

# FiX1

## Automated stockpile monitoring system

### Installation manual





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# INTRODUCTION AND OVERVIEW

# 1 Customer information

## 1.1 Dear customer

The FiX1 laser scanning system is designed to offer end users 'hands off' operation and to deliver automated, accurate volumetric results without any intervention required. The safe and reliable running of the FiX1, as well as the quality of the results, are fully dependent on the correct installation and mobilization of the system on the customer's site.

This manual is for personnel involved in the installation, running and maintenance of a FiX1 system. It covers all hardware components, installation, care, troubleshooting and day-to-day usage of a FiX1 system.

It is important that you read this manual carefully before beginning to work with a FiX1 system. Thereafter, always keep the manual available for reference.

A separate FiX1 users' manual is available for end users of the FiX1. The users' manual is only concerned with minor configuration of the system through its web-interface during normal day-to-day use.

This manual has been compiled with care. However, should you discover any errors, we would be grateful if you could contact Carlson directly.

For any feedback or comments, or if there are questions about the FiX1 system which are beyond the scope of this manual, contact Carlson.

Alternatively, for information on your local Carlson-approved service centre, visit our website: [www.carlsonsw.com](http://www.carlsonsw.com).

The information in this document is subject to change without notice.

## 2 FiX1 system overview

### 2.1 System introduction

Computing stockpile volumes is an essential job within many industries such as quarrying, mining, agriculture, or highway maintenance. Whether the aim of the exercise is related to optimising logistics, satisfying accounting requirements or assisting operational planning, the required deliverables are the same: accurate, repeatable, scheduled volumes of stockpiled material.

Commonly a team of surveyors may be employed to carry out a survey of stockpiles using GNSS systems or traditional survey equipment. More recently drones are used to carry out surveys from the air. Sometimes rough guesses are relied on, with volumes being arrived at via experience, visual inspections or with reference to indirect data such as vehicle movements to and from the stockpile.

The FiX1 has been introduced to provide a fully automated stockpile measurement system which negates the need to involve survey teams, estimates, drone operations or inaccurate, indirect calculations.

After trained staff have carried out the initial FiX1 system mobilisation, accurate volumes can be produced with no intervention from any personnel.

The provision of accurate volumes via the FiX1's automated scanning and processing routines helps to increase on-site safety and operational efficiency. It ensures the absolute minimum involvement of on-site personnel. This is invaluable in industries where sites can be dangerous or inaccessible, or where time-consuming permits and authorisations are required for on-site access.

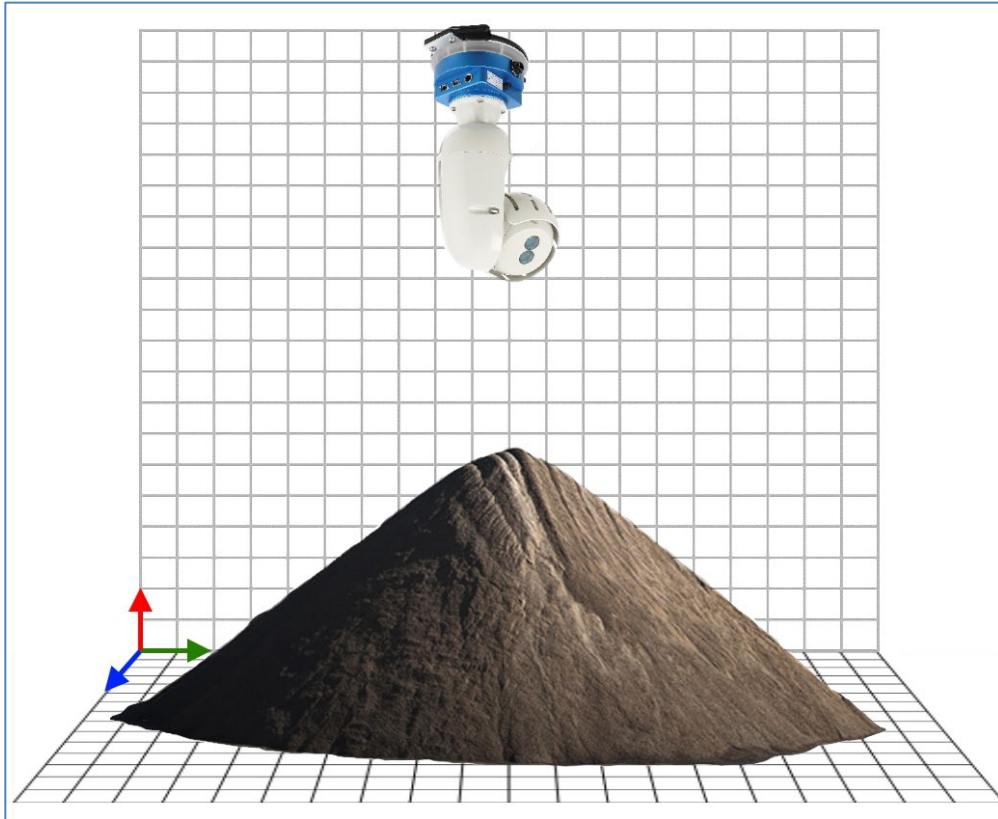
### 2.2 Operation

This section gives an initial overview of the setup and operation of the FiX1. Each stage is dealt with in greater depth later in this manual.

## 2.2.1 Installation

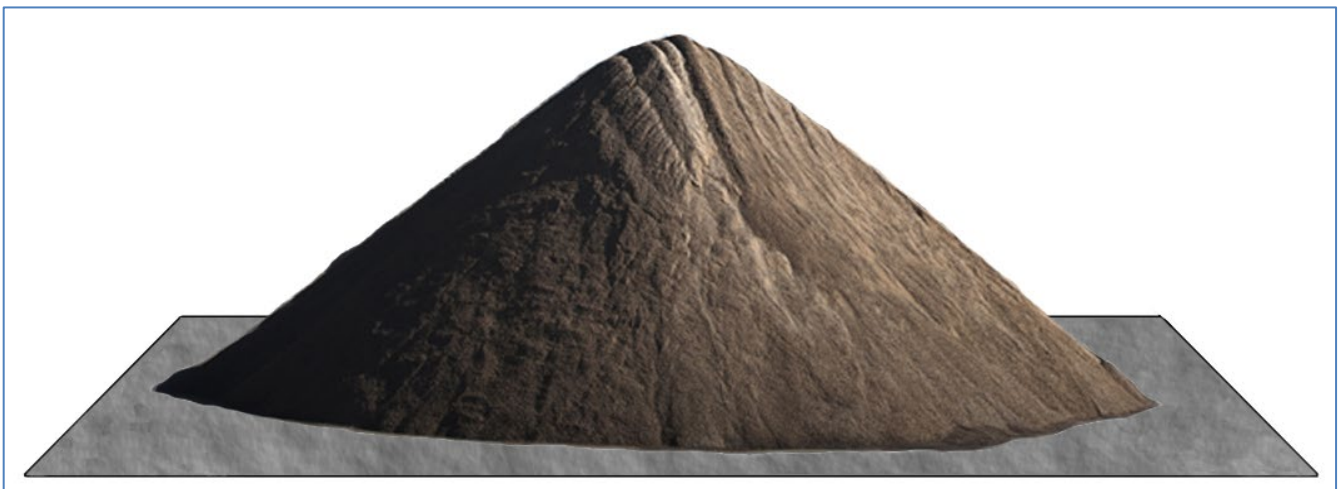
During the initial installation of the FiX1 by trained staff, the unit is secured in position above the stockpiles to be scanned. The FiX1's position should give the clearest possible view of the area of interest.

Once installed, the FiX1 is surveyed in place on the site's local coordinate system. This ensures that all data collected by the FiX1 is correctly georeferenced.



*Figure 1 Fix1 installation surveyed into the local coordinate system*

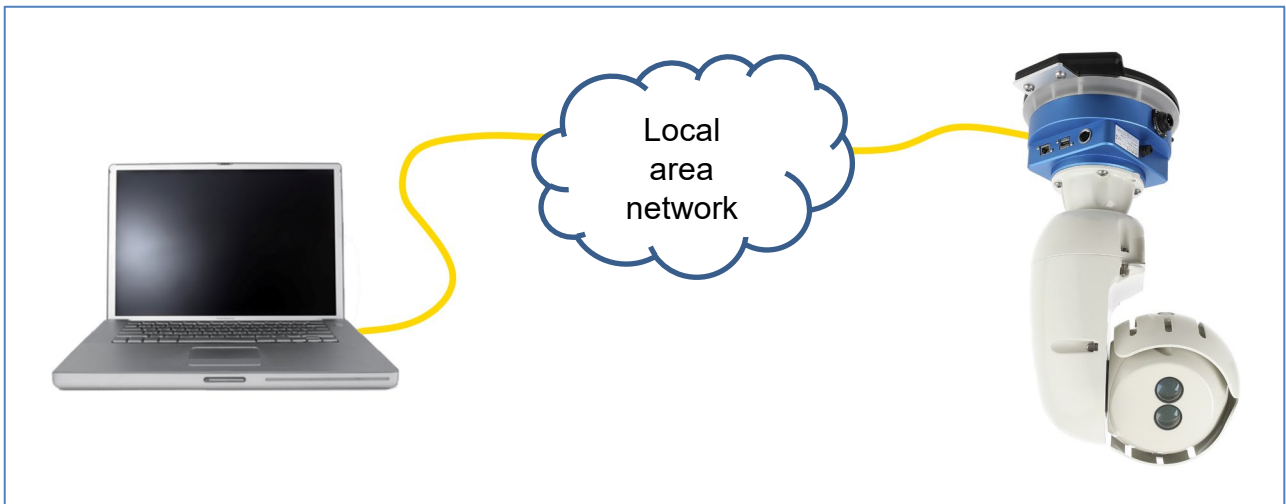
A base surface, geo-referenced on the same coordinate system as the FiX1 and representing the floor level beneath the stockpile, is uploaded into the FiX1. This acts as a reference for all volumetric calculations.



