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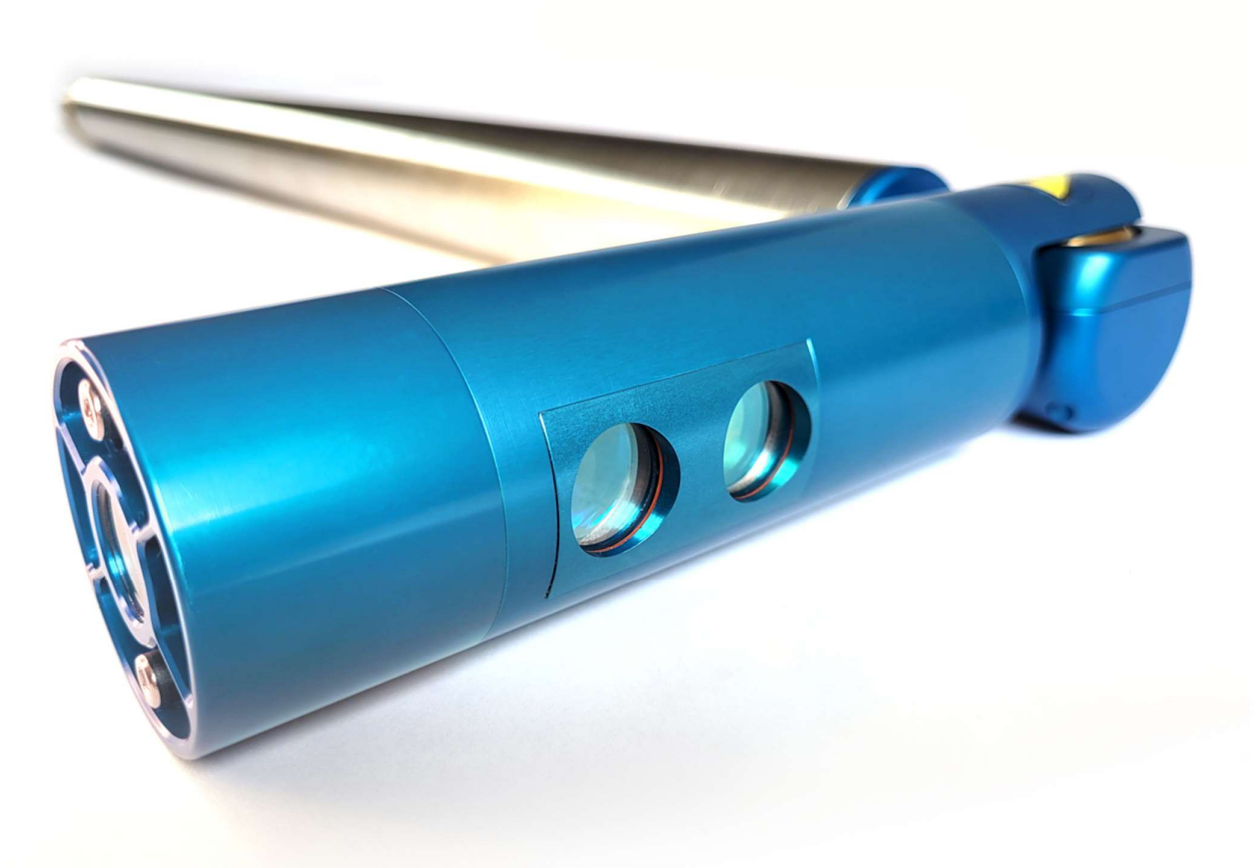
C-ALS HD

Underground cavity scanning system

Hardware manual



Contents

1 Customer information

1.1 Dear customer

The C-ALS HD system is designed to be easy to operate. However, we would ask you to take the time to read these operating instructions carefully before using the system, and to keep the manual with the instrument at all times.

For any feedback or comments, or if there are questions about the C-ALS HD system which are beyond the scope of this manual, contact the product support department at Carlson, or your local Carlson representative.

Alternatively, for information on your local Carlson-approved service centre, visit our website at www.carlsonsw.com.

To ensure best service, please make a note of the serial number. This can be found on a label on the C-ALS probe.

1.2 Head office contacts

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1.3 User manual

It is important that you read this manual carefully before using the instrument.

There are two manuals available with the C-ALS HD system, both of which are loaded onto the supplied Carlson USB drive:

- This C-ALS HD hardware manual, which gives a full description of the hardware components of the C-ALS HD system and some optional accessories.
- A **Carlson Scan** software and operations manual.

It is essential that the accompanying **Carlson Scan** software and operations manual is read and understood. As well as describing the software, that manual gives an overview of a typical deployment. Some troubleshooting guidelines are also offered which address the most common problems and questions that arise from users of the C-ALS HD.

This manual has been compiled with care. However, should you discover any errors, we would be grateful if you could contact Carlson directly. The information in this document is subject to change without notice.

1.3.1 Manual version

The document number of this manual is H-5913-8500-02-D. Compiled in January 2024.

The manual is based on C-ALS HD units running firmware version 1.1.5.2.

Manual version H-5913-8500-02-D

- *Tidy of formatting and references throughout.*
- *'Calibration' changed to 'Alignment' throughout to match software terminology changes.*

Manual version H-5913-8500-02-C

- *Updated photos to account for design changes from C-ALS Gyro to C-ALS HD.*
- *Added 'Basic inspection of voids' to camera applications (section 2.1.3).*
- *Changed Surface unit voltage rating (2.3).*
- *Added warning regarding mixing surface units for different versions of C-ALS (2.3 & 3).*
- *Added Sling ring drum and Slip ring drum with winch sections (2.4).*
- *Updated Specifications table (5).*

2 Introduction

1.4 Features

Carlson's C-ALS HD is a ruggedised 3D laser scanning system. With a diameter of just 50 mm, the unit is designed to be deployable through boreholes for surveys of underground voids and cavities. The C-ALS HD remotely measures the three-dimensional shape of the void and, through the accompanying software, can produce a detailed digital model of the surveyed space.

Figure 1 The C-ALS in use

The instrument employs the 'time-of-flight' laser measurement technique to measure ranges to rock faces and other surfaces without the need to place reflectors on the target. This allows accurate measurements to be made of inaccessible areas such as ore passes and cavities.

A motorised 2-axis scanning head ensures a complete 360° scan covering the entire void up to a range of 150 m.

The C-ALS probe incorporates a miniature, inertial measurement unit (IMU) which contains a triaxial accelerometer, magnetometer, and gyro. The IMU provides the C-ALS HD with an accurate heading and inclination.

An integrated borehole camera in the 'nose' of the unit aids deployment and placement of the scanning head.

1.5 Deployment

The C-ALS HD system is most commonly lowered along a borehole using the supplied, load-bearing main cable.

During the deployment, the main C-ALS cable provides power to the C-ALS probe and enables two-way data communications between the C-ALS HD and a Windows tablet running **Carlson Scan** software.

Prior to deployment, the C-ALS probe is aligned against a known orientation on a supplied jig. This establishes a starting, reference heading for the gyro. The known coordinate of the hole collar gives a starting location for the survey.

Readings of the internal IMU are taken at fixed intervals as the C-ALS probe is deployed along the borehole. At each of these intervals, information from the sensors is collected, and coordinates are calculated with reference back to the known collar location. Thus, a picture of the path that the C-ALS probe has taken is built up. The IMU sensors also enable accurate positioning of the unit when it is scanning and ensure that each point in the resulting 'point cloud' can be correctly geo-referenced.

Carlson Scan software enables the C-ALS HD to be controlled remotely by operators in a safe location. The deployment, the borehole video and all scans can be viewed on-screen in real-time.

Carlson Scan software processes the data for editing, viewing and export to third-party modelling and CAD packages.

2 Hardware components

This section details the full range of components that are available in a C-ALS HD system. As various models of the C-ALS have been produced and supplied, and the technology is constantly evolving and improving, some components described below may not feature in every C-ALS HD system, or may differ in some way.

