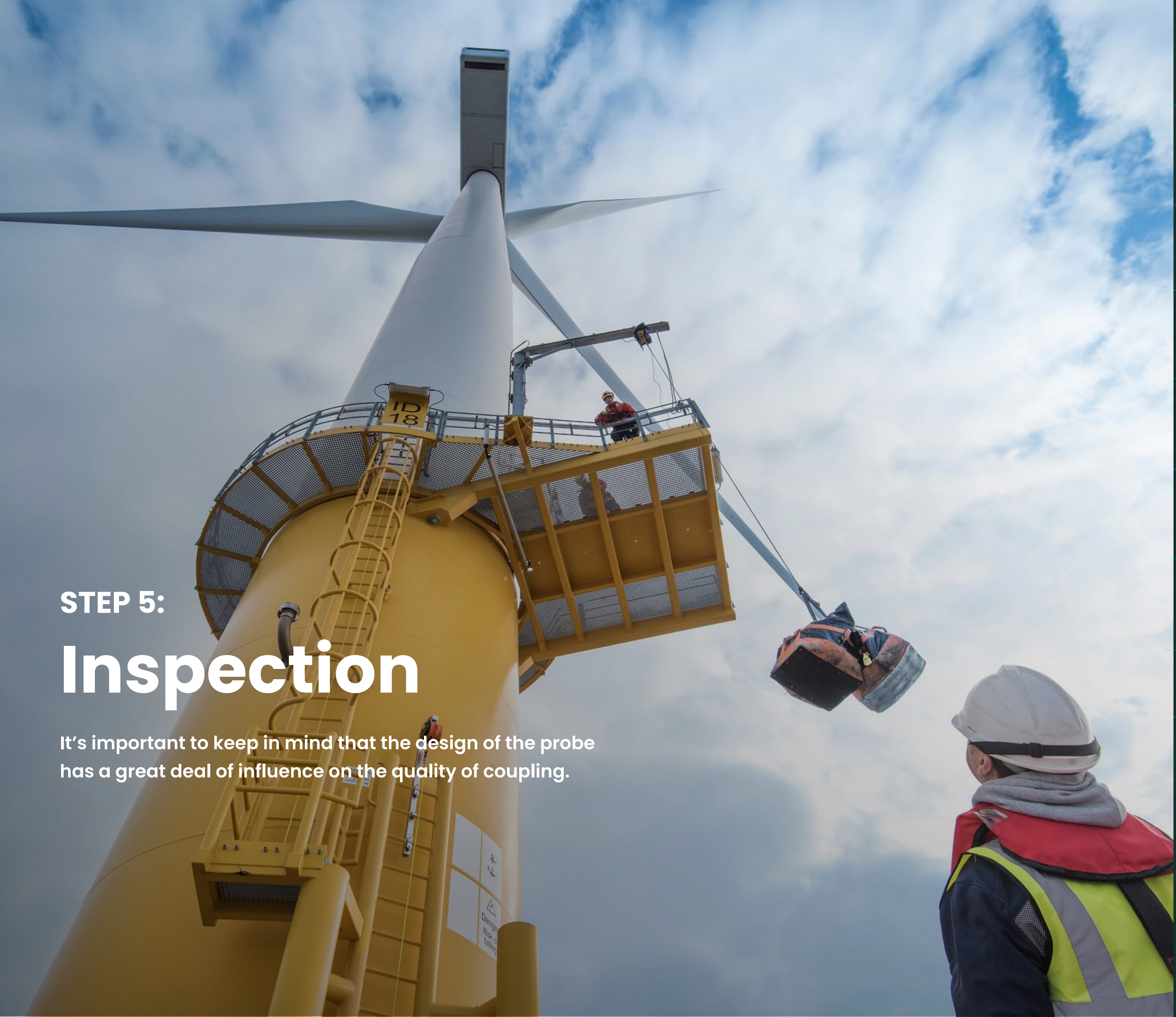
Delay and velocity calibration are essential measurements of the phased array probe and the inspection material, allowing accurate measurements of thickness, as well as the depths of any detected defects, to occur. The amplitude of reflections is one method used to determine the size of those defects. In attenuative materials like the composite wind blades, similarly sized defects appear at lower amplitudes since they occur deeper in the material.

After characterizing the material, a Time Corrected Gain (TCG) calibration compensates for spatial attenuation by adjusting input gain according to the expected attenuation. As a result, the evaluation of indications can be easily supported by the use of a monitor gate on the device, and the amplitude of the indication above the threshold displayed.

These two steps can be achieved much more quickly with newer phased array technology. For instance, you can build the calibration block you're using right into an app for less button pushing and clicks, reduced part requirements and zero parameter menus to deal with. And with phased array, the element delay and velocity calibrations are typically simple checks, as opposed to the many manual adjustments that conventional ultrasonic inspections require.