*Figure 2 The base surface file defines the floor level on the local coordinate system*

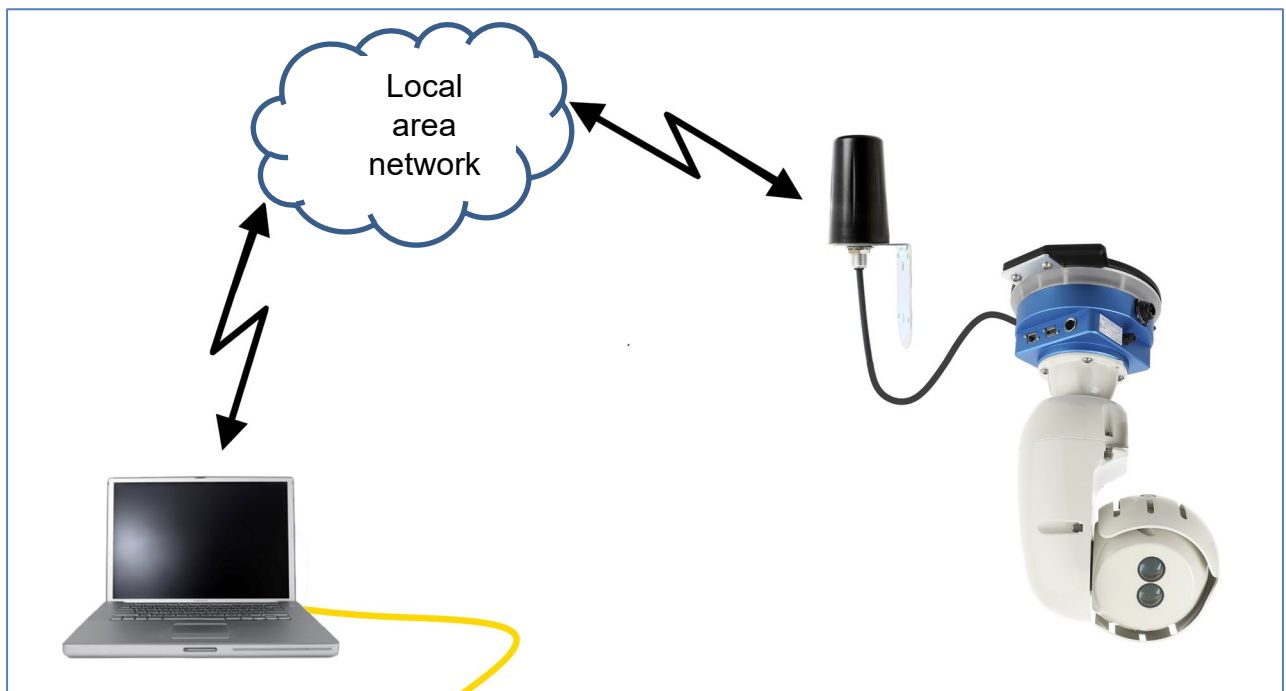
## 2.2.2 Data connections

You may setup a data connection to the FiX1 in a variety of ways. The recommended configuration is to connect the unit to the local area network by Ethernet cable so the FiX1 can be accessed conveniently from any device on the network.



*Figure 3 Wired Ethernet connection*

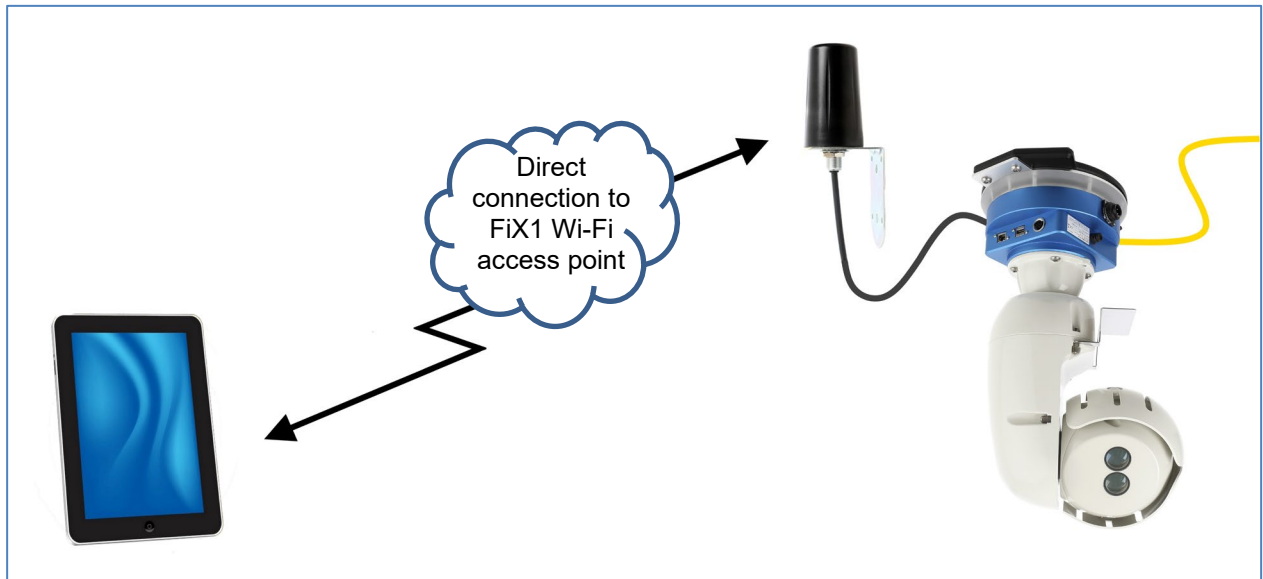
The FiX1 can also be connected wirelessly to the local area network using the Wi-Fi client mode.



*Figure 4 Wi-Fi client mode*

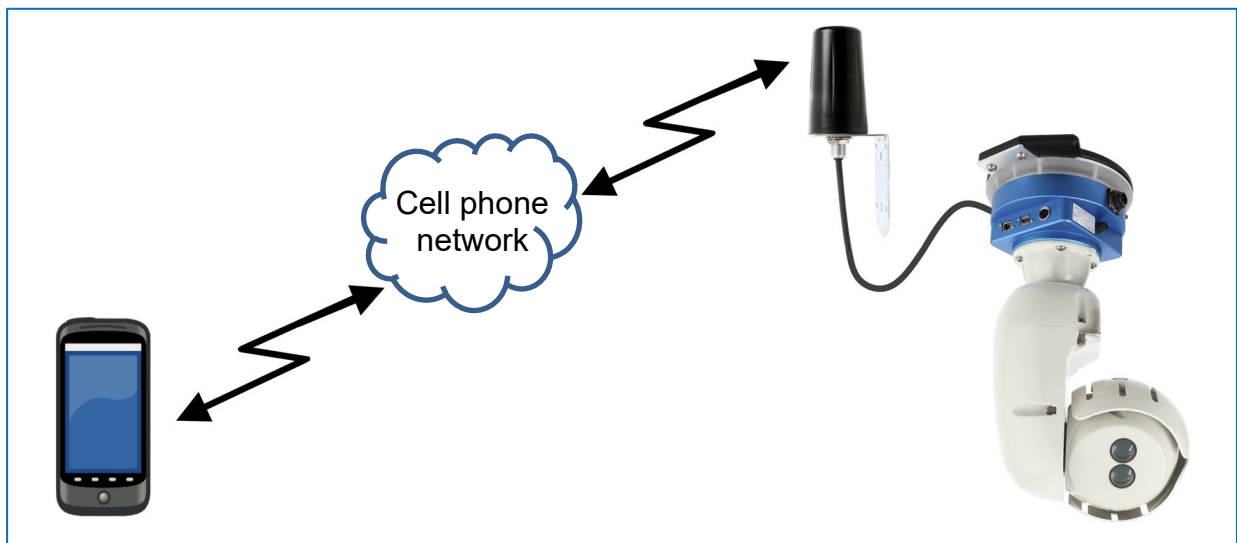


The FiX1 can be set as a Wi-Fi access point, allowing direct connection from another Wi-Fi enabled device.



*Figure 5 Wi-Fi access point mode*

Alternatively, a SIM card in the FiX1 allows connection by mobile phone. This sets up a connection completely independent of the site network.



*Figure 6 Connection using the cell phone network*

Once there is a successful connection to the FiX1, you can access the web application which is run from the processor onboard the FiX1. This is also where all computations are run, and all data is stored. No additional software is required on your laptop or mobile device.

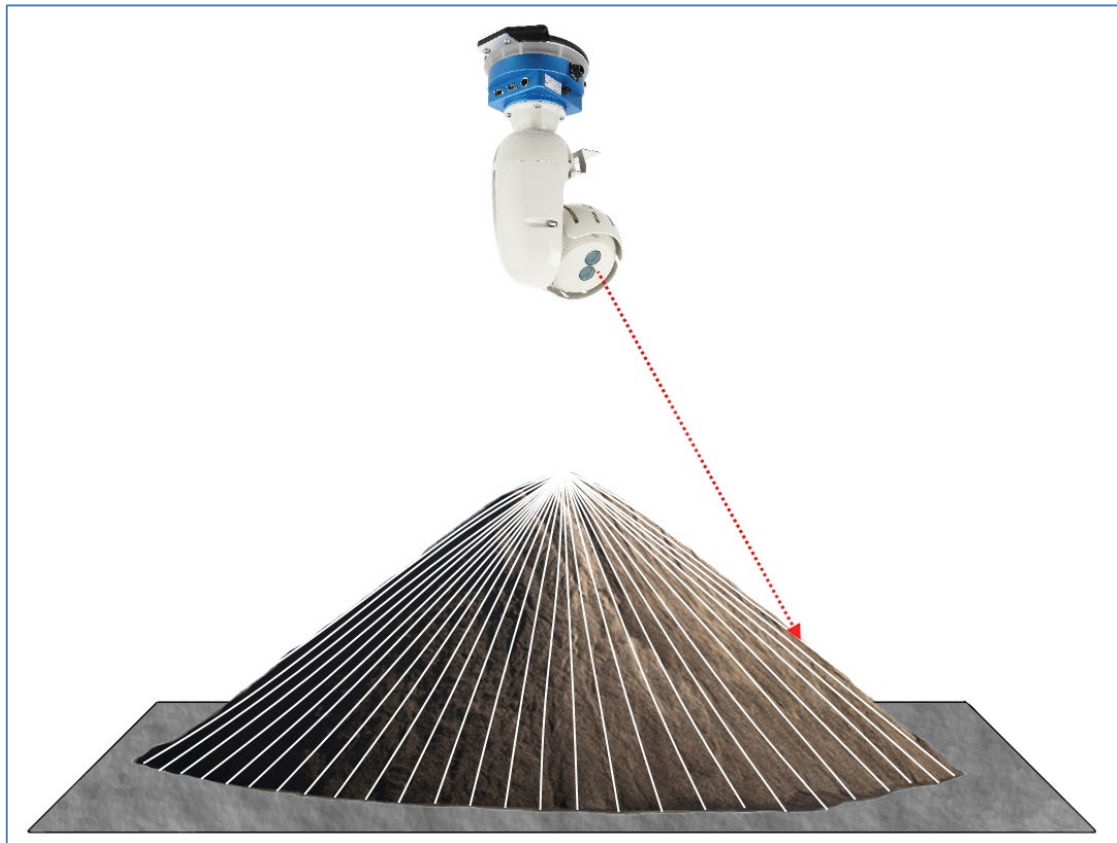
### 2.2.3 Scanning and results

Once fully mobilised, the FiX1 runs a laser scan across the area of interest. This can take place at scheduled times, or on demand. When carrying out a scan, the body of the FiX1 rotates horizontally at a relatively slow speed, while at the same time the laser head rotates vertically at a higher speed. The laser itself is firing constantly at a pre-determined rate.