2.1 Probe

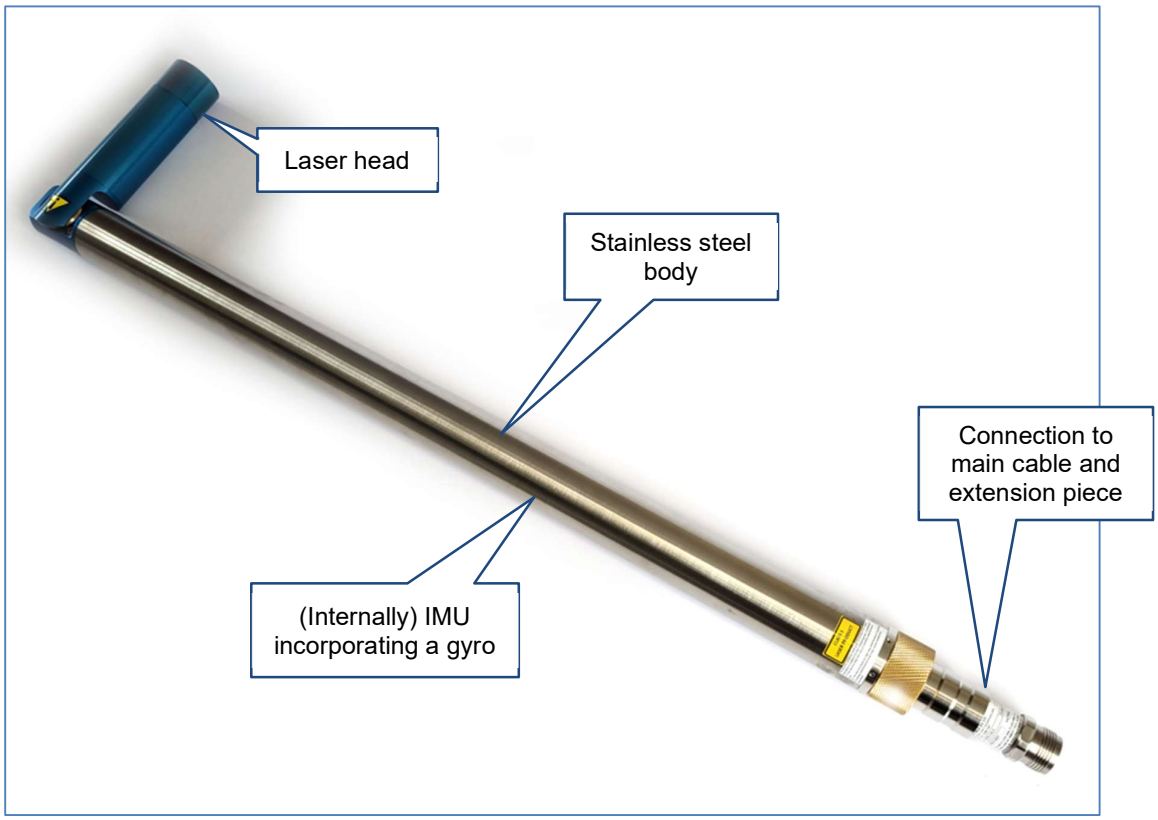


Figure 2 C-ALS HD probe

2.1.1 Laser head

The C-ALS probe incorporates the laser head, which contains the measuring laser module. The laser head is constructed of lightweight aluminium.

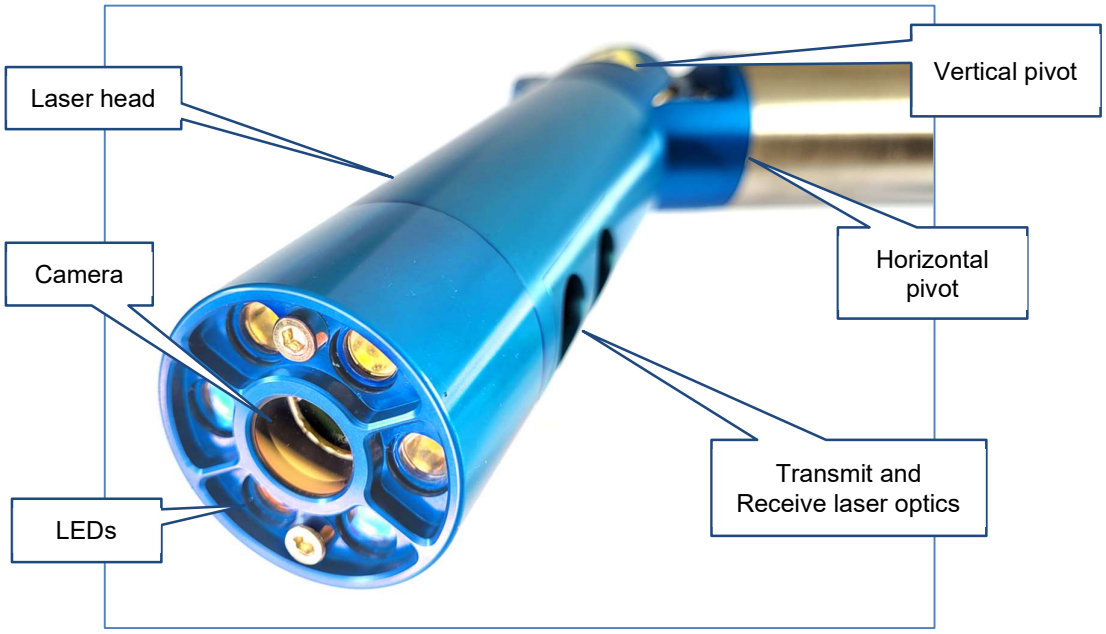


Figure 3 C-ALS HD Laser head and borehole camera

The laser head is designed to enable full 360° coverage for all surveys. Servo-driven gear systems within the C-ALS probe drive a pivot for both vertical and horizontal movement. Both drive systems incorporate a clutch mechanism coupled with firmware control to minimise the risk of damage if the laser head becomes obstructed during scanning operations.

The brake on the vertical motor is only engaged once power is connected to the probe. When power is removed from the probe, each axis is able to rotate and will back-drive the gearing and motor. This is most noticeable in the vertical motion, and the laser head may be seen to swing vertically as gravity pulls the laser head down on the vertical pivot. This movement will not damage the probe drive system.

To run a full scan, the laser head requires at least 20 cm clearance from the vertical pivot, on all sides of the probe.

Note that the laser head around the camera may become hot when the C-ALS HD is powered ON with the LEDs fully lit.

2.1.2 Probe body

The probe housing is constructed of robust stainless steel. The accelerometers and optional gyro, which monitor the inclination and heading of the probe, are contained within this housing.

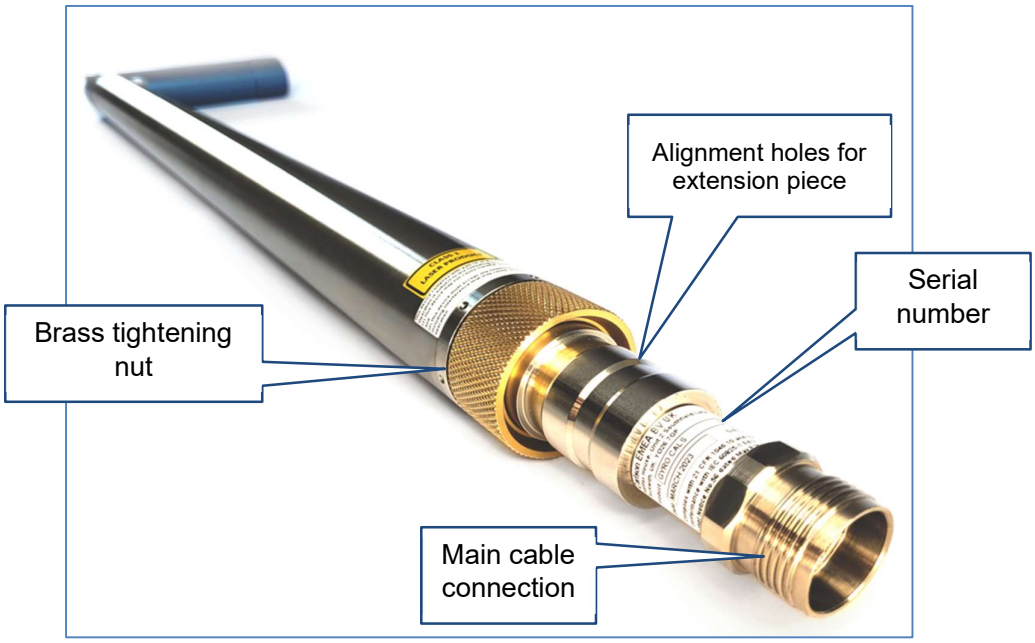


Figure 4 C-ALS HD probe end

A connector at the opposite end of the C-ALS to the laser head provides the connection point for the main C-ALS power/data cable. Above this connector are alignment holes and a brass tightening nut, both of which are designed to ensure the extension piece can be securely fixed to the probe in the correct alignment (see section 2.2).

The C-ALS serial number label is on the probe beside the main cable connection.

2.1.3 Camera

The nose of the laser head incorporates a high definition camera, which is designed to be used during the deployment of the C-ALS probe (Figure 3). LEDs around the camera provide sufficient lighting to illuminate the borehole in front of the C-ALS probe as it is deployed, and then up to 25 m in the void for inspection purposes.

The camera serves three purposes:

1. To gauge the distance that the probe is deployed beyond the 'breakout' point of the borehole. The laser head and the rotating horizontal shaft must be deployed far enough from the borehole to ensure unrestricted motion. However, the C-ALS probe must not be so far out of the borehole that its full length 'flops' into the void. If this occurs, it may be impossible to retrieve the unit. Thus, it is critical that the unit is deployed within these two limits.

2. To check the condition of the borehole. The camera will pick up any obstructions, blockages or 'cave-ins'. This can help to manage the deployment and, where necessary, to protect the C-ALS probe from potential damage.

3. Basic inspection of voids.

The first two functions can be carried out during the deployment at the same time as IMU readings are being taken. This negates the need to deploy a separate camera system down the borehole prior to using the C-ALS HD. However, in some circumstances – for example, if there are concerns about the stability of the borehole – it is

advisable that, prior to using the C-ALS HD, a separate camera should be deployed down the borehole. In this way the condition of the borehole can be checked before the C-ALS probe is deployed and put at risk.

2.2 Extension piece

The extension piece is constructed of stainless steel and incorporates an adaptor for attaching Boretrak rods (Figure 5).

