



SINGLE VS TWIN CRYSTAL

Choosing the right UT probe for your Elios 3

Discover the different probe types compatible with the Elios 3
and their appropriate applications

The Elios 3 Drone and Ultrasonic Thickness Measurements in Non-Destructive Testing

The Elios 3 drone is a world-leading example of how robotics can be used to simplify and improve industrial inspections, including deploying non-destructive testing. In this guide, we explain how the ultrasonic testing (UT) probes compatible with the Elios 3 should be used according to the job at hand. This is a comprehensive resource, providing straightforward tables and a flowchart alongside in-depth explanations about the different probe types and available measurement modes. If, at its conclusion, you would like more information, you will find details of how to contact the Flyability team on the final page.

The [UT payload mounted on the Elios 3](#) was designed in partnership with [Cygnus Instruments](#), who have over 42 years of experience in ultrasonic thickness gauge design and production. Together, Flyability and Cygnus devised a custom UT system for the drone that includes Cygnus' electronics for UT, a choice of compatible ultrasonic probes, a smart probe arm, a couplant dispenser, and a cleaning module accessory. This payload, when correctly mounted, enables the drone to provide location-tagged accurate thickness measurements and, when using a twin crystal probe, a live A-scan.

This combination of a drone and UT system enables inspectors to take ultrasonic thickness measurements (UTM) of critical industrial structures in extreme environments, be it at height or in confined areas. The Elios 3 empowers remote access ultrasonic thickness gauging (UTG), with results trusted by industry leaders worldwide, including Classification Societies in the maritime sector. In addition, the Elios 3 offers prolonged flight time with its optional tether power unit delivering continuous power to the drone via a 50-meter (164-foot) cable. As a result, the Elios 3 can take on long data collection missions inside tanks and machinery, carrying out UT without risk to humans.

The Elios 3 supports a single crystal probe in addition to three twin crystal probes. On the following page you will find a flowchart outlining the correct uses for each ultrasonic probe, in line with guidance from both Flyability and the UT manufacturer, Cygnus Instruments.



The Elios 3 drone with the UT payload mounted, including a laser pointer to target the measurement area

Selecting the Correct Probe Based on the Test Material Conditions

FLOW CHART

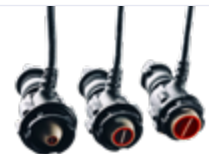
How to select the right UT probe type



Probe Compatibility with the Elios 3

The Elios 3 UT Payload can use three different frequencies of twin crystal (dual element) probes or a single crystal (single element) probe. This section explains the differences between the twin and single crystal probe types, along with the choice of probe frequencies.

Twin Crystal Probes



Probe	Frequency	Face size	Measuring range in steel		Typical applications
			Single Echo mode	Echo-Echo mode	
T2C	2.0 MHz	17 mm	2.5 – 350mm	5 – 50mm	Attenuative materials, where a large signal is required for sound penetration
T5B	5.0 MHz	13 mm	1.5 – 200mm	4 – 50mm	General purpose, surfaces with heavily corroded / pitted walls
T7A	7.5MHz	6mm	0.8 – 50mm	3 – 25mm	Small diameter pipes, thin, corroded plate

Single Crystal Probe



Probe	Frequency	Face size	Measuring range in steel	Typical applications
			Multiple Echo mode	
S2C	2.25 MHz	13 mm	3 – 250 mm	Standard probe, best for all-around measurement of wall thickness with moderate corrosion through coatings

The Twin Crystal Probe (or Transducer) Type

Three different twin crystal probe frequencies are available and compatible with the Elios 3 UT payload: 2 MHz, 5 MHz, and 7.5 MHz. As the name “twin” suggests, this probe type has two piezoelectric crystals or elements within it - one for transmitting ultrasound and the other for receiving the echo or return signal. These two crystals are housed within the probe at a slight angle, creating a “V” shaped path for the ultrasound energy, focusing the sound beam to a point in the back wall of the material under test and enabling it to return to the receiving crystal. This V shape mitigates scatter from back wall corrosion and loss of signal (attenuation) during the thickness measurements, making it the preferred choice when assessing corroded material. It is effective in measuring through thin coatings when Echo-Echo mode is deployed.