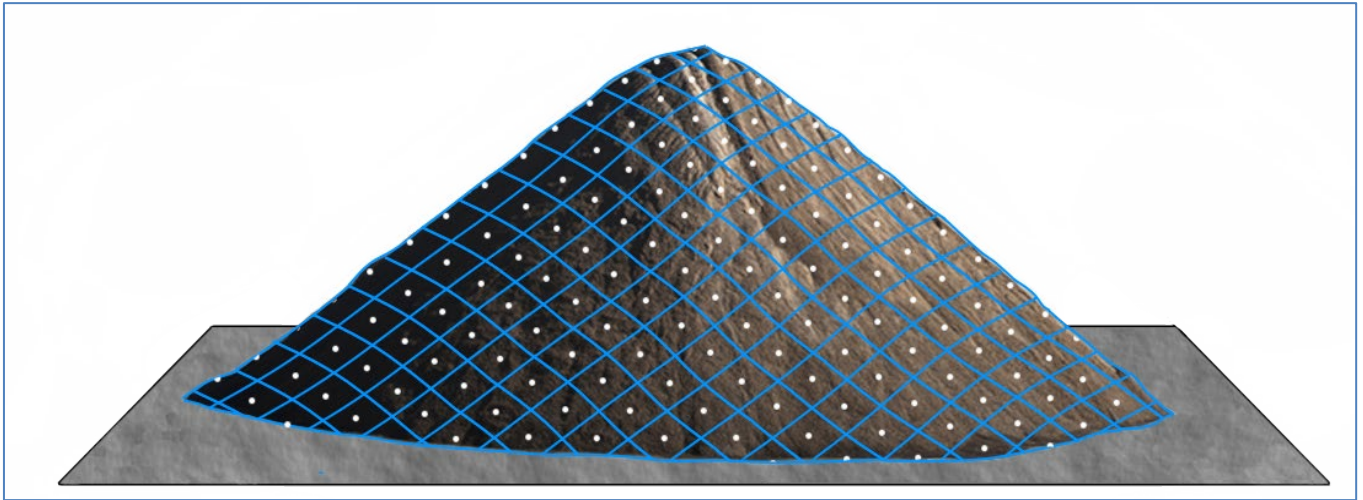
*Figure 7 FiX1 Scan action*

The result of this scanning action is a pattern of radial scan lines which form a dense point cloud covering the area of interest beneath the FiX1.



*Figure 8 FiX1 running radial scan lines over the targeted area*

After each scan, automated intelligence onboard the FiX1 processes the raw point cloud to filter the data, eliminate spurious points and form a gridded 3D surface model. This model is compared to the uploaded base surface and the volume between the two surfaces is computed.



*Figure 9 Gridded surface created from the raw point cloud*

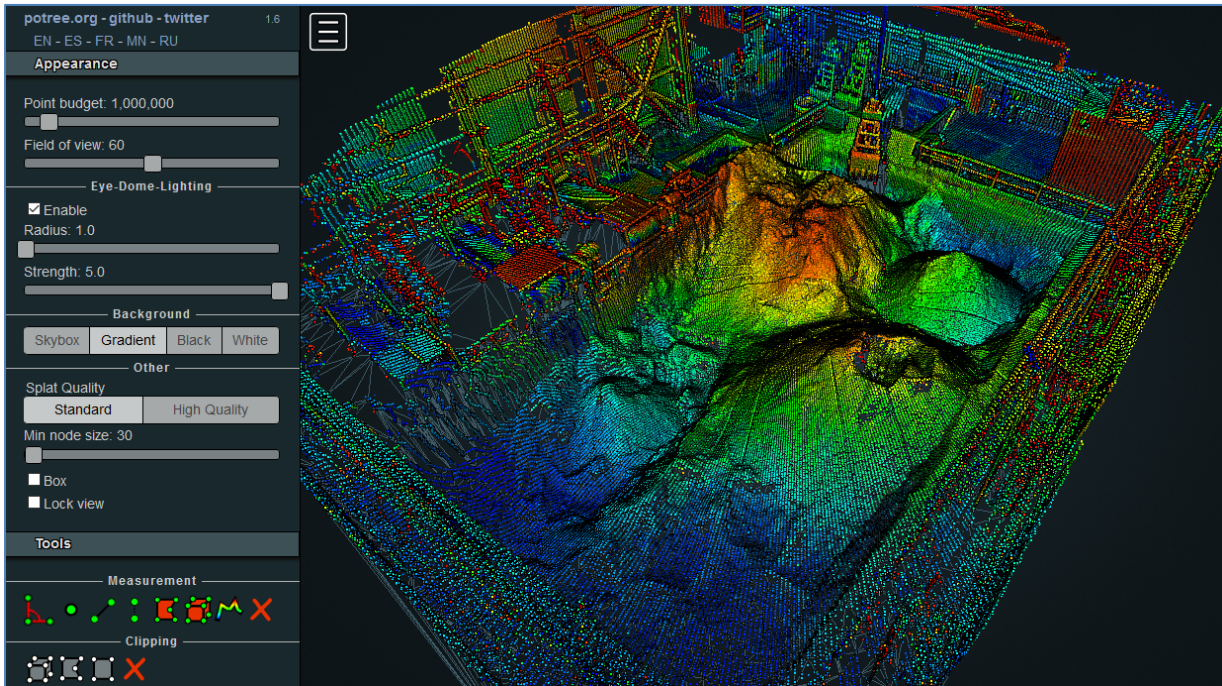
The volume is reported on the FiX1's web application and is visible, along with historical data, to anyone logging on to the system.

Reports of all volumes are available to download, if required.



*Figure 10 FiX1 web application (left) and volume report (right)*

If necessary, the scan data can also be viewed online in the integrated 3D viewer.



*Figure 11 3D point viewer embedded in the FiX1 web application*

For troubleshooting or record keeping, raw point cloud data can also be downloaded for further analysis in third party software. This is not required for normal day-to-day operations.

If network access to the FiX1 is available, Carlson offers remote support and system upgrades.

## 2.3 Single and multiple unit installations

Many sites will have stockpiles located in a relatively restricted area which can be adequately covered by a scan from a single, strategically positioned FiX1. However, other sites may have stockpiles spread out over larger areas. In this case some parts of the stockpiles may be obscured from the line-of-sight of a single FiX1 unit, or some parts of the site may be beyond its maximum range.

In such situations, multiple FiX1 units are required. This is a hub-and-spoke installation: an integrated network of strategically positioned units can ensure full, uninterrupted coverage of the area of interest.

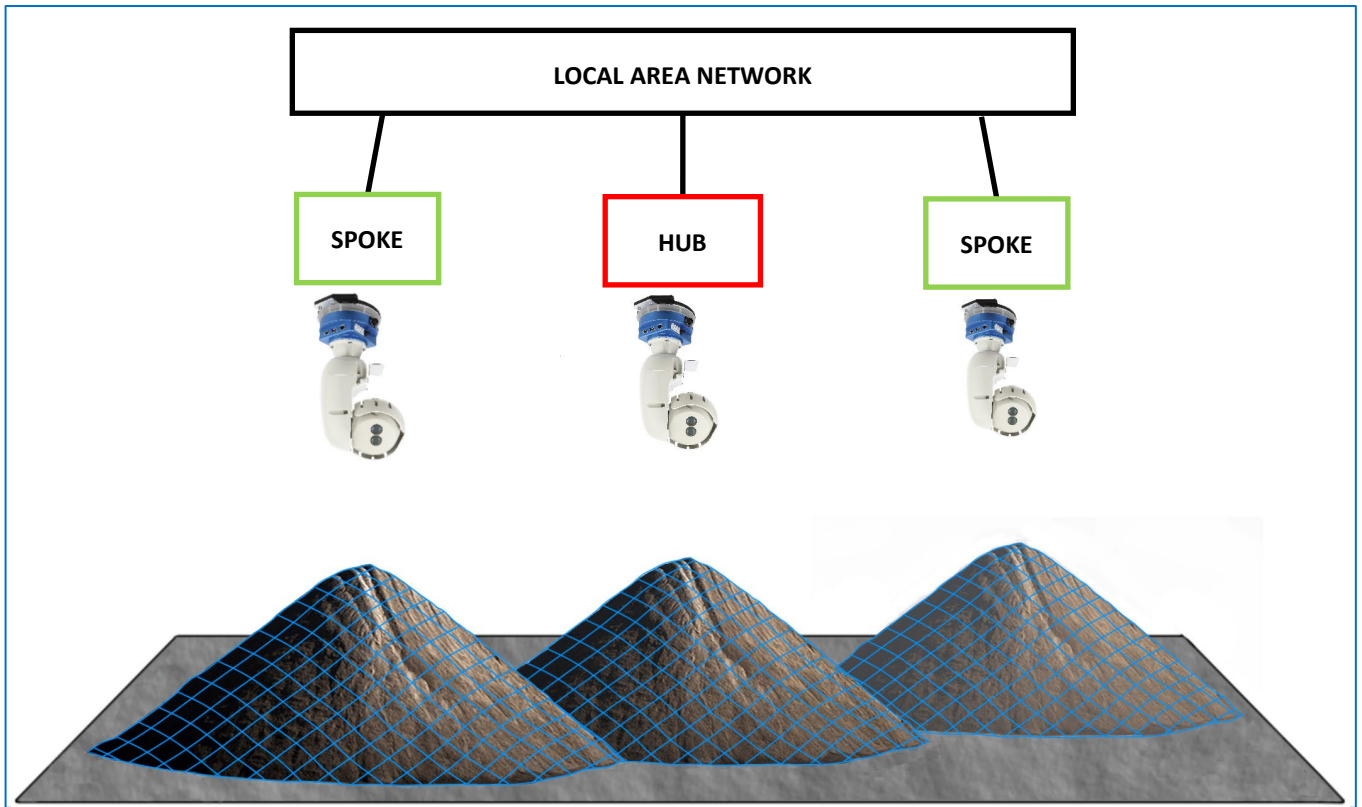
When multiple FiX1 units are first installed on a single site, they must all be surveyed in place relative to each other.

One unit in the network is designated the 'hub' and all others are the 'spokes'. All units in the installation must be connected to the local area network.

The user communicates only with the hub. When a scan is requested, the hub instructs all the spokes to conduct a simultaneous scan. On completion of the scan, the spokes send their gridded data back to the hub. At the hub, a single volume is computed and reported back to the web application.

The correct installation and geo-location of the FiX1 units in a hub-and-spoke installation is essential. Thereafter, just as with a single unit setup, the system is automated and requires no user intervention.