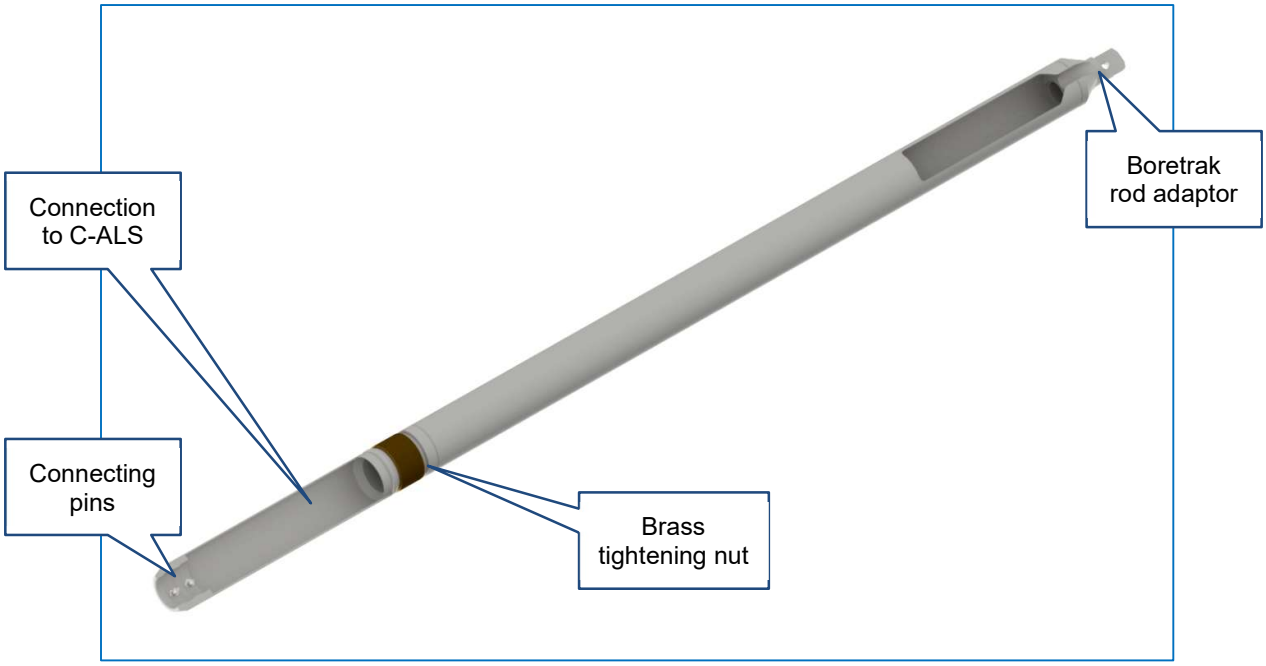


Figure 5 C-ALS HD Extension piece

The extension piece gives greater length to the probe, allowing more scope for the C-ALS HD to be held further out into the void. It also helps to increase the stability of the probe while it is scanning.

The extension piece is attached to the C-ALS probe by aligning the two connecting pins on the extension piece with the two alignment holes on the probe. The two brass nuts (one on the extension piece, the other on the probe) can then be tightened around the separate cover piece (Figure 6).

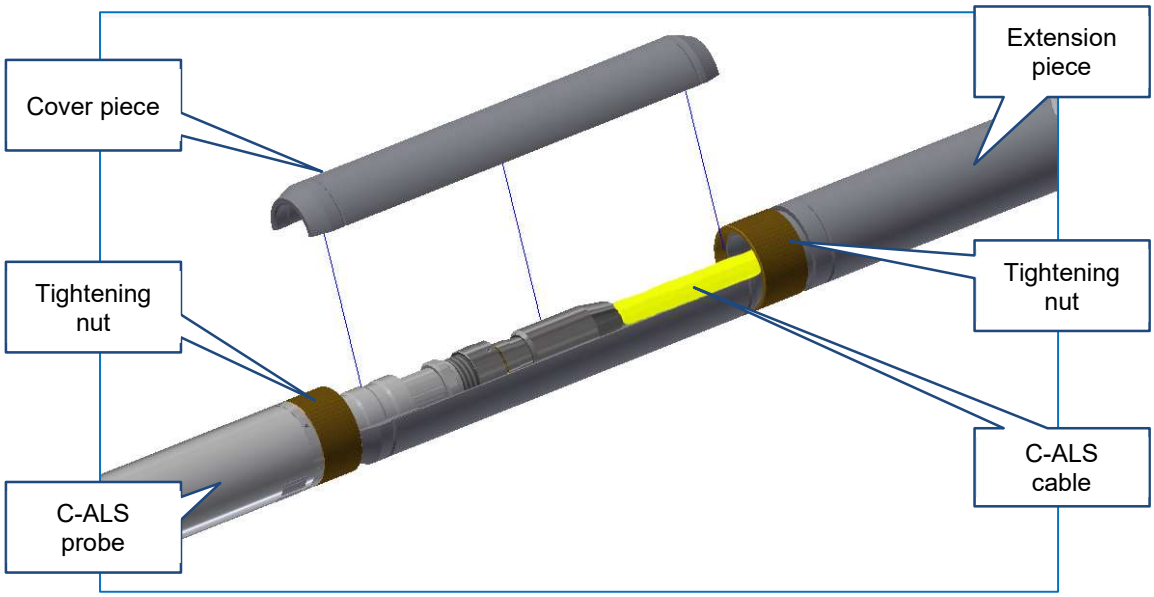


Figure 6 Attaching the cover piece

The main C-ALS cable must be threaded through the extension piece and connected to the probe before the extension piece is connected to the probe.

The 'scan origin' – to which all laser measurements and IMU readings are reduced – is inside the probe at the vertical pivot point. From this point back to the hole in the rod adaptor is exactly 2 m.

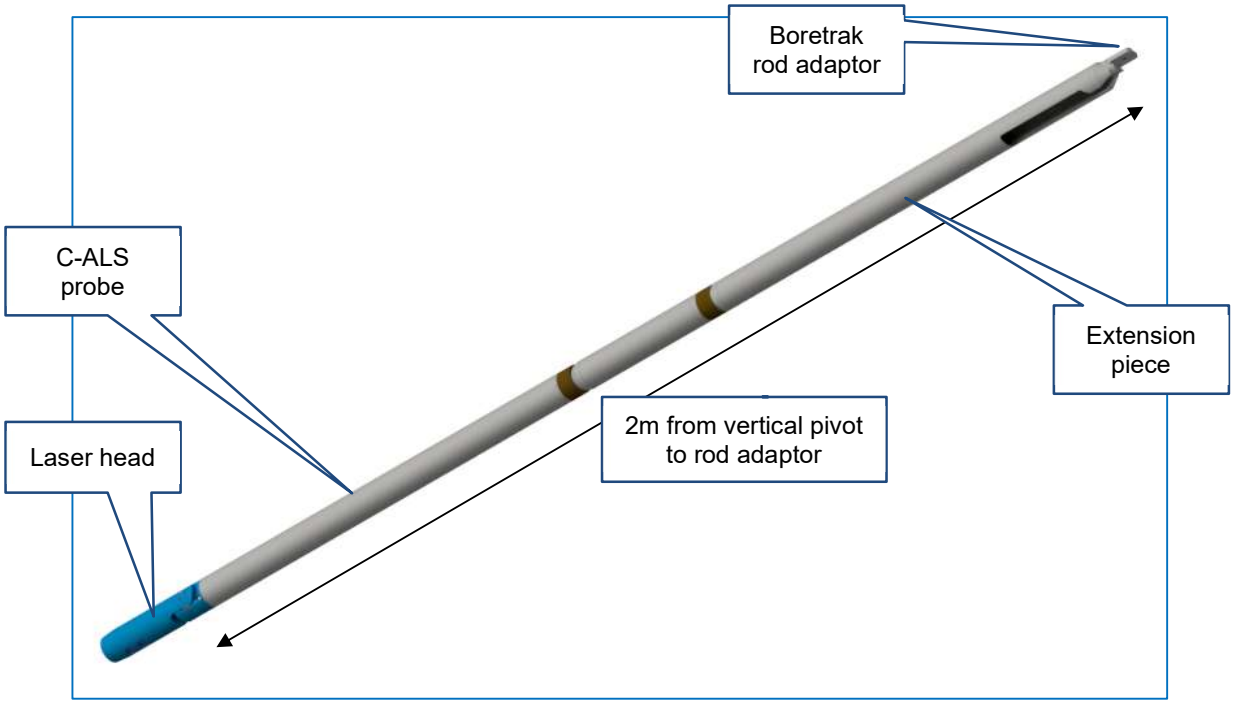


Figure 7 Complete unit with probe and extension piece

2.3 Surface unit

The surface unit is housed in a durable, watertight 'Peli' case (Figure 8). It manages the communications and power requirements of the C-ALS probe.

Figure 8 Surface unit

The surface unit incorporates four Mil-Spec connectors which accept the supplied cables (Figure 9):

- The main C-ALS cable, which connects directly to the probe. The main cable supplies power to the probe and enables two-way data communications between the probe and the PC.
- An Ethernet cable that connects the surface unit to the PC running C-ALS control software. As an alternative to using this cable, a Wi-Fi base unit inside the surface unit allows wireless connectivity.
- Two identical power connections to supply power to the surface unit from an external power source. Either, or both, of these ports can be used to supply power to the unit. This allows 'hot-swapping' between, or simultaneous use of, two different power sources.

Figure 9 Surface unit connections from left to right: main C-ALS cable, data cable, one power cable and a spare connector for an additional power cable

The surface unit is powered from an external source of 11.5-15 Vdc. A mains adaptor (110-240 Vac input) and a

cable with crocodile clip connectors are included with the system for this purpose, together with a dedicated lead acid battery and connecting cable. All three of these power cable options fit the two power connectors on the side of the surface unit.

Underneath the lid of the surface unit is the internal panel (Figure 10). This incorporates the ON/OFF switch which powers up the C-ALS system and sends power to the probe. An LED indicates that the surface unit is switched ON.