The latest portable ultrasonic technology allows for the sensitivity setup to be performed across all beams with a single-button touch, flattening the amplitudes to improve image quality for more accurate readings. And once you're ready to set up the encoder, all that's needed is to move its wheel across the part — much more efficient than prior technology.

Most instruments have fixed menus for every single parameter. The latest technology allows you to simplify the entire calibration process, customizing it so that only the parameters you need are displayed for each individual step.



STEP 5:

Inspection

It's important to keep in mind that the design of the probe has a great deal of influence on the quality of coupling.

A good acoustic impedance match between the probe and material under test is necessary for efficient transmission of sound energy. Soft-faced rolling probes provide this match with minimal couplant needed, an important feature when working in wind turbine environments where large water flows are impractical. Wheel probe inspections also adapt well to variations in the surface of the blade.

If you're using a hard-faced probe — more often preferred for inspection of metallic specimens — the range of measurement can become restricted and inaccurate due to both the lighter wind blade material and the fact that sound doesn't travel well through the air. Further measurement errors can occur because of phase shifts in the echoes. Hard-faced probes require a flood of couplant (water) while scanning to ensure good sound transmission, while the soft roller probe works with a light spray of water.

For reliable wind blade inspection, probes using soft coupling surfaces suffer less from variation in the surface of the material under test, and make for a faster, more reliable inspection.

STEP 6:

Analysis

After setup of the parameters takes place and the inspection procedure is completed, the results are ready for analysis.

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Reporting has traditionally been a process of sifting through snapshots of data saved on the instrument, taken at specific indications. These were often simple signal views with accompanying setup parameters, but couldn't easily be examined with changes in setup.

The latest technology provides both rapid scanning and recording of all raw ultrasonic data while at high dynamic range. This allows the data to be analyzed later, in a more convenient location for making adjustments to gate positions and gain, for better zoom-in on detected defects. In short: Scan on the tower, analyze later on the ground.

In review

There are many components of wind turbines that require regular inspection, with wind blades being the most critical. Blade failure can have a significant impact on turbine downtime, safety and public exposure. With wind turbine blades posing a unique set of inspection challenges, the need for reliable and accurate inspections is essential for cost-effective operations — the most effective of which is phased array ultrasonic testing.

Our solution

Waygate Technologies has developed a phased array solution dedicated to the inspection of wind blades. Although their shape and structure add additional challenges, our Mentor UT system integrates customizable features, utilizing the user-friendly Mentor Create software interface that enables easy parameter setting (e.g., ultrasound power, amplifier, data sampling frequency, scanning range) and instrument operation with step-by-step guidance through the inspection process.

Apps built with Create provide a simple and focused solution to particular inspections. Apps may be simple, going straight to a known scanning setup, or step-by-step, leading the operator through needed checks and calibrations to inspection. All of the settings are saved, allowing for immediate setup when starting the app.

The RotoArray is an essential component for wind blade inspection, as it features a flexible, transparent tire that conforms with the blade, allowing air-free coupling to occur. The liquid sound connection is made within the tire, plus a fine spray of water on the surface of the part. Without the complexities of cables, the RotoArray can also cover larger surface areas than a single probe.

And should the need arise, Mentor UT is the first ultrasonic device to easily allow wireless connectivity and remote live-streaming, so inspectors can get a second opinion in real time. The ultrasonic device can even guide each inspector step by step, through specific app-based workflows you've customized, for a consistent and reliable wind blade inspection every time.

For the most optimal phased array ultrasonic inspection of wind blades, we recommend the following configuration:

Mentor UT Base Kit
[Part Number: 100N3883]

- Mentor UT Base Instrument
- Mentor AC/DC Power Supply
- External Battery
- Power Cord: USA, UK, or European
- Encoder Connectivity Module
- Mentor Create Software on USB
- Soft Carrying Case
- Transport Case
- Manual on USB

MUX 32:128 Mentor UT Connector
[Part Number: Mentor-UT-MUX-T]

Compatible with up to 128 element arrays. Standard Phasor connector. Also includes extra-hot swappable battery, HDMI, and ethernet ports. Compatible with DM and linear arrays.

Mentor UT RotoArray, 81.3 mm
[Part Number: 115-910-525]

500 KHz, 60el, 1.3 mm pitch, 8 mm elevation, Phasor connector

RotoArray Small Case Bundle
[Part Number: 389-087-380]

Includes small transportation storage case, and accessories necessary for RotoArray operation and maintenance.

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To learn more about this solution, or to customize the configuration that works for your specific needs, visit Waygate Technologies at waygate-tech.com

Waygate Technologies, formerly GE Inspection Technologies, is a global leader in NDT solutions with more than 125 years of experience in ensuring quality, safety and productivity.