*Figure 12 Three FiX1 units in a hub-and-spoke installation*

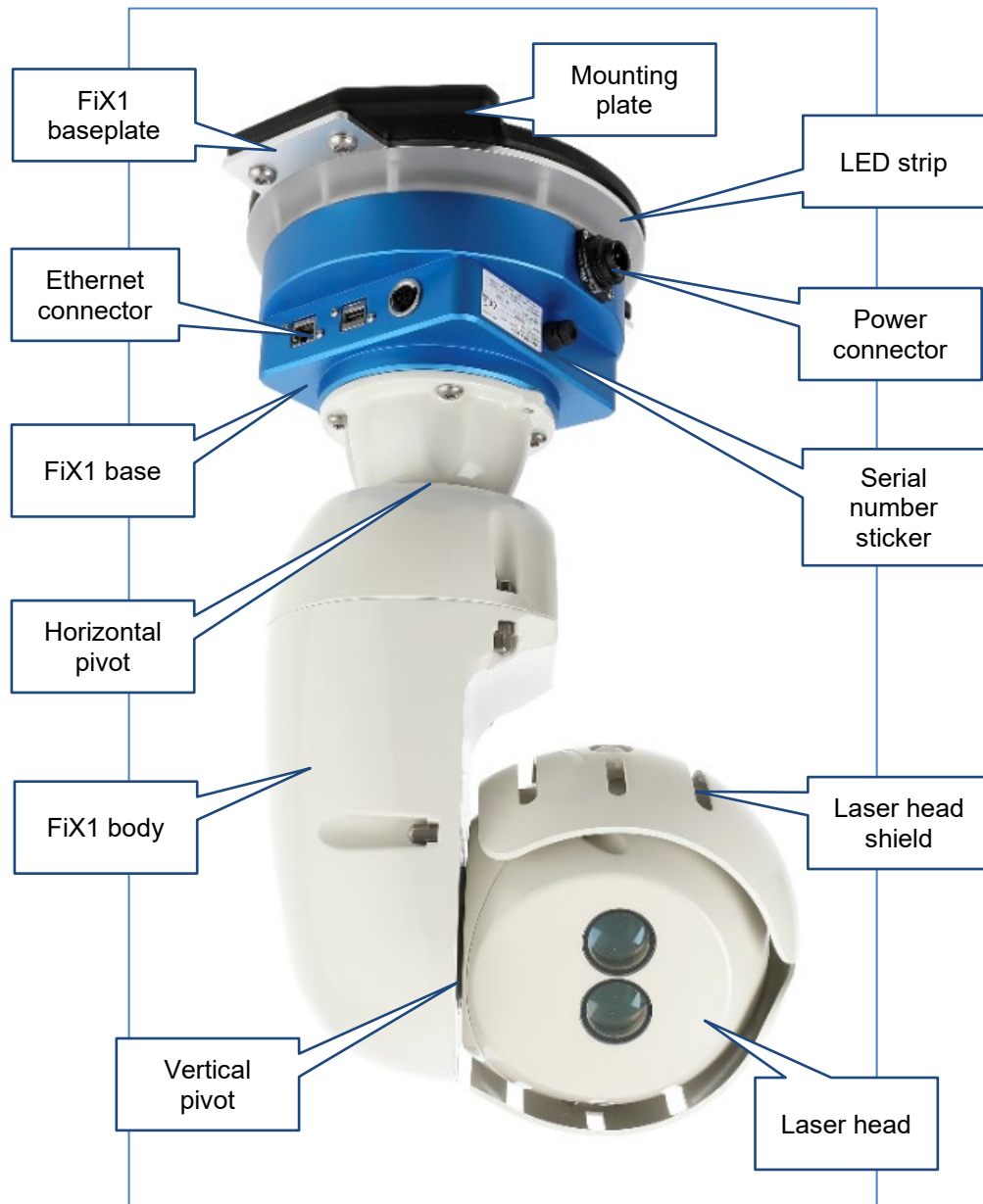
# HARDWARE

### 3 FiX1 components

The hardware components of a FiX1 system are described below.

#### 3.1 FiX1 unit

The FiX1 consists of a laser head which pivots vertically on the body of the unit which in turn pivots horizontally on the FiX1 base.



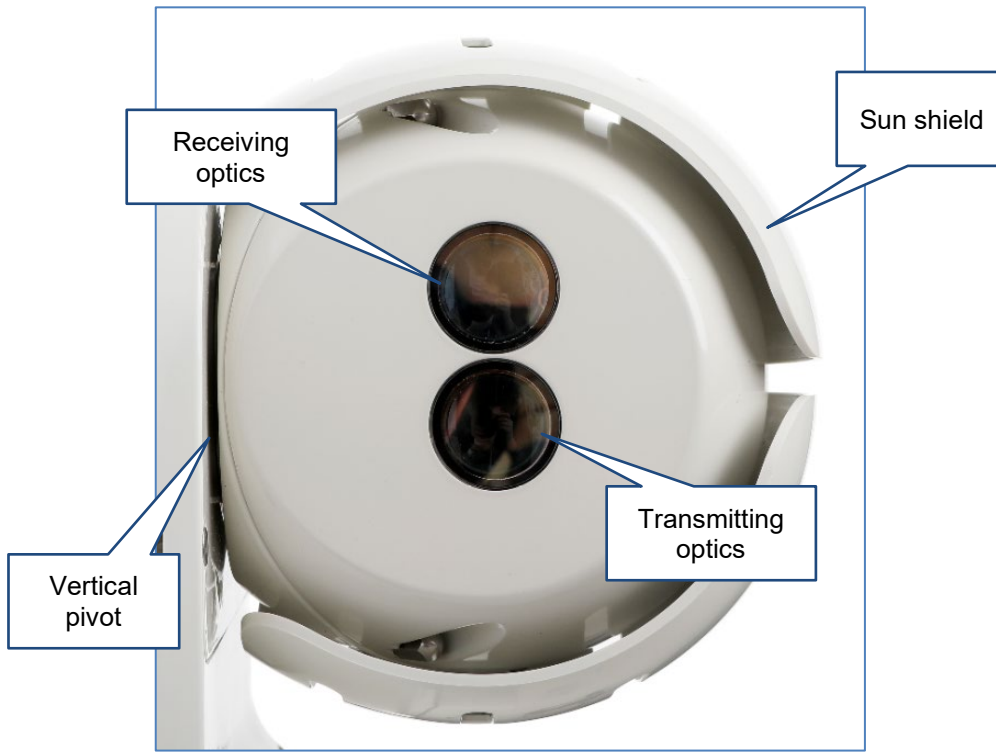
*Figure 13 FiX1 unit*

The FiX1 base houses all connectors and processing capacity.

The base plate allows attachment of the FiX1 to the mounting plate which is attached to the site superstructure.

### 3.1.1 Laser head

The laser head is where the FiX1's laser is housed. The laser head spins vertically on the vertical pivot.



*Figure 14 FiX1 laser head*

The measuring laser is an infra-red 'time of flight' device.

Laser pulses are fired through the transmitting optics. The laser pulses hit the targeted surface where they are scattered. A tiny fraction of the scattered pulse reflects back into the FiX1's receiving optics. The measured range is derived from the time taken for the pulse to return to the laser, multiplied by the speed of light.

The laser measures between 5,000 and 15,000 points per second. The maximum distance that the laser can measure is 250 m. Typically, ranges are measured to an accuracy of 1 cm.

The laser head rotates vertically on the vertical pivot which joins the laser head and the FiX1 body. Avoid placing strain on the vertical pivot when handling the unit.

The laser head is surrounded by a sun shield which protects the body of the laser from direct sunlight.

### 3.1.2 FiX1 body

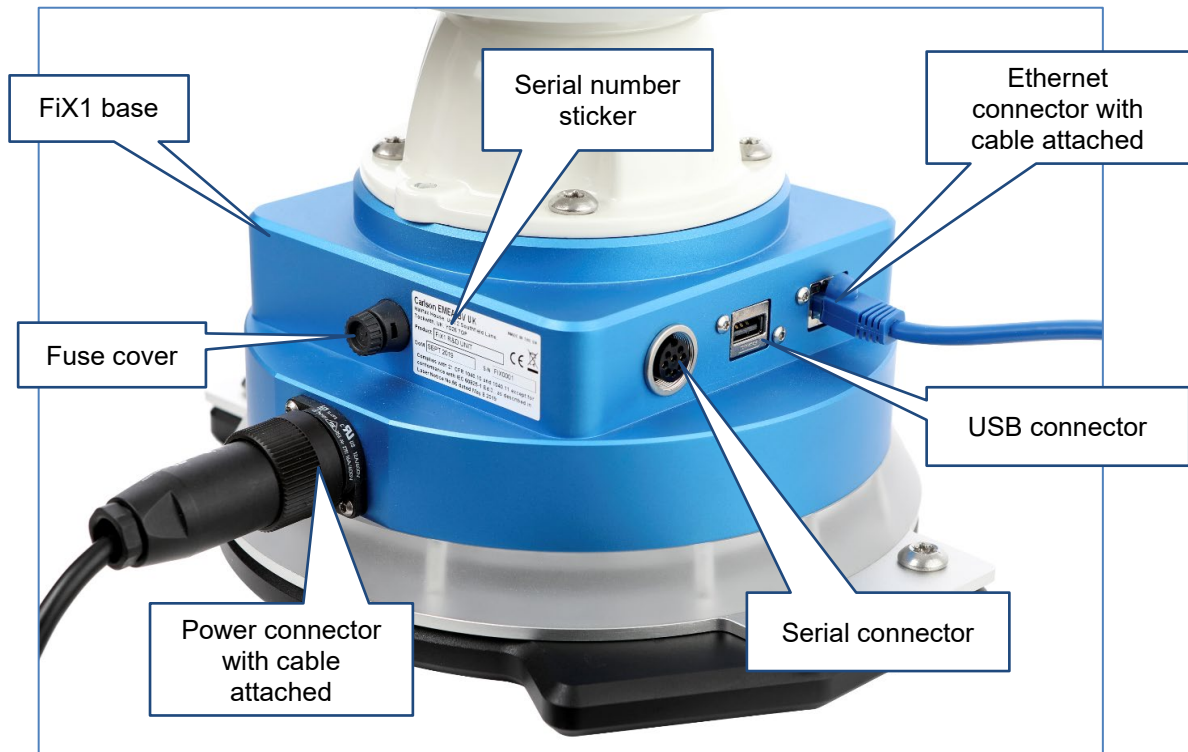
The FiX1 body rotates on the horizontal pivot which joins the FiX1 body and base.

The FiX1 body is connected to the laser head by the vertical pivot.



### 3.1.3 FiX1 base

The blue metal base of the FiX1 incorporates all connectors.



*Figure 15 FiX1 base connections - 1*

The main power connector accepts the supplied power cable. The power must originate from a stable ac mains supply.

Above the power connector is the fuse cover. Unscrew the fuse cover to access the cartridge fuse. The rating of the fuse is T3.15AH250V.

On the adjacent side of the FiX1 base are arranged:

- The serial connector: available for external accessories to connect with the FiX1.
- The USB connector: available for external accessories to connect with the FiX1.
- The Ethernet connector: allows a wired network connection using a standard Ethernet cable with an RJ45 connector.

On the side of the base opposite the power connector are arranged:

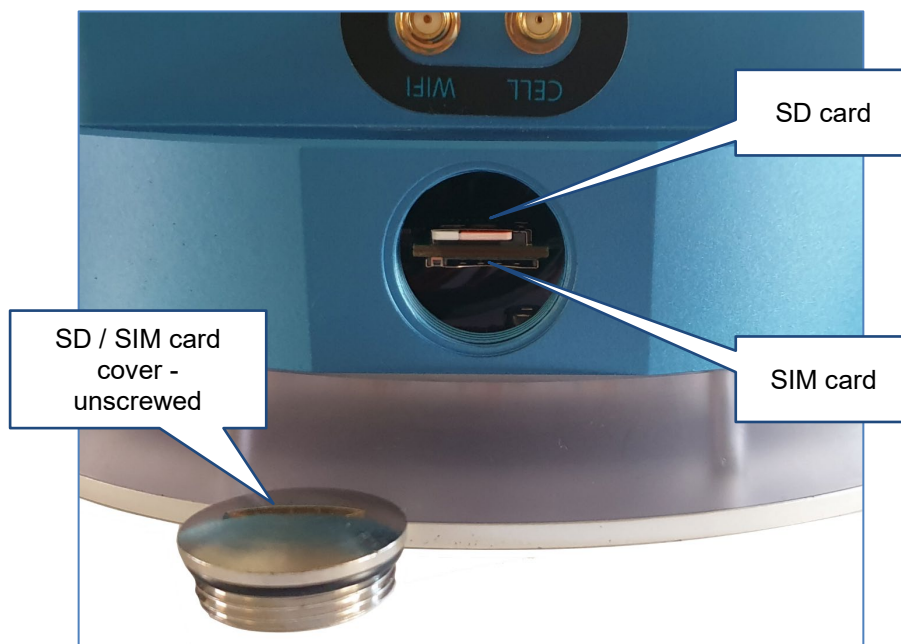
- Wi-Fi antenna connection: an SMA coaxial RF connector to fit the supplied Wi-Fi antenna.
- Cell antenna connection: an SMA coaxial RF connector to fit the supplied cell antenna.
- A protective cover for the SD card / SIM card port: this can be unscrewed for access, if required.