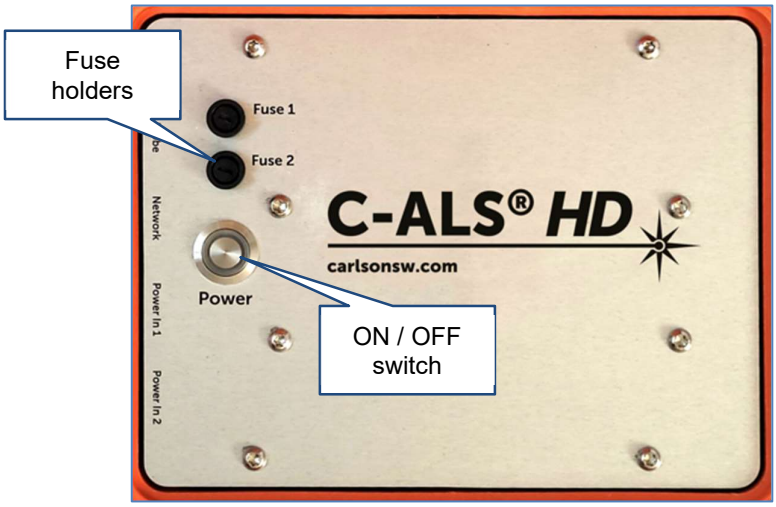


Figure 10 Surface unit internal panel

The surface unit is fused for use with two external power sources. The fuses are located in holders mounted inside the unit. T3.15 A anti-surge fuses are used.

The Wi-Fi antenna is housed inside the surface unit. In good conditions, the wireless datalink will work at up to 50 m if there is a line-of-sight between the PC and the surface unit.

Keep the lid of the surface unit closed during operations to maximise protection against water ingress. Closing the lid does not affect the performance of the Wi-Fi signal.

The supplied surface unit can be used with any C-ALS HD unit. However, it should <u>never</u> be used with an earlier C-ALS model such as a C-ALS Gyro, standard C-ALS or C-ALS mk3 unit. These earlier models would have been supplied with a yellow surface unit incorporating a LEMO connector for the main C-ALS cable.

Using a C-ALS HD surface unit with an earlier C-ALS model, will void any product warranty and could cause serious damage to the C-ALS probe. Check the serial label on the C-ALS probe to confirm which variety of C-ALS you are working with. Alternatively, contact Carlson for further information.

Figure 11 C-ALS Gyro (left) / C-ALS Mk3 (centre) models should not be used with the C-ALS HD surface unit. These C-ALS probes would have been supplied with a yellow surface unit (right).

2.4 Main C-ALS cable

The main C-ALS cable delivers power to the probe, enables two-way data communications and carries the video signal from the borehole camera.

The main cable can be supplied in various lengths, up to a maximum of 205 m. A moulded connector on one end screws into the threaded end of the C-ALS probe. At the other end is a Mil-Spec connector. This connects either directly to the surface unit or to the inside of the slip ring drum.

The main cable and its connectors are highly durable. The cable and the moulded connector have a breaking strain of 500 kg.

The main cable is marked at metre intervals by alternate red and black rubber nodules to ensure regular, accurate intervals between IMU readings as the probe is deployed into the hole.

An unmarked, 5 m section of main cable is supplied with every C-ALS system. This can be used for operations where there is only a very short deployment necessary or to facilitate simple system tests in an office environment.

This short cable is also used to connect the optional slip ring drum to the surface unit.

Figure 12 C-ALS main power/data cable on reel (left) and short 5m cable (right)

By default, the main cable is supplied wound onto a simple steel drum. There is no slip ring in the drum so, before connecting the cable to the surface unit and the C-ALS probe, unspool as much cable as will be needed for the operation.

2.5 Slip ring drum

The C-ALS cable can be also supplied on an optional slip ring drum.

The slip ring ensures that the cable can be reeled out and hauled back in while still retaining a connection to the surface unit.

The Mil-Spec end of the C-ALS cable attaches to a connector on the inside of the drum.

Figure 13 Slip ring drum

The short 5 m test cable runs from the connector on the outside of the drum frame to the appropriately sized Mil-Spec connector on the surface unit.

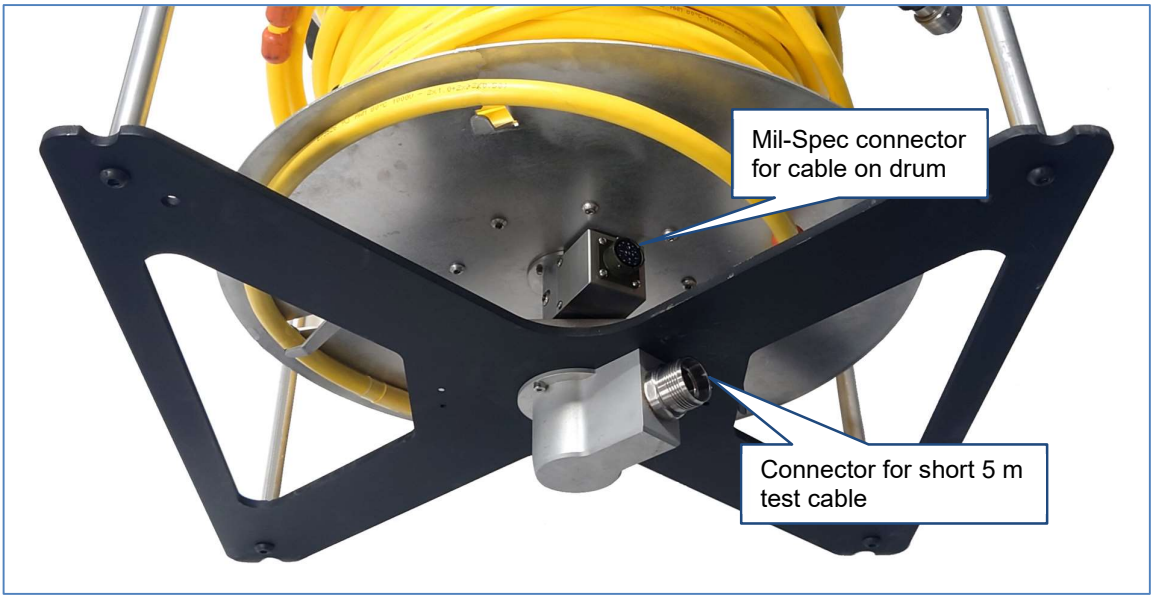


Figure 14 Connectors on the slip ring drum

An ungeared handle is used to wind the cable back onto the reel.

When using any drum in the field, ensure that it is secured in place during a deployment and while a scan is taking place.

2.5.1 Slip ring drum with winch

A further option is a winch attachment on the side of the slip ring drum.

An inbuilt brake ensures that the reel is kept under control and holds fast under load.

To disengage the brake and allow free unspooling, fully unscrew the handle hub to expose the retaining thread.

The handle can be detached from the handle hub. This exposes a ¼" square connection point on the handle hub. Use a battery-powered hand drill with a ¼" socket attachment to haul in the cable.

The gear ratios on the winch can be switched between 4:1 for manual winding, and 24:1 for winding with the drill.

To switch to the lower gear, push the gear lever towards the drum. Apply pressure to both sides of the gear lever to shift between the two possible positions.

Figure 15 Winch handle and gear lever

Figure 16 Handle hub removed to allow free spooling

Figure 17 Sliding the gear lever to change to a lower gear

Note that in order to change the gear, you may need to turn the handle until the gear lever engages. In addition, if there is a load on the winch, you may need to briefly take the weight off the winch in order to change the gear.

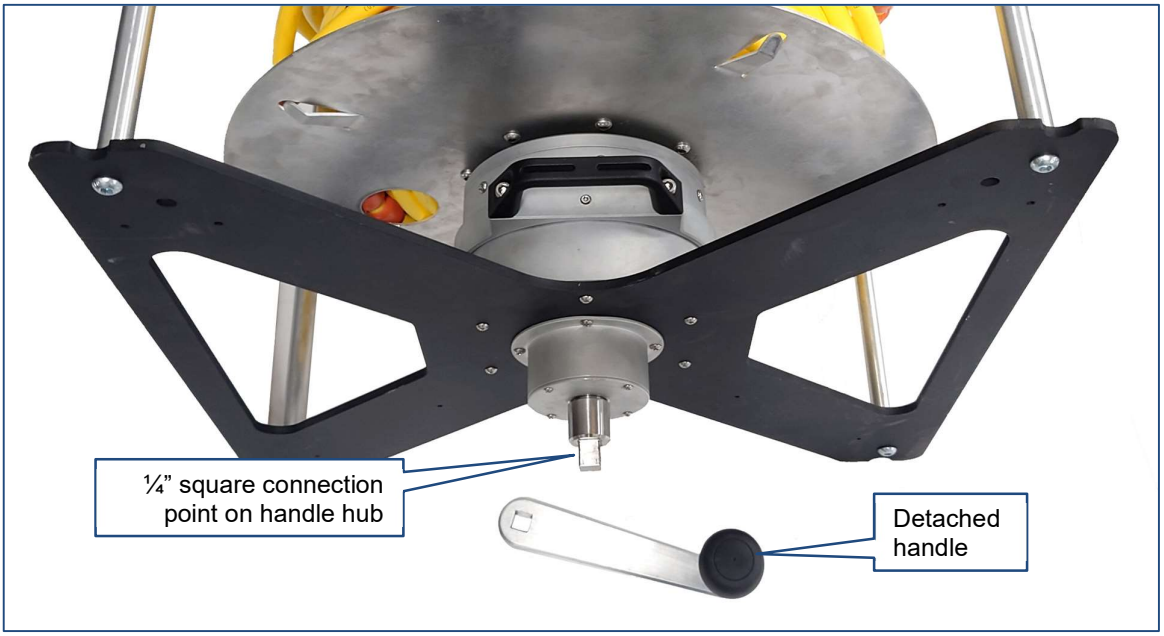


Figure 18 Winch handle removed showing the 1/4" square attachment

Figure 19 Drill with 1/4" socket attachment

Using a drill, the winch can be raised around 13 m / minute.