The lower frequency option is better for attenuative materials where sound penetration is required. The 2.0 MHz twin-crystal probe can measure the thickness of carbon steel between 2.5 - 350 mm in Single Echo measuring mode or 5 – 50 mm in Echo-Echo mode.

The medium frequency (5.0 MHz) model is better suited for general surfaces that are heavily corroded or pitted and can achieve measurements of slightly thinner materials. The 5.0 MHz twin-crystal probe can measure 1.5 - 200 mm of carbon steel in Single Echo mode or 4 – 50 mm in Echo-Echo mode.

The final, highest frequency (7.5 MHz) twin-crystal probe is best suited for small diameter pipes or thin, corroded plates. This probe can measure carbon steel between 0.8 mm to 50 mm thick in Single Echo mode or 3 – 25 mm in Echo-Echo mode.

All of the above ranges are based on measurements of carbon steel. However, other materials have different velocities of sound and thus the probes have different measuring ranges specific to other metals and dense plastics. More information on this is available on the [Cygnus Instruments website](#), where example materials are listed, but it’s always recommended to calibrate the UT Payload with a sample or known thickness of the exact material under test.



*The different twin crystal probes
available for the Elios 3*

The Single Crystal Probe (or Transducer) Type

There is only one single crystal probe currently supported by the Elios 3 UT Payload. This probe or transducer features one piezoelectric crystal housed within it, which both emits and receives ultrasound at a frequency of 2.25 MHz. The UT Payload operates this probe by rapidly switching between transmitting and receiving a signal.

The single crystal probe is used in Multiple Echo measuring mode and is very effective at measuring material thickness through coatings. Even when thick or multi-layered coatings are present, this probe will only capture the metal thickness that sits behind the coating. An additional benefit is the Multiple Echo technique self-verifies, ensuring an accurate result regardless of whether the test surface is coated or not.

The 2.25 MHz single crystal probe can measure 3 - 250 mm of carbon steel, and the probe face itself is only 13mm wide. This probe is best for all-around measurements for wall thickness, including material which is coated and moderately corroded. This is the most commonly used probe in the maritime sector.

All metals have different velocities of sound and therefore, the single crystal probe has different measurement ranges when measuring different materials. More information on this is available on the [Cygnus Instruments website](https://www.flyability.com/cygnus-instruments), where example materials are listed, but it's always recommended to calibrate the UT Payload with a sample or known thickness of the exact material under test.

Cygnus Instruments recommends that operators with limited UT experience should only use the S2C (single crystal 2.25 MHz) probe with Multiple Echo mode, while operators with a Level 1 or above UT qualification can consider using the twin crystal probes with the other (Single Echo or Echo-Echo) measuring modes, together with A-scan analysis to verify measurements taken.



*The new single crystal probe
for the Elios 3*

Measurement Modes

There are 3 available measurement modes for the Elios 3 UT payload, each of which is deployed according to the combination of the probe type, how corroded the material under test is, the presence or absence of coating(s), and material type and thickness.

I **Single Echo Mode: using 1 back wall echo.**

In this mode, a probe emits a pulse of ultrasound into the material under test and the system measures the time taken between the sound's emission and its reflection (from the back wall of the material) returning to the probe. The user always calibrates the UT payload to the correct speed of sound for the material being measured, so the device calculates the distance traveled by the sound within the material and therefore its thickness. Please note that in Single Echo mode, the thickness of any surface coating is included within the overall measurement, making this mode unsuitable for measuring coated materials (including paint). This measurement mode is best suited for extremely corroded bare metal or dense plastics, but cannot be used for coated material. In the case of the Elios 3's UT payload, Single Echo mode is compatible with any twin crystal probe but readings will be incorrect if a coating is present.