All connectors on the FiX1 base are environmentally protected to a rating of IP67.

The serial number sticker is also located on the FiX1 base, next to the fuse cover. Quote the serial number during any contact you have with Carlson concerning your FiX1 unit.



*Figure 17 FiX1 base connections - 2*



*Figure 16 SD / SIM card cover unscrewed*

### **3.1.4 SD card**

A 64GB Micro SD card is supplied installed into every FiX1 unit. There should be no reason to remove or change the card. However, in case this is required, the card must be formatted to Linux's ext4 file system.

### **3.1.5 SIM card**

For use on a cellular network, a SIM card is required. Supplying a SIM card appropriate for your region is the responsibility of the end user. See section 5.8.6.

### 3.1.6 LED strip

Above the FiX1 baseplate is the LED strip. During operations the LED strip displays different colour combinations depending on the current state of the FiX1.



*Figure 18 FiX1 LED strip*

FiX1 state	LED display
Booting up	Green - solid
Checking for, or installing, firmware updates	White - flashing
Kernel running	Green - breathing
Powered on, idle	Green - blinking
Initialising before a scan	Blue - solid
Scanning	Blue - chasing around base
Processing after a scan	Blue - blinking
Error	Red - solid

### 3.1.7 FiX1 baseplate

The FiX1 baseplate is at the base of the FiX1 Unit. The baseplate attaches to the separate mounting plate which, in turn, is directly attached to the building superstructure.

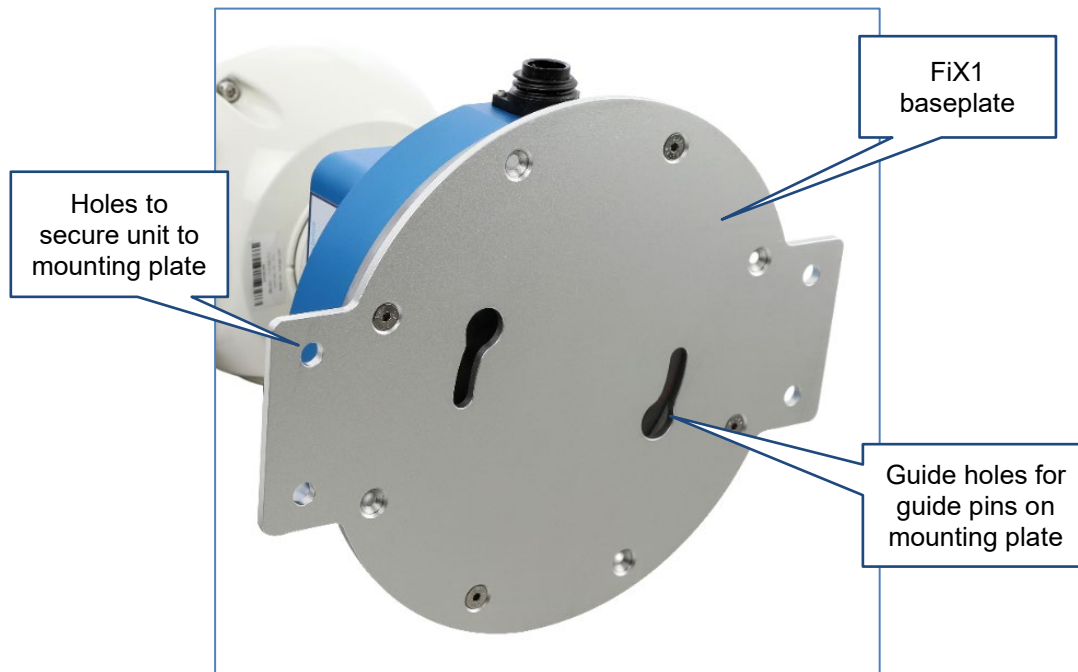


Figure 19 FiX1 baseplate

### 3.2 Mounting plate

The mounting plate is designed to be permanently or semi-permanently fixed to the site superstructure. The FiX1 can then be easily attached once the mounting plate is in place. The FiX1 can also be easily detached from the mounting plate, if required for site operations or for servicing.

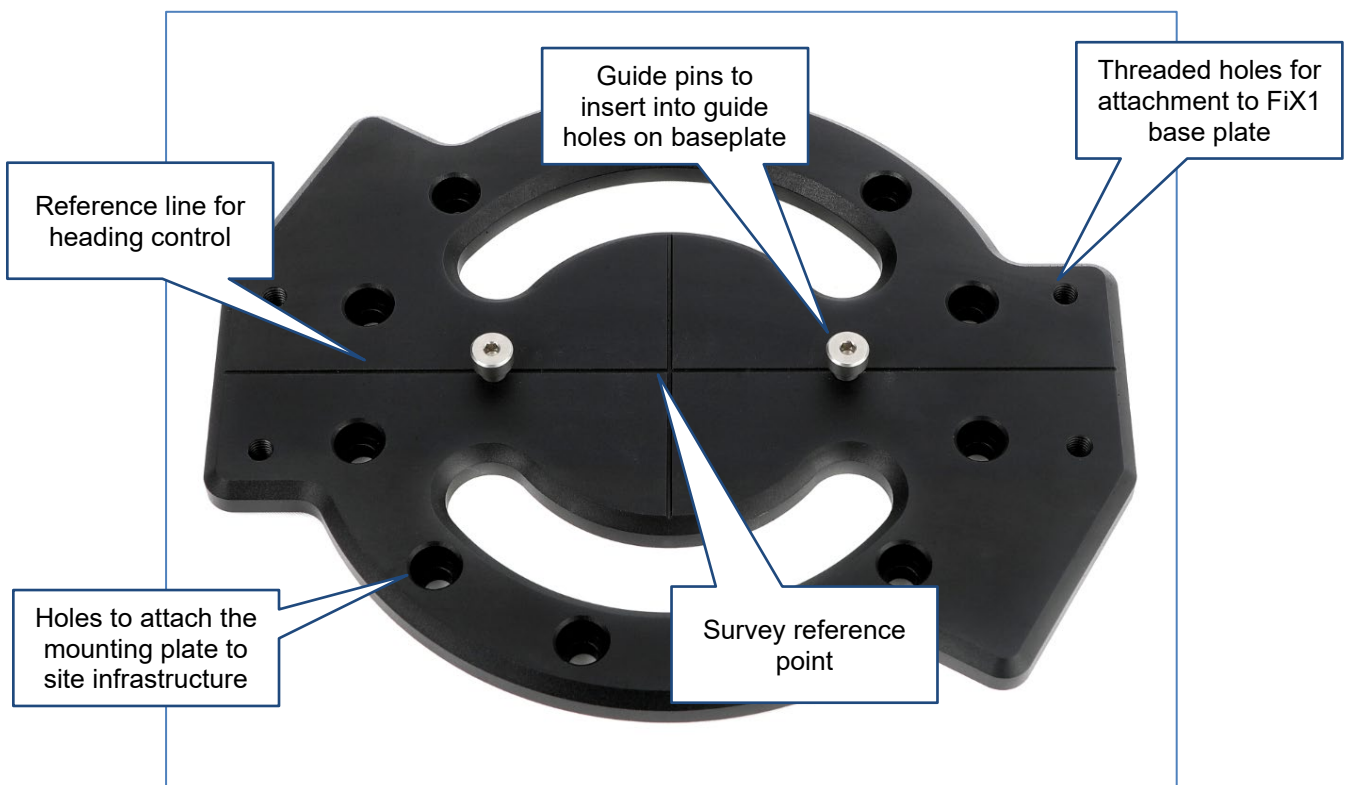


Figure 20 FiX1 mounting plate

The centre of the mounting plate is marked with an etched cross. To ensure that all FiX1 data is correctly georeferenced, use traditional survey techniques to survey in the FiX1 reference point on the local site coordinate system.

The long axis of the etched cross provides a reference line to indicate the heading of the FiX1. Use traditional survey techniques to survey in the FiX1 reference line on the local site coordinate system.

Twelve holes – for size M8 bolts – are positioned in a circle, at 30° intervals. These provide options for attaching the mounting plate to the site superstructure.

Four threaded holes – also size M8 – are positioned with two at either end of the mounting plate. These line up with holes in the FiX1 baseplate and are used to directly attach the FiX1 unit to the mounting plate.

Two guide pins ensure that the FiX1 can be held in place while the unit is screwed onto the mounting plate.

See section 5 for details on installing the mounting plate, surveying the system into a site coordinate system, and attaching the FiX1 unit to the mounting plate.

### 3.3 Ethernet cable

The Ethernet cable supplied is a standard Cat-5e cable with RJ45 connectors.

The Ethernet cable is 2 m long and can be used for testing the system before it is mounted. When the FiX1 is in position on-site, you will usually require a much longer Ethernet cable. The length will depend on where the FiX1 is mounted in relation to the nearest network connection point.

See section 5.8 for information on data connections.

### 3.4 Power cable

A 2 m power cable is supplied with a mains power plug.



*Figure 21 FiX1 power cable (Europe version)*

Variants of the power cable are available for different mains plugs found in different regions of the world.

Extension cables will probably be required onsite to reach to your mains power supply.

See section 5.7 for information on connection power to the FiX1.

### 3.5 USB and serial cable

USB and serial ports are incorporated into the FiX1 to allow accessories to be added to the system.

These ports are not currently active, so no cables are supplied to connect to these ports.

Carlson continues to update and expand the functionality of the FiX1 and will soon be activating these ports to increase the unit's capabilities.

Please contact Carlson for further information.

### 3.6 Wi-Fi and cell antennae

Two robust, omni-directional antennae are supplied. They can be used to facilitate communication with the FiX1 via cell phone and Wi-Fi.

The antennae are supplied with 5m of cable which is terminated with an SMA connector. This connector plugs into the appropriate connector on the FiX1 base.

The two supplied antennae are identical and work on the frequency 700-2700Mhz. Whether an antenna is used for Wi-Fi or cell connection will depend on which connector on the FiX1 base the antenna is plugged into.

Each antenna incorporates a mounting bracket to allow attachment to the site superstructure.

See section 5.6 for information on mounting the antennae.