Figure 20 Using a drill to operate the winch

Note: when using a hand drill, it should be set to the highest clutch setting in conjunction with the 'screw' symbol.

Do not use the drill settings showing a 'drill bit' or a 'hammer' symbol.

An incorrect selection could cause injury or damage to the equipment. It is the user's responsibility to select and correctly operate the drill equipment and to correctly manage

2.6 Battery pack

The C-ALS HD requires a 11.5 Vdc to 15 Vdc power source. This can be supplied from a mains power adaptor or a third-party battery (see section 2.7). However, a dedicated battery pack is also supplied with the system (Figure 21).

This lead acid battery pack is rated to 7 Ah, which will allow continuous operation for up to 2 hours before recharging. To optimise the battery life, ensure that the C-ALS camera LEDs are turned off during scanning.

Figure 21 Battery pack

The battery pack is fitted with two connectors: one with three pins, and one with four pins. The 4-pin connector is labelled **Power/Scanner**. This will accept the black battery cable which attaches directly to the surface unit or interface box (Figure 22).

The 3-pin connector is labelled **Data.** This is not required for C-ALS operations.

Please note: Australian and New Zealand customers are supplied with the DC power cable only. Users must use a certified 12 V power supply. Carlson Software staff in Australia will provide alternative options that meet compliance requirements. Advice may change without notice, please contact Carlson staff for up-to-date offerings.

Figure 22 Battery cable (left) and battery charger (right)

A separate battery charger is supplied, which plugs directly into a mains power socket and connects to the battery pack through the 4-pin power connector (Figure 22). A fully discharged battery requires between 12 and 16 hours to charge. The battery charger is supplied with a selection of plug types to fit mains sockets around the world. An LED on the charger shows an amber light while charging and a green light when the battery is fully charged.

All batteries contain highly reactive, poisonous and corrosive chemicals, which are hazardous if released due to physical damage. Should the battery or battery charger approach end-of-life, become non-functional or damaged, stop using it and request a replacement unit from a Carlson-approved source.

2.7 Alternate power cables

The C-ALS HD requires a 11.5 Vdc to 15 Vdc power source, input into the surface unit. The power can be provided by the supplied Carlson battery (see section 2.6) or by a third-party battery or from a mains power adaptor.

The supplied power adaptor connects the surface unit to a standard mains power supply 110 Vac to 240 Vac (Figure 23). A standard 'kettle' cable connects the power adaptor to the mains socket.

A second power cable is provided for use with an external dc source (Figure 23). This cable incorporates two crocodile clips which can be used to connect to the positive (red) and negative (black) terminals of a battery.

Figure 23 DC power cable (left) and AC power adaptor (right)

Any voltage source connected to the C-ALS surface unit must be from a regulated supply and must be within the specified voltage range. This includes car batteries as an acceptable stand-alone power source, but does not include a car battery connected to a powered vehicle or from a dc power generator.

2.8 Ethernet cable

An Ethernet cable connects the surface unit to the PC running **Carlson Scan** software (Figure 24). Alternatively, use the Wi-Fi connection to link to your PC.

Figure 24 Ethernet cable

2.9 Boretrak rods

The lightweight Boretrak rods are designed to deploy and stabilise the C-ALS probe.

Since the C-ALS probe incorporates an IMU it is possible to deploy it directly into a borehole on a cable alone. However, there may be some circumstances where it is still advisable to use Boretrak rods to stabilize the probe during deployment and during the scanning process.

Using rods with a C-ALS HD system ensures that the probe cannot exceed the 400°/sec maximum rotation rate during a deployment.

Boretrak rods are certainly required if the borehole is horizontal or uphole. In this case the probe must be pushed with the rods.

The rods are available in one-metre sections and are provided in a rack (Figure 25). The rod rack can accommodate two stacks of eighteen rods.

Figure 25 Rack of rods

Figure 26 Quick release joint

The first rod incorporates a metal, male quick release joint which connects to the rod adaptor on the C-ALS extension piece. It also connects to the female quick release joint on the last rod on the bottom of a previous stack

(Figure 26).

The sections of fibreglass rods are designed to be flexible, but the hinges between them ensure that the probe cannot twist from its original orientation. Special hinges for uphole or horizontal deployment are available (Figure 28). These help to lock the rods in place as they are pushed into a hole.

Figure 27 Standard rod joint

Figure 28 Uphole rod joint

The Boretrak rods are designed to be load-bearing along their length (tensional loads) so they can withstand the weight of a C-ALS deployment. However, take care not to force the rods in a twisting action (torsional loads) or a lever action (transversal loads).

When the probe is held in position to scan, avoid fixing the rods in a position where the weight of the deployed equipment is putting stress in a lever action across the length of the rod which is positioned outside the hole collar.

See the C-ALS software and operations manual for further details on rod use and recommendations for best practice.

Check the rods and hinges prior to every deployment. Ensure that they are in good condition, that there is no apparent 'twist' in the rods, and that all nuts and bolts and connecting pins are in place and secure. Should any rod approach end-of-life, become non-functional or damaged, stop using it immediately and request a replacement from a Carlson-approved source.

2.10 Transit case

The C-ALS and accessories are supplied in rugged transit cases to protect the system from damage and from the environment.

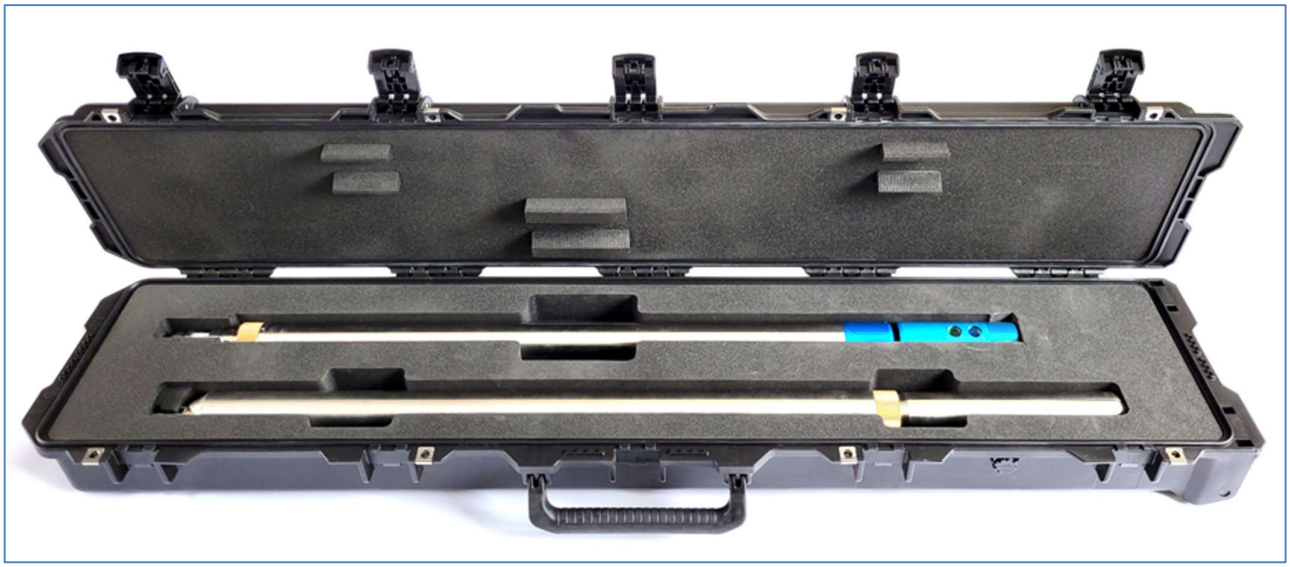


Figure 29 C-ALS probe and extension piece in their transit case

The probe and extension piece are grouped together in a ‘rifle’ case for easy shipping and transit on-site (Figure 29).

The other system accessories including the surface unit, battery and associated cables are supplied in an accompanying Peli case (Figure 30).

Figure 30 C-ALS accessories in their transit case

2.11 Alignment jig

An alignment jig is supplied with all C-ALS HD systems. When in use, the gyro must be aligned at the start of every survey session. The alignment performs two functions:

- The probe is held absolutely stable during the alignment, which allows the C-ALS to monitor and model any systematic drift in the gyro without having to account for any noise from movement or vibration.
- The gyro is not a north-seeking device so an initial starting azimuth must be defined. The starting azimuth forms the basis of all subsequent orientation data collected over the course of a deployment. During the alignment therefore, the probe is held in a position where the starting azimuth can be surveyed.

The aim of the jig then is to provide a simple platform which holds the probe stable during the alignment, and which provides a basis from which to survey an accurate heading.