II **Echo-Echo Mode: using 2 back wall echoes.**

When using this measurement mode, the probe emits a pulse of ultrasound into the material under test and the system listens for both its first and second reflections from the back wall, generated by the sound bouncing back and forth within the material. The UT payload then compares the time taken between the first and second return echoes, which gives the distance traveled within the material behind a coated surface. Unlike Single Echo mode, the Echo-to-Echo method can ignore a thin layer of paint (no thicker than 1 mm). The key advantage of this method is that it can ignore thinner coatings, whilst also being effective when backwall corrosion is present. It is also more accurate than the Single Echo measurement method, making it a good, general-purpose mode. Echo-Echo mode is offered by the Elios 3's UT Payload and can be used with any twin crystal probe, but should be deployed with care, as readings will be incorrect if a thick coating is present.

III **Multiple Echo Mode: using 3 back wall echoes.**

In Multiple Echo measurement mode, the specialist single-crystal probe transmits into the test surface a pulse of ultrasound, which then bounces back and forth multiple times within the material (between its front and back walls). In Multiple Echo mode, the Elios 3 UT Payload records the time taken for the second and third reflections to return from the back wall. By matching the timings of the second and third echoes, the device can verify if the calculated distance is correct before confirming an accurate thickness measurement. The power of this measurement technique is that it can effectively ignore coatings. Provided the coating is well-bonded to the surface of the structure being inspected, there's no need to remove the coating to measure the base material which sits behind the coating. Even a coating as thick as 20 mm can be ignored in optimal conditions (i.e. a clean back wall with a good bond between the coating and material, and where both the coating and test material are non-attenuative, such as a paint coating on steel). This measurement mode is deployed with the Elios 3's single-crystal probe and can measure base metal through a range of more challenging coating materials, including rubber, glass, 3LPP, 3LP*, FBE, Epoxy, and GRE. It can even measure through layered coatings and still give an accurate, verified reading for only the base material thickness. Multiple Echo mode is limited by heavy corrosion and pitting on the back wall, and a very thick or deep coating can reduce the probe's maximum measuring range of the base material.

Regardless of the selected measurement mode, we recommend that inspectors should be UT qualified and verify measurements by analyzing the A-scan provided in our user interface software.

Where possible, it is preferable to use Echo-Echo mode with the twin crystal probes. With the single crystal probe, you should always be using Multi-Echo mode.

Why Are These Probes Appropriate for the Elios 3 UT Payload?

The probe options provided in the UT Payload for the Elios 3 are based on Cygnus Instruments' 42 years of experience in designing, manufacturing, and supplying ultrasonic thickness gauges (UTG) across multiple industries and markets. These are the most commonly used in the industrial sectors where the Elios 3 is already present, including oil and gas non-destructive testing (NDT) and maritime. They have been tailored by Flyability and Cygnus Instruments to suit a wide range of possible applications and the UT Payload has been optimised to take quick measurements whilst in flight, equipping the drone for a variety of challenging environments.

When deployed, the selected probe is mounted on the Elios 3 via the smart arm. The smart arm was specifically designed to give flexibility and imitate the human hand to maneuver and adjust according to the structure being measured. Flyability's optimisation of the Elios 3's flight control software, laser target for probe contact and couplant release design all serve to enhance this adaptability.



Thanks to the design of the UT payload and Cygnus Instruments' UTG technology, there is the potential to expand the number of probes supported by the Elios 3. As it is, 90% of the applications for thickness measurements are already covered by the probes that are already compatible with the Elios 3.

Getting Started with the Elios 3 UT Payload

The Elios 3 UT payload is capable of non-destructive testing inside tanks, ships, and pipes, entering confined and dangerous spaces to gather thickness measurement data without putting people at risk.

Based on this guide, you should have a clear understanding of how to select the right probe for the job at hand. We also recommend completing the UT (ultrasonic testing) [training from the Flyability team](#) to ensure you are comfortable with using the UT payload on the drone, as well as being UT certified by a relevant authority. Want to learn more? Head to the [Flyability Knowledge Base](#)!