*Figure 22 Wi-Fi / cell antenna*

### 3.7 Transit case

All components of the FiX1 system are contained within a dedicated transit case. The case ensures the system is protected from shocks and vibrations.



*Figure 23 FiX1 system in transit case*

When the lid is closed and the latches are snapped in place, the case is both dust tight and watertight (IP67).

Always pack the FiX1 unit and accessories into the transit case for storage and transportation.

Clean and dry the FiX1 unit and accessories prior to packing them in the transit case.



## 4 Hardware checks and preventative maintenance

Attempts to dismantle or repair the FiX1 unit 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 or installer 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.

Carlson recommends a yearly calibration and service of the FiX1 system in one of Carlson's approved service centres.

### 4.1 In use

Avoid having the FiX1 laser pointed directly into the sun or other high-powered infrared light sources.

Ensure the FiX1 unit is mounted on a stable platform that is not subject to shocks, severe winds or vibrations of any frequency.

Only locate the FiX1 where the temperature is guaranteed not to be outside of the recommending operating temperature of the system: -40° C to + 50° C.

When handling the FiX1, use two hands to support the system by the base and body of the unit. Do not carry the unit by the head and do not put strain on the vertical or horizontal pivots.

The FiX1 must be mounted within 1° of level, to ensure that undue strain is not place on the bearings.

### 4.2 FiX1 unit

If necessary, use clean water to remove mud, grit and other materials from the FiX1 unit. Do not immerse any part of the system in water. The FiX1 is rated IP67: it is dust-tight and protected against water spray from all directions, but not against submersion.

For further cleaning of the FiX1 metalwork and body panels, Carlson recommends that you use a product such as Amberclens anti-static foam cleaner. 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 FiX1 unit. 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.

Ensure that the laser windows in the laser head are kept clean and free of any dust or grime that may affect the path of the laser. To clean the lens windows, use HPLC-grade (> 99.8%) acetone in combination with lint-free cotton wool buds or wipes.

Store within the specified environmental temperature limits of -40° C to + 85°C.

Always pack the FiX1 system into the transit case supplied for storage and transportation. Clean and dry the FiX1 unit and other accessories prior to packing them in the transit case.

Do not allow the FiX1 system to slide around inside transport vehicles or containers.

# **INSTALLING AND NETWORKING THE FIX1**

## 5 Locating and installing the FiX1 unit

The results that are achieved by the FiX1, and the safe and reliable running of the system, are fully dependent on the correct installation and mobilization of the system on the customer's site. This installation must be carried out only by authorised parties with the appropriate product training certified by Carlson.

### 5.1 Safety

Installing the FiX1 system could be a hazardous task if undertaken carelessly. Note the points below which should be regarded as minimum precautions.

The potential dangers at each site could vary therefore a safety risk assessment should be completed before the installation takes place.

Carlson recommend that where appropriate, personnel involved in a FiX1 installation should be trained in 'working at height', 'operating and using lift platforms' and 'mains electrical safety'. In many situations, you must use a certified electrical engineer for the mains power supply installation.

The details of any certification and training will depend on the regulations local to the country of installation or the rules specific to the site where the FiX1 is being installed.

Electrical installation should be compliant to all local regulations at the country of installation and the use of automatic disconnection of mains supply for current, voltage or earth leakage faults is recommended. The earth bonding should be appropriately connected and tested/checked periodically to ensure it is within specified limits.

The use of an appropriate location for the FiX1 (e.g. clean, dry, within temperature specifications) is important for the functionality of the system. The structural strength of the superstructure onto which the FiX1 system is being mounted, should be checked by a qualified engineer before commencing the install. The dimensions and material of any customised mounting braces/brackets/fasteners should be appropriate for the system.

Appropriate Personal Protective Equipment (PPE) should always be used.

If already fitted, the FiX1 unit should be removed from the mounting plate before installation to reduce manual handling related issues.

Installing the FiX1 should be regarded as, at a minimum, a two-person operation.

At all times during the installation there should be no other persons present within a minimum of 10 metre diameter of the installation point at ground level in case of falling components. A similar minimum exclusion should apply to any lifting equipment.

The installation area should be cordoned off and 'Danger falling objects' warning signs should be located at appropriate, visible locations during the installation.

### 5.2 Determining the best location on-site

Prior to physically installing the FiX1, great care should be taken to establish the best location to mount the system. A full site recce should be undertaken, being aware of the considerations outlined below.

#### 5.2.1 Line of sight coverage

The primary concern is what the FiX1 can 'see' from its proposed location. The laser in the FiX1 can only measure along a direct 'line of sight' from its fixed position. Outside of this line of sight, there will be blank spaces in the data.

Take into account the points below.

- The FiX1 must be able to see all open sides of a stockpile in order to compute an accurate volume.
- The maximum height to which the stockpile material will be piled and whether the peak may obscure the view of the FiX1.
- The maximum angle of repose of the material. Steeper sides may be harder for the FiX1 to see, and harder for the laser to receive returns from.
- The height at which the FiX1 can be mounted. The higher the better for increased coverage.
- The footprint of the area of interest where the stockpiles are located.
- Other parts of the facility superstructure, cranes, scoops and gantries which may obscure the line of sight of the FiX1, either permanently or temporarily during routine operations on-site.
- Walkways or roads where personnel and vehicles may pass or pause, temporarily obscuring the view of the FiX1.

### **5.2.2 Laser range**

Under Carlson test conditions, the FiX1 laser ranges up to a limit of 250 m. This range is achievable to 90% reflective material (e.g. Kodak white card), where the target is larger than the footprint of the laser and where the angle of incidence is perpendicular to the path of the laser.

However, in real-world situations, the maximum achievable range at any given time or location will depend on a number of factors. The following conditions will limit the range to an unpredictable degree, produce spurious data, or, in some circumstances, may prevent any readings from being taken.

- Very dark, unreflective targets absorb the laser pulse and so lead to severely reduced ranges. An example of this is coal which may give ranges of less than 100 m. Different grades of coal will have different effects.
- An acute angle between the laser and the targeted surface reduces the range as a smaller fraction of the laser pulse is reflected back to the receiving optics.
- Wet, slick, shiny or very smooth surfaces can reflect the laser pulse away from the receiving optics. This can result in spurious points beyond the targeted surface, or in holes in the dataset.
- Dusty environments can impede the path of the laser and in some cases may obscure the targeted surface entirely. This can result in false returns and data appearing in front of the real surface.
- Fog, snow or heavy rain can have the same effect as dust: intercepting or reflecting the laser pulse before it reaches the targeted surface.
- Direct sunlight can lead to spurious data points between the FiX1 and the sun.

These factors should be accounted for when considering the location of the FiX1.

Note, particularly if the unit is located outside, that some of these factors will change due to the time of day, nearby on-site activities and weather conditions. Plan for a 'worse-case' scenario.

### **5.2.3 Number of FiX1 units required**

For many locations, a single FiX1, suitably positioned, can provide full coverage of the area of interest. However, if the footprint of the area of interest is beyond the working range of the FiX1 laser, or if the relative height and position of the FiX1 and the stockpiled material do not allow full line-of-sight coverage of the top of the stockpiles, multiple FiX1 systems may be required. These units form a 'hub-and-spoke' installation.

In case a hub-and-spoke installation is required, multiple mounting locations must be established to ensure the collected data not only covers the full area, but also that a reasonable overlap is achieved. The considerations listed in this section should be applied to each mounting location.

Each FiX1 location must be correctly geo-referenced in relation to each other so that the scans are able to form a single, cohesive surface from which a volume can be computed. Any errors in the registration of the scans will lead to errors in the computed volumes.

### 5.2.4 Structure on which to mount the FiX1

The FiX1 mounting plate is directly fixed to a location on the site superstructure. This location must be capable of supporting the weight of the FiX1 unit and of holding the unit rigid. Avoid any location which may be prone to shocks, jolts or vibrations of any frequency from, for example: heavy machinery, conveyors, moving gantries or direct, severe winds.

The FiX1 must be mounted within 1° of level, to ensure that undue strain is not place on the bearings.

In some cases, an additional, customised mounting bracket must be fabricated to allow the mounting plate to be attached to the superstructure. In the example below, the site's roof is slanted. Therefore, a level platform was fabricated to form a base on which to attach the mounting plate.



*Figure 24 FiX1 installation on a customised bracket*

### 5.2.5 Environmental conditions

Only locate the FiX1 where the temperature is guaranteed not to be outside of the recommending operating temperature of the system: -40° C to + 50° C. In temperatures below 0° make sure, where possible, that the FiX1 is powered on at all times. This helps provide heat to the system if the temperature drops further.

Ensure that the FiX1 mounting location is not subject to any high or low frequency vibrations.

If the FiX1 is mounted externally, protect the unit from constant direct sunlight.

The FiX1 unit is rated as IP 67, so it is thoroughly protected against water. However, where possible, ensure that the mounting location, and especially the laser optics, will not be subject to a constant flow of water which may interfere with laser measurements.

Avoid any locations near exhaust vents or any other systems which may coat the FiX1 in grime or produce thick

clouds around the unit. These phenomena may lead to the laser optics being obscured which will greatly affect the quality and integrity of the collected scan data.

### **5.2.6 Power availability**

The FiX1 system must be supplied with 'clean' mains power from 90-264 V ac. Ensure that there is a clear cable run from the power source to the FiX1.

### **5.2.7 Data connection**

A robust data connection is required to facilitate two-way communications with the operator.

This is most reliably achieved with a physical Ethernet cable connection. In this case, there must be an accessible connection and a clear cable run.

Note that Ethernet cable is generally designed to function at over lengths of less than 100 m. For cables that are longer than this, the signal begins to attenuate. This leads to reduced speed and reliability of connections.

A Wi-Fi link can be used instead of a hard-wired Ethernet connection. In this case, the supplied FiX1 Wi-Fi antenna must be mounted in a location where it can connect to a local Wi-Fi access point.

A cell phone connection to the FiX1 can also be used. In this case, a SIM card appropriate for your region must be installed in the FiX1. The supplied FiX1 cell antenna must be mounted in a location where it can receive adequate cell phone coverage.

### **5.2.8 Cable runs**

The power, Ethernet and antenna cable runs must be well protected from any nearby moving parts, sharp edges and high temperatures. Care should also be taken to ensure the cables are out of the way of any other on-site operations and that they do not present a trip-hazard to personnel.

### **5.2.9 Accessibility for service and maintenance**

Once installed and calibrated, the FiX1 is designed to be an automated system with minimal need for user intervention. However, there may be times when access to the system will be required.

An annual service is recommended, troubleshooting may be required and there may be occasions where personnel are required to physically access the FiX1 unit, cable connections, antennae or cable runs for routine checks or maintenance.

Bear this in mind when deciding on the location of the FiX1 system. Pay attention to the accessibility of all elements of the system, even if the requirement for access will be rare.

### 5.3 Installing the mounting plate

The FiX1 mounting plate is the part of the FiX1 system which is directly fixed to the site superstructure. The FiX1 is, in turn, attached to the mounting plate using a quick-release mechanism and supplied bolts. The mounting plate is effectively a permanently installed base: the FiX1 can be easily attached to, and removed from, the mounting plate, once it is in place. If it is likely that the FiX1 may be used in more than one location, Carlson recommends that multiple mounting plates and cable runs are installed and left in place. In this case, just the FiX1 unit itself would need to be relocated.