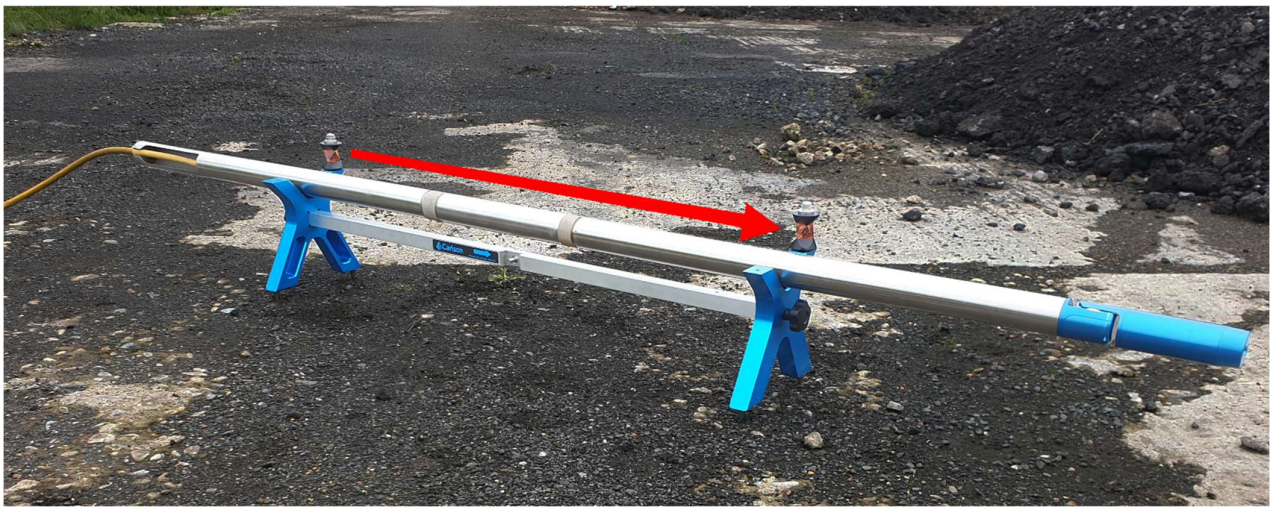


Figure 31 C-ALS HD on an alignment jig

Figure 31 shows the C-ALS probe held for horizontal alignment.

Two 360° prisms are supplied with the jig and there are threads for these prisms on top of the end-pieces. Survey between the two prisms (from the back of the C-ALS probe towards the scanning head) to establish your starting heading.

For horizontal alignments, the feet on the end-pieces have detachable spikes which can be stamped into the ground to ensure the jig does not move (Figure 32). Subsequent alignments can thus be repeatable, if required, or else the jig can be left in place for a surveyor to shoot in with their total station after the deployment.

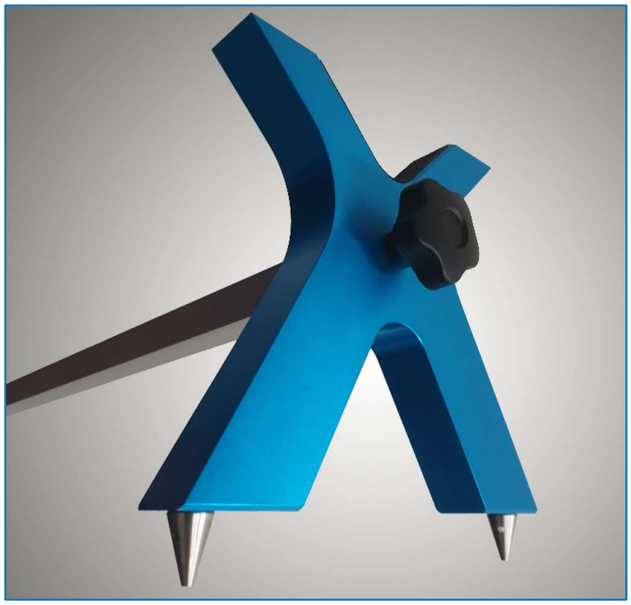


Figure 32 Alignment jig end-piece

The alignment jig is designed to be dismantled for storage and transit.

The end-pieces can be disconnected by unscrewing the two end-bolts.

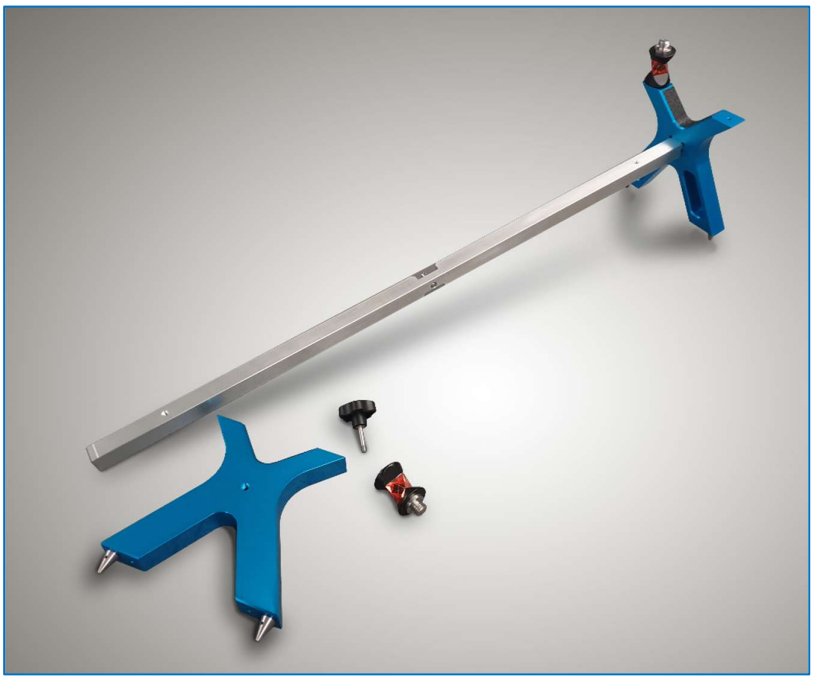


Figure 33 Removing the end-pieces

With the end-pieces disconnected, use the bar on its own for vertical alignments. The adaptor pin in the centre of the bar is the same as that on a lead Boretrak rod (Figure 33).

Figure 34 Adaptor pin for vertical alignments

Figure 35 C-ALS hanging from adaptor for vertical alignment

The bar can sit on the collar with the probe in the hole. There are additional threads on either end of the bar for the prisms (Figure 36).

Again, survey between the two prisms to establish the starting heading of the gyro. A sticker on the bar denotes the correct direction to survey along the bar: looking along the bar with the adaptor pin pointing to the right.

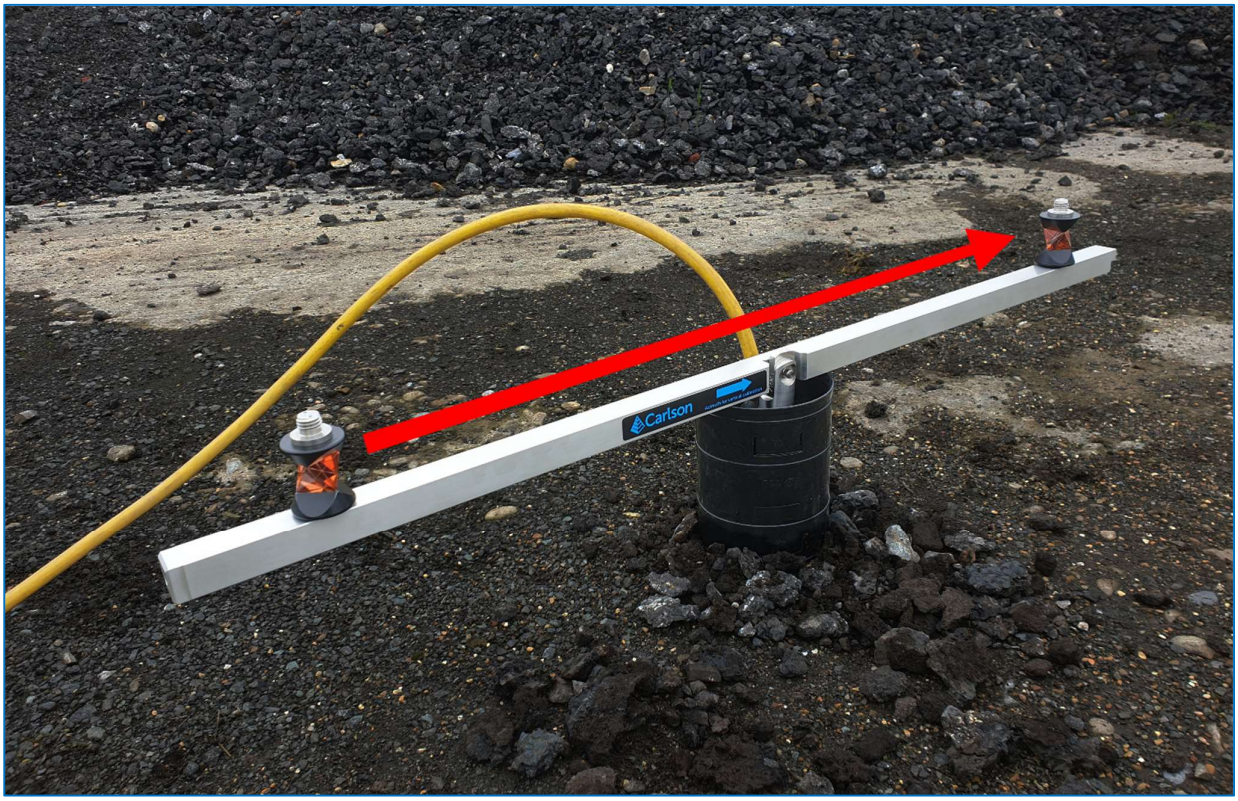


Figure 36 CALS probe in a borehole on a vertical alignment jig - showing direction of reference azimuth

Alternatively, if the ground is suitable, keep the end-pieces fitted and stand the jig over the collar (Figure 37).

Figure 37 Vertical alignment with end-pieces in place

Once the vertical alignment is complete, detach the C-ALS probe from the bar and commence the deployment. You can do this without having to remove the C-ALS probe from the hole.

If required, when the C-ALS probe has been deployed down to the void, the jig can be placed back over the collar and used to tie off the C-ALS system ready for a scan.