The FiX1 mounting plate also provides a target for surveying in the location of the FiX1 and thus for geo-referencing all collected data. The surveyed position is entered into the web application. A fixed offset is automatically applied to this position, ensuring that the scan origin is the centre of the horizontal and vertical rotation of the FiX1 laser head.

The mounting plate must be fixed in place in such a way that it is within 1° of level. If it is beyond 1°, the mechanics of the FiX1 unit will be put under strain and operation of the system may suffer over time. Therefore, it is important when installing the mounting plate that you use a calibrated spirit level to ensure that the mounting plate is level.

Note that although the mounting plate may be installed within 1° of level, it is likely that there are small pitch and roll values which need to be taken into account to ensure subsequent FiX1 scans are correctly levelled. These pitch and roll values can be entered into the FiX1 web application (see section 9.5.2).

12 holes for M8 bolts provide flexible options for attaching the mounting plate to different surfaces. The drawing below gives dimensions for the mounting plate and the locations of the M8 bolt holes.

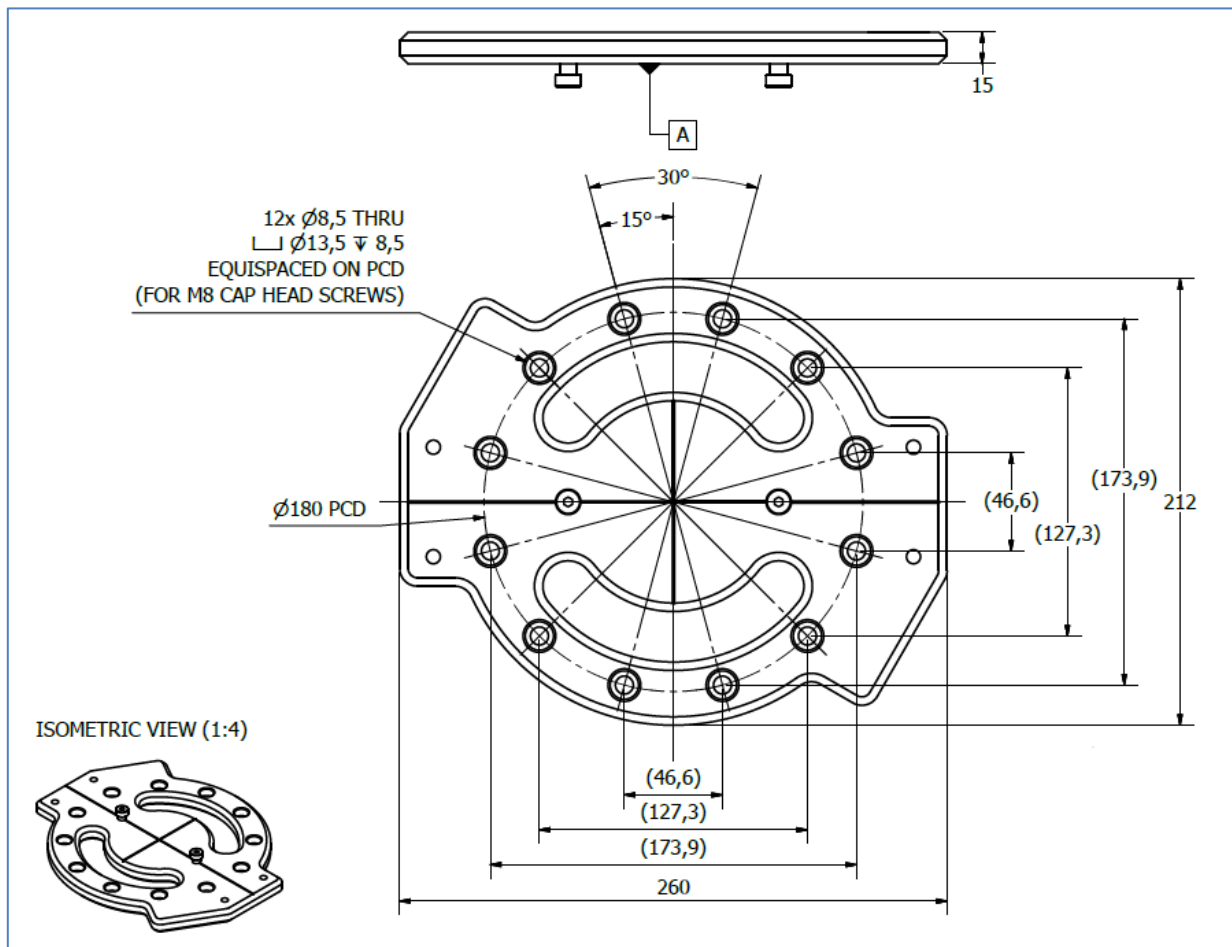


Figure 25 Mounting plate dimensions

## 5.4 Surveying in the mounting plate

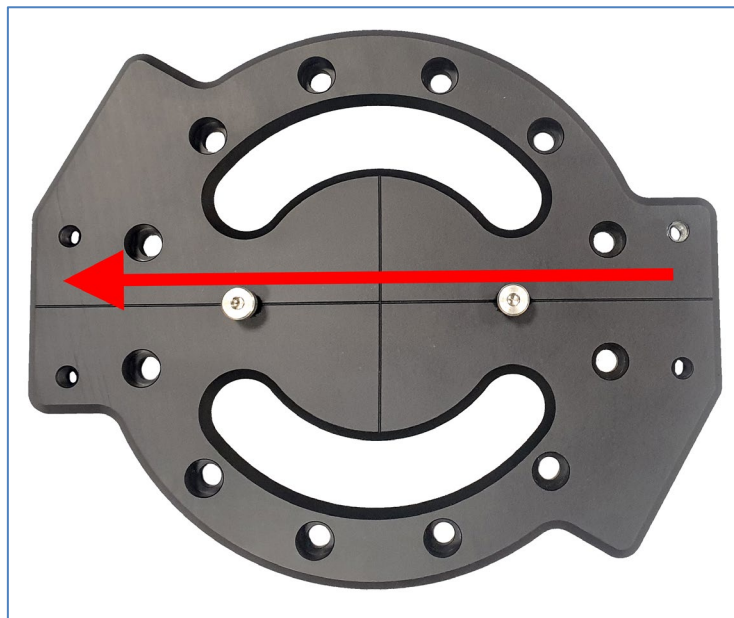
Any base surface uploaded into the FiX1 will be located on a specific coordinate system: usually the local site coordinate system. In order to correctly utilise this base surface to compute volumes from FiX1 data, the FiX1 must be georeferenced on this same coordinate system.

When the mounting plate has been fixed in place, it can be surveyed in by a trained surveyor with a total station.

With the total station referenced to the local site coordinate system, establish the coordinate of the survey reference point at the centre of the mounting plate. An etched cross clearly indicates the location of this point.

During normal operations, all collected scan data is automatically adjusted to account for the offset from this coordinate on the mounting plate to the scan origin. The scan origin is at the junction of the horizontal and vertical axes.

Establish additional coordinates at either end of the reference line. The heading between these two points can be computed and can be used to help establish the heading of the system as a whole.



*Figure 26 The mounting plate reference line for establishing heading*

Note that for this heading to be meaningful, it must be related to the orientation of the FiX1 on the mounting plate. The FiX1 can be mounted in one of two positions on the mounting plate, 180° rotated from each other. In Figure 27, note the relative positions of the power connector and Ethernet connector in relation to the direction surveyed.

Currently there is an additional offset of around 74° which must be added to the entered heading. Contact Carlson for the exact value for your FiX1 unit.



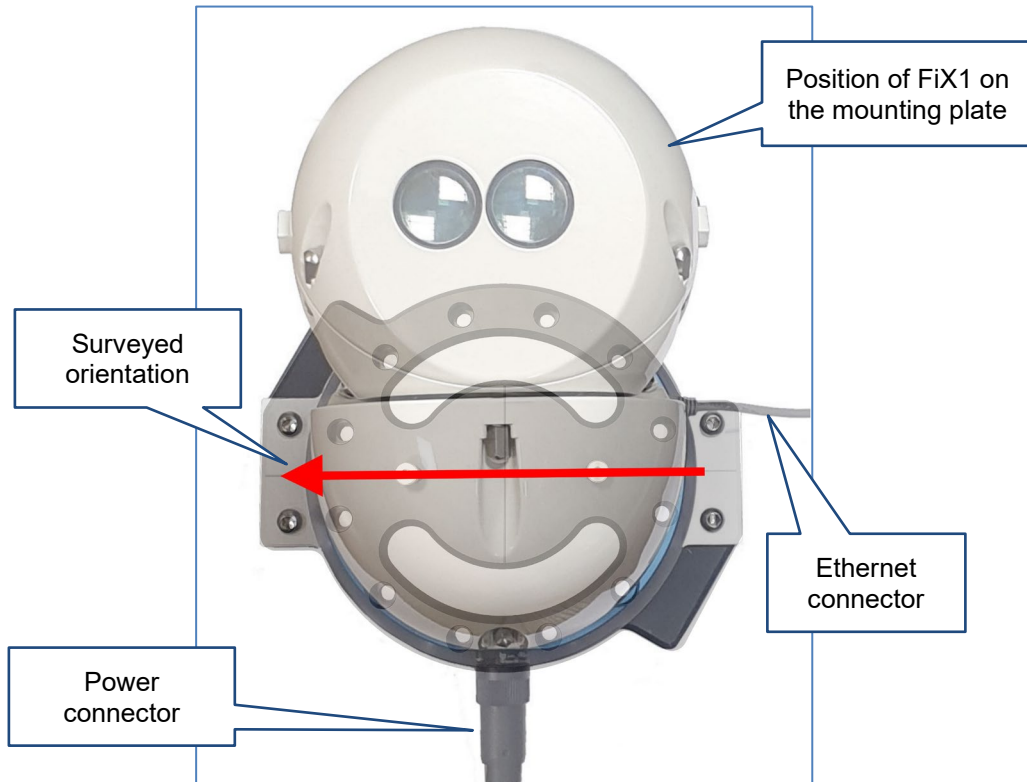


Figure 27 Looking up to a FiX1 which is mounted above and hanging down. Survey direction shown by the red arrow.

Surveyed values are entered into the **Calculation** section of the web application (see section 7.5.1).

## 5.5 Attaching the FiX1 to the mounting plate

With the FiX1 mounting plate installed and surveyed, the FiX1 unit can be fixed in place.