2.12 Alternative deployment methods

The C-ALS HD has been called on to tackle such a variety of applications in a wide range of environments that occasionally the standard deployment methods have not been sufficient. For this reason, Carlson has worked with a number of companies to produce methods of deployment suitable for specific operations. For example, a C-ALS system has been:

- mounted on a carriage to lower down a strained wire for ore pass surveys
- deployed horizontally on a boom into a stope
- deployed down an ore pass in a specially adapted buggy
- mounted on a cage for surveying shafts

These are 'non-standard' systems that are beyond the scope of this manual. However, they indicate the versatility of the system and the potential for use in many different applications. Carlson is happy to discuss other deployment systems that may be required for specific operations and we can offer consultation on customized deployment devices and accessories as required.

Figure 38 Some examples of alternative deployment methods

3 Maintenance and care of the C-ALS HD system

3.1 General

Attempts to dismantle or repair the C-ALS HD and accessories can be hazardous and costly if attempted by untrained personnel. Unauthorised attempts to carry out maintenance work on the equipment will void all warranty cover. Maintenance carried out by the operator therefore, should be restricted to the cleaning and inspection of external surfaces, lens windows and operating controls.

In addition, you should carry out regular functional testing of the system. Detect and report damage, malfunctions or poor performance to Carlson or a local Carlson representative.

Arrange a yearly calibration for your C-ALS HD system to ensure that it is kept in optimum condition and to ensure the highest possible quality of data.

A troubleshooting guide which outlines some of the most common support questions is included in the accompanying **Carlson Scan** software and operations manual. For other issues, contact Carlson or a local Carlson representative for further assistance.

3.2 Preventative maintenance

Avoid directing the C-ALS HD laser towards the sun or other high-power, infrared light sources.

Avoid mechanical shock.

Inspect and check the probe and accessories for damage after each use.

Always ensure that the probe and accessories are thoroughly cleaned and dried before packing them in the transit case after a deployment: see section 3.3.

During operations, the C-ALS probe may be deployed into corrosive environments. Failure to clean the probe after such a deployment may result in corrosion and permanent damage to the probe and accessories.

Check the Boretrak rods and hinges prior to every deployment. Ensure that they are in good condition, that there is no apparent ‘twist’ in the rods, and that all nuts and bolts and connecting pins are in place and secure.

Regularly clean the rod system, taking care to clear the joints of mud and grit.

Carry out regular functional testing of the system.

It is highly recommended that the C-ALS HD system be sent into one of Carlson’s service centres for an annual service and calibration.

Avoid manually moving the laser head as this can strain the mechanics inside the probe. In particular, do not grab the laser head and attempt to rotate it around the horizontal axis. This can result in the alignment of the optical system being twisted out of calibration.

The C-ALS is waterproof up to a depth of 1 m. It can move mechanically in waterlogged environments but will not produce data in these circumstances.

The supplied orange surface unit can be used with any C-ALS HD unit. However, it should never be used with an earlier C-ALS model such as a C-ALS Gyro, standard C-ALS or C-ALS mk3 unit. These earlier models would have been supplied with a yellow surface unit incorporating a LEMO connector for the main C-ALS cable. Using a C-ALS HD surface unit with an earlier C-ALS model, will void any product warranty and could cause serious damage to the C-ALS probe. Check the serial label on the C-ALS probe to confirm which variety of C-ALS you are working with. Alternatively, contact Carlson for further information.

3.3 Cleaning the C-ALS

Always ensure that the C-ALS HD and all accessories are thoroughly cleaned and dried before packing them in the transit case after a deployment.

Use clean water to remove mud, grit and other materials from the main body of the probe after use.

For further cleaning of the C-ALS HD metalwork, Carlson recommends that you use a product such as Amberclens anti-static foam cleaner. If this is not available then use a generic, mild dishwashing liquid diluted in warm water (0.001%, i.e. 1 ml for every 1l of water). Do not use paint solvents or any other personal, laundry, or household cleaning detergents as they may contain chemicals that could corrode seals in the C-ALS HD. Apply the diluted detergent with a non-abrasive, lint-free cloth.

Rinse the unit with plain water after using a detergent.

Dry the unit thoroughly after cleaning. Where possible, leave the unit unpacked until it is dry. In case the system is packed before it has dried, the equipment should be unpacked at the earliest opportunity. Clean and dry the system, and the inside of the transit case, before repacking the C-ALS system for storage.

To clean the lens windows and the red dot laser pointer window on the laser module, use HPLC-grade (> 99.8%) acetone in combination with lint-free cotton wool buds or wipes.

NOTE: repeated exposure to acetone may cause skin dryness or cracking. It is recommended that personal protective equipment (PPE) such as eye-shields and/or face-shields as well as protective gloves is used when dispensing and using HPLC-grade acetone.

3.4 Storing and transporting

Dry all elements of the C-ALS system thoroughly before storing.

If the instrument remains unused for several weeks, it is advisable to disconnect power sources from the instrument.

Store within the environmental temperature limits of -25 °C to +70 °C.

Ensure all equipment is packed in the supplied transit cases prior to transportation.

The surface unit should not be shipped without being packed in its transit case.

Secure all transit cases to prevent the possibility of shock or vibration during transport.

Do not allow the equipment to slide around inside transport vehicles or containers.

4 Operational use

4.1 Software and field operations

A full description of the operational use of the C-ALS HD hardware is included in the separate **Carlson Scan** software and operations manual. A full account of the software installation and operation is provided, along with a step-by-step field operation guide.

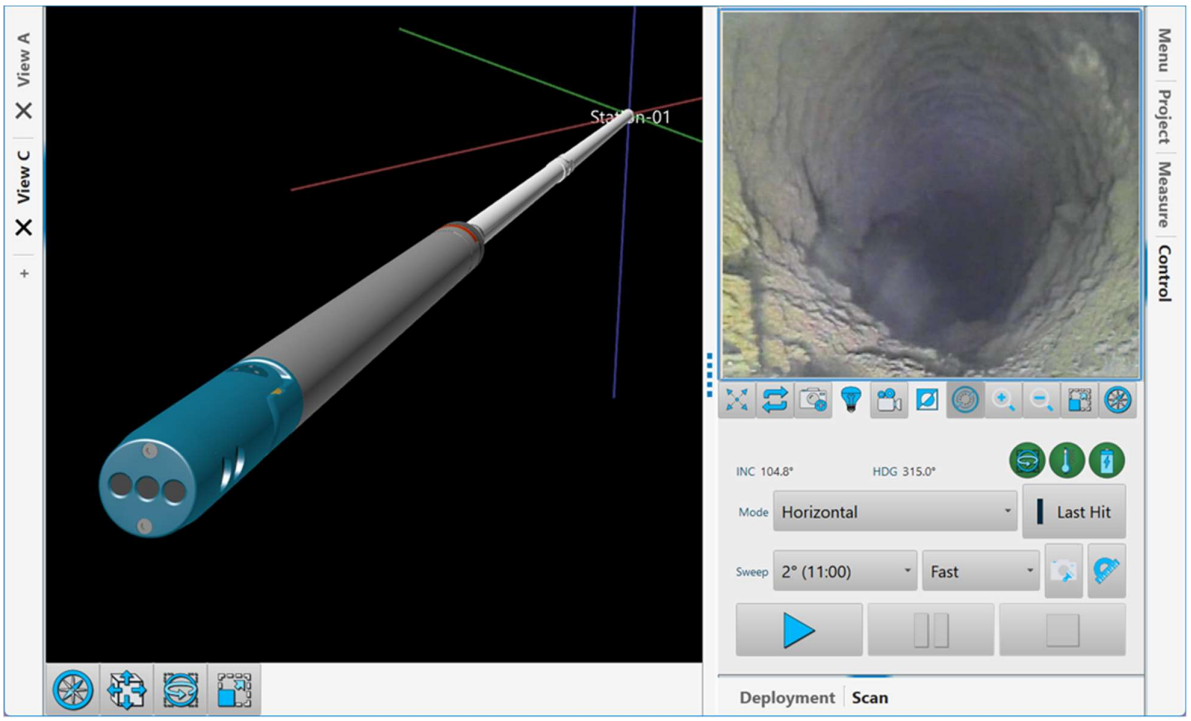


Figure 39 Carlson Scan software

4.2 System limitations

4.2.1 Environmental protection

The C-ALS HD is waterproof up to a depth of 1 m. It can move mechanically in waterlogged environments but will not produce data in these circumstances.

The surface unit is not watertight when its lid is open. It is thus advisable that the lid should be closed once the unit has been switched on.

If the probe is being deployed through a borehole, it is recommended that the hole should be lined to reduce wear and tear on the unit and to reduce any flow of water over the unit.

4.2.2 Sensors

A gyro is installed in the C-ALS HD unit. These sensors ensure that the probe can be tracked during its deployment from the known collar coordinates to the scan location. The sensors also correct the alignment and inclination of all data when the probe is inclined during a scan.

The gyro is limited to measuring rates of rotation of up to 400°/sec in each axis. In practice this should not be a limiting factor providing no sudden rotational accelerations are encountered or constant rotations of greater than ~1.1Hz are not encountered. Deploy the C-ALS probe in such a manner that minimizes rotation speeds and ensure that no sudden 'jerks' in rotation occur.

If the gyro does rotate at >400°/sec in any axis, an out-of-range error will be displayed. In this case it is advised to retrieve and realign the C-ALS HD before starting the deployment again.

To avoid exceeding this rotational speed limit, once the C-ALS HD is aligned, handle the C-ALS probe carefully as it is being moved into the hole. During the deployment, lower the probe carefully and try to ensure as little rotation as possible is introduced through twist in the cable.

The C-ALS HD can produce scan data while positioned at any angle. However, readings should not be taken if the probe is moving, swinging or spinning. Further, if the probe moves during a scan, no account of this is taken in the collected data. A message appears in **Carlson Scan** software once the scan is complete, warning that the probe has moved. The operator should make a judgement as to whether the scan needs to be restarted.

4.2.3 Laser ranging

The laser ranges up to a limit of 150 m. However, the maximum achievable range at any given time or location will depend on a number of factors. The following factors will limit the range to some degree and, in some circumstances, may prevent any readings from being taken:

- dark, light-absorbent surfaces, such as coal
- very dusty environments
- wet, slick, shiny or very smooth surfaces
- an acute angle between the laser and the surface.

The minimum range of the laser is 0.5 m. At shorter distances, readings may still be recorded, but their precision will be severely diminished.

4.2.4 Mechanical

If the C-ALS HD is deployed down a borehole, then the laser head and the rotating horizontal shaft must be free of the hole to allow unrestricted motion but must not be so far down the borehole that its full-length flops out of the borehole. If this occurs, it may be impossible to retrieve the unit.

The C-ALS HD has an integrated borehole camera that can be used to monitor the borehole, as well as to gauge exactly the distance from the collar to the 'breakout' point. However, in some circumstances – for example, if there are concerns about the stability of the borehole – it is advised that, prior to using the C-ALS HD, a separate camera should first be deployed down the borehole. In this way, the condition of the borehole can be checked before the C-ALS probe is deployed.

5 C-ALS HD Specifications

Laser module		
Laser certification (IEC / EN 60825-1: 2014). Complies with 21 CRF 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.)		Class 1
Type		InGaAs laser diode
Wavelength (typically)		905 nm
Divergence		<2 milliradians
Maximum average power		20.5 µW
Accuracy		+/- 5cm (under Carlson test conditions)
Resolution		1 cm
Minimum range		0.5 m
Maximum range to a passive target		Up to 150 m (to Kodak white card - 90% reflectivity)
Angle measurement		
Accuracy		0.2°
Resolution		0.1°
Range	Vertical	-90° to 90°
	Horizontal	0° to 360°
Motion		Servo-driven gear systems with manual clutch override
IMU sensors		
Type		IMU comprising triaxial gyro and accelerometers
Pitch-and-roll accuracy		±0.2°
Pitch-and-roll range		360°
Gyro heading drift		Typically, <1° during a 20 minutes deployment
Power		
External power input		11.5 Vdc to 15 Vdc
Mains power adaptor input		110 Vac to 240 Vac
Max current draw during scan		4.5 A
Camera		
Lighting		874 Lumens
Lens		10 mm fixed
Video signal		AHD
Resolution		Full HD (1920 x 1080) @25fps

Physical data		
Construction		Machined aluminium and stainless steel
Environmental protection	Probe	IP67
	Surface unit (lid closed)	IP67
Operating temperature	Probe	-10° C to +60° C
	Surface unit	0° C to 50° C
Storage temperature	Probe	-25° C to +75° C
	Surface unit	-25° C to +75° C
Dimensions	Probe	1110 mm x 50 mm
	Probe and extension piece	2189 mm × 50 mm
	Surface unit	270 mm × 245 mm × 170 mm
	Slip ring drum (small)	0.6 m x 0.5 m x 0.5 m
	Slip ring drum (large)	0.9 m x 0.5 m x 0.5 m
Weight	Stainless steel probe	6 kg
	Single-section steel extension piece	3 kg
	Main C-ALS cable	0.18 kg/m
	1 m Boretrak rod	0.4 kg
	Surface unit	4.1 kg
	Slip ring drum (small)	13 kg
	Slip ring drum (large)	15 kg

6 Safety information

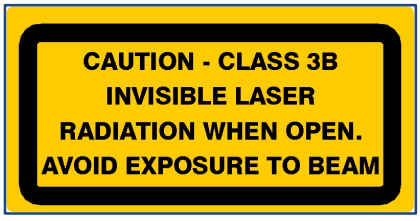
6.1 Laser safety

The C-ALS is classified as a Class 1 laser product in compliance with the International Electrotechnical Commission (IEC) and European standard (EN) for the safety of laser products, IEC / EN 60825-1: 2014.

CAUTION: Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

An internal panel of a protective housing which, when removed or displaced, permits human access to laser radiation that does not exceed the AEL for Class 3B, has affixed a label that bears the notices below.

WARNING – Opening the protective housing may result in exposure to Class 3B radiation.



The C-ALS is intended for use only in restricted access areas (where minors are not likely to be present) with only qualified and trained persons assigned to operate the C-ALS. When not in use, the laser should be stored in a location where unauthorised personnel cannot gain access.

We recommend that the instrument is not directly pointed at people's eyes, especially if they are using binoculars. **Do not unnecessarily look into the transmitter lens of the C-ALS.**

Do not operate evidently damaged instruments. If the instrument is mishandled, the manufacturer's warranty may be voided.

This product is intended for use in a locale where the emitted radiation is unlikely to be viewed with optical instruments.

The C-ALS should not be aligned with the lenses of CCD-cameras or infrared night vision devices, as this can result in damage to the system.

6.2 Batteries

Dispose of used batteries sensibly. Under no circumstances must the batteries (or instrument) be disposed of by burning. An explosion may occur.

All batteries contain highly reactive, poisonous and corrosive chemicals, which are hazardous if released due to physical damage. Should the battery or battery charger approach end-of-life, become non-functional or damaged, stop using it and request a replacement unit from a Carlson-approved source.

7 Product information

Trademarks

Changes to Carlson products

Carlson reserves the right to improve, change or modify its products and documentation without incurring any obligation to make changes to equipment previously sold or distributed.

Carlson has made considerable efforts to ensure the content of this document is correct at the date of publication but makes no warranties or representations regarding the contact. Carlson excludes liability, howsoever arising, for any inaccuracies in the document.

Warranty

Unless otherwise specified, Carlson warrants all supplied equipment for a period of 12 months from the date of delivery. This warranty is given subject to the following conditions:

- Carlson shall be under no liability in respect of any defects in the equipment arising from any drawing, design or specification supplied or modification requested by the customer.
- Carlson shall be under no liability in respect of defects arising from willful damage, negligence, abnormal working conditions, failure to follow Carlson's instructions (whether oral or in writing), misuse or alteration or repair of the equipment without Carlson's approval.
- Software is not covered by this warranty.
- Claims in respect of defective equipment must be made in writing to Carlson and the equipment must be retained by the customer pending written instructions from Carlson.

Following authorised return of the equipment, which must be made by the customer on freight prepaid basis, Carlson will examine the equipment and, if the claim is justified in Carlson's opinion, will repair the defective equipment or will make replacement without charge. Carlson will have no further liability to the customer.

Safety

The C-ALS is a ruggedised field instrument designed to provide fast, efficient 3D laser scans of underground voids where access is limited, dangerous or prohibitive. It is essential that the unit and all accessories are operated in accordance with the instructions in this user manual and it is the responsibility of the user to ensure that, in the event of a failure of any part of the Carlson system, the motion system remains safe.

In the case of equipment with powers or speeds capable of causing injury, it is essential that appropriate safety protection measures are included in the machine usage. Further guidance can be found in *BS EN ISO 12100:2010 Safety of machinery – General principles for design – Risk assessment and risk reduction*.

Laser Safety

DO NOT STARE DIRECTLY INTO THE BEAM.

C-ALS laser probes are Class 1 invisible laser products where safety goggles are not required. The unit complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019. Do not stare into the beam or shine it into the eyes of others. It is safe to view a diffuse-reflected beam. Do not dismantle the unit in any way; doing so may expose laser radiation in excess of Class 1 combined limits. CAUTION – LASER LIGHT IS BRIGHT AND BLINDING – DO NOT SHINE AT AIRCRAFT OR VEHICLES AT ANY DISTANCE.

Safety information

This symbol is used in this manual wherever important safety information is present.

Before proceeding with any electrical connection or operation of the laser system, refer to the general safety information throughout this manual.

Information to the equipment supplier/ installer

It is the equipment supplier's responsibility to ensure that the user is made aware of any hazards involved in any operations involving the C-ALS system, including those mentioned in Carlson product literature.

EC declaration of conformity

CE

Carlson declares that the C-ALS system complies with the applicable standards and regulations.

Contact Carlson or visit www.carlsonsw.com for the full EC declaration of conformity.

FCC (USA only)

Information to the user (47CFR section 15.19)

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Information to the user (47CFR section 15.21)

The user is cautioned that any changes or modifications not expressly approved by Carlson or authorised representative could void the user's authority to operate the equipment.

Information to the user (47CFR section 15.105)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WEEE directive

The use of this symbol on Carlson products and/or accompanying documentation indicates that the product should not be mixed with general household waste on disposal. It is the responsibility of the end user to dispose of this product at a designated collection point for waste electrical and electronic equipment (WEEE) to enable reuse or recycling. Correct disposal of this product will help to save valuable resources and prevent potential negative effects on the environment. For more information, please contact your local waste disposal service or Carlson representative.

Battery disposal

The use of this symbol on the batteries, packaging or accompanying documents indicates that used batteries should not be mixed with general household waste. Please dispose of the used batteries at a designated collection point. This will prevent potential negative effects on the environment and human health which could otherwise arise from inappropriate waste handling. Please contact your local authority or waste disposal service concerning the separate collection and disposal of batteries. All lithium and rechargeable batteries must be fully discharged or protected from short circuiting prior to disposal.