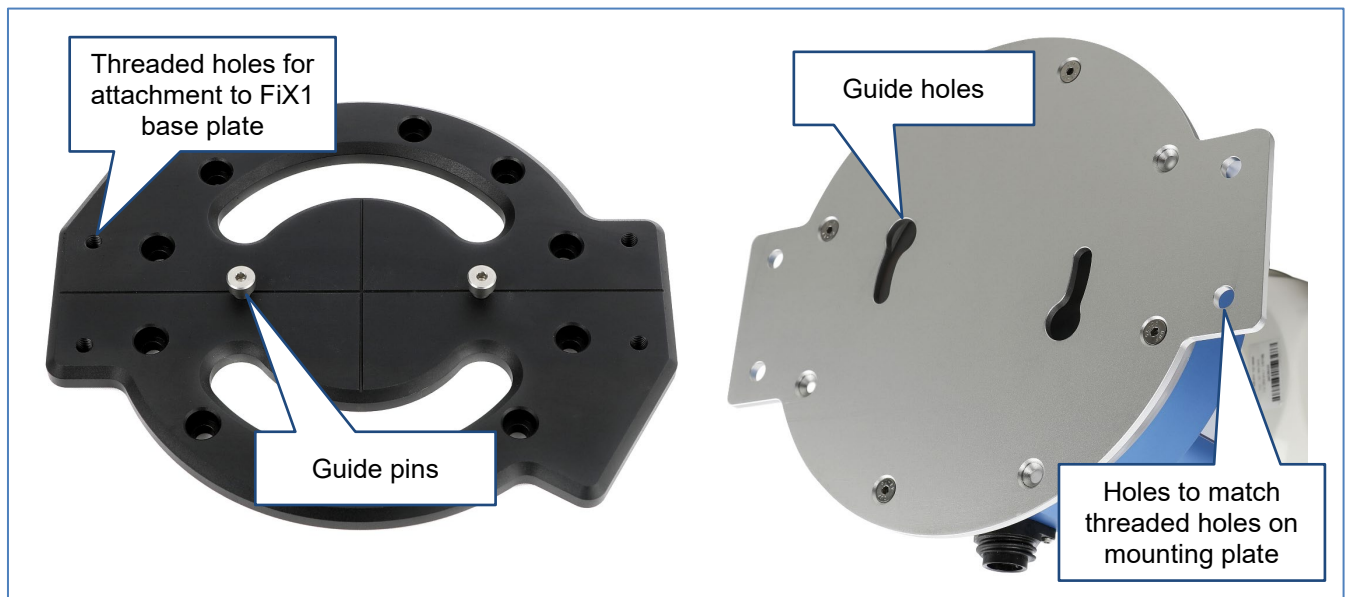


Figure 28 Attaching the baseplate to the mounting plate

To ensure a safe and simple attachment, the guide pins on the mounting plate act as a secure, temporary support for the system while you are bolting it in place.

Lift the FiX1 unit up to the mounting plate, thread the guide pins into the guide holes on the underside of the FiX1 baseplate and twist the FiX1 unit clockwise. The FiX1 is now held temporarily in place by the guide pins.

Holes on the baseplate are aligned with threaded holes on the mounting plate. Use the supplied M8 bolts to secure the FiX1 to the mounting plate.

## **5.6 Mounting the cell phone and Wi-Fi antennae**

One or both antennae should be connected and mounted if you need to connect to the FiX1 using a cell phone network and/or Wi-Fi.

Both antennae are physically identical. The port on the FiX1 into which they are connected determines whether they are used for Wi-Fi or cell phone connectivity.

The antennae are weatherproof, so can be mounted externally if required.

The antenna should be mounted vertically, but they are omni-directional, so you do not need to consider the horizontal heading of the antenna.

If mounting an antenna for connection to a Wi-Fi network, consider the position of the antenna location in relation to the device(s) which will connect to the FiX1.

If mounting an antenna for connection to a cellular network, consider the position of the antenna location in relation to the strength of the cell signal. An external mounting location may be the best option in this case.

Maintain at least 300mm separation between the antenna and nearby metal objects and surfaces.

Ensure that there is a clear cable run from the antenna to the FiX1.

Take care to avoid running the cable adjacent to existing wiring or fouling any moving controls or components. Ensure that any loose cable is safely secured away.

### **5.6.1 Bracket mounting**

The antenna should be mounted vertically, with the cable exiting downwards.

When mounting the antenna to a metal housing, object, surface or mast, ensure that the antenna housing is elevated above the metal surface to which it is mounted.

It is important for RF performance that the antenna is only bracket mounted using the supplied bracket. Mounting the antenna using a different bracket could adversely affect performance.

The antenna can be bracket mounted using the four 4.5mm fixing holes – suitable for M4 screws or 4mm self-tapping screws – or mast mounted using a jubilee or worm drive hose clip with a maximum width of 14mm.

### **5.6.2 Panel mounting**

The antenna must be fitted to a ground plane of suitable size. It will fit panels of between 1-12 mm thick. The recommended minimum diameter of the surface is 200 mm.

Select a mounting location. Ensure that there is adequate clearance under the mounting panel and measure to check for central positioning if necessary.

Drill a 14 mm hole in the panel. Clean the hole, removing any swarf and sharp edges. Remove any paint from the panel's lower surface to ensure adequate electrical contact when the washer and nut are attached.

Remove the nut and washer and the adhesive pad backing from the underside of the antenna and feed the coaxial cable through the panel. Position the antenna over the mounting hole and stick it to the panel, applying firm pressure. Assemble the nut and washer from under the panel and tighten fully.

## **5.7 Power connection**

The FiX1 requires a stable mains power supply at 90-264 Vac. The power requirement is 80 W.

## 6 Networking the FiX1

### 6.1 Data connections - introduction

There are a variety of methods that can be used to connect to the FiX1.

The recommended setup when using a FiX1 on a local area network is:

- a physical Ethernet cable linking the FiX1 to the network,
- the FiX1 set to use a Dynamic IP address,
- reserve a fixed IP address on your network router to ensure the FiX1 unit always uses the same address.

However, this setup not always practical or desirable. Ultimately, the connection used on any particular site will depend on a number of factors. These include:

- The physical accessibility of the site,
- The network infrastructure in place at the site,
- Whether the FiX1 is being located outside or in a facility,
- Whether the FiX1 needs to be accessible to numerous personnel on a network, or just one individual overseeing the unit,
- Whether there is a viable cable run from the FiX1 to an Ethernet connection socket,
- The availability of a Wi-Fi access point,
- The site's IT policy.

The various methods of connecting to the FiX1 are outlined below. Whichever method is selected, the correct hardware setup must be matched with the corresponding software configuration.

The FiX1's software configuration is carried out through the **Network setup options** in the web application. To make any changes to these settings, click the **Unlock** button, select the required configuration, then click **Apply network settings**.

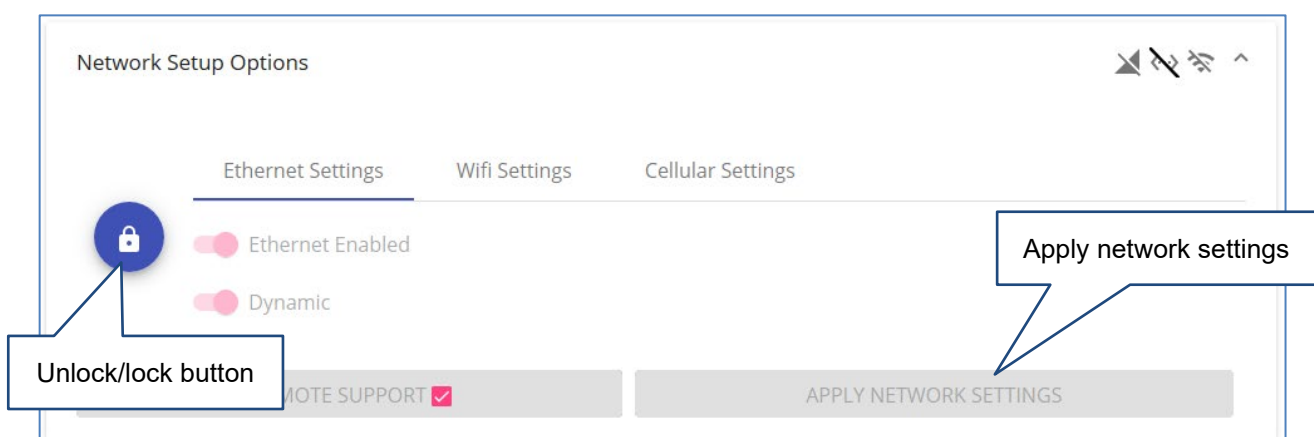


Figure 29 Network setup options

## 6.2 First connection to the FiX1

When it leaves the factory, the FiX1 is setup with a dynamic IP address.

The FiX1 is automatically allocated an IP address on connection to a network with a DHCP server.

Power up the FiX1 and use the supplied Ethernet cable to connect the unit into your network.

To identify the IP addresses allocated to the FiX1, you may use a tool such as Colasoft's MAC Scanner: [https://www.colasoft.com/mac\\_scanner/](https://www.colasoft.com/mac_scanner/).

Run MAC Scanner on a PC which is also connected to your network to identify the devices present. A FiX1 is identified by the name 'Variscite' under the heading 'Manufacturer'.

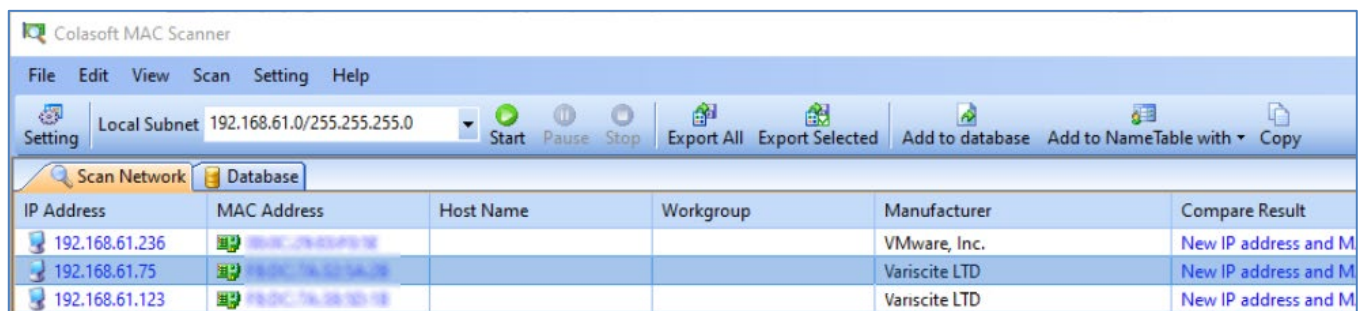


Figure 30 MAC Scanner used to identify a FiX1 on the local network

The IP address of each device is listed in the left-hand column. Enter the IP address of the FiX1 into a web browser to access the FiX1 web application.

## 6.3 Recovery mode

In case you have trouble establishing a connection to the FiX1 at any time, a recovery mode is built into the unit. This may be useful when first setting up the FiX1, but it is primarily to allow emergency access to the FiX1 if the IP address has been changed, forgotten or if there are other reasons why no connection can be made to the unit.

The FiX1 enters recovery mode when it has been switched on for around five minutes and has detected no network connection.

On entering recovery mode, the following settings are activated, independent from any network settings which may have been previously configured in the web application:

- Ethernet is switched to DHCP mode (automatic IP allocation). If an Ethernet cable is plugged in to the FiX1 and DHCP is available, the unit can obtain an IP address automatically.
- The cell modem is activated. Connect an antenna to the Cell connector to make use of this option.
- Wi-Fi is switched to access point mode. Connect an antenna to the Wi-Fi connector to make use of this option.

To connect to the FiX1 using the automatically created Wi-Fi access point, open your Windows Wi-Fi connections dialog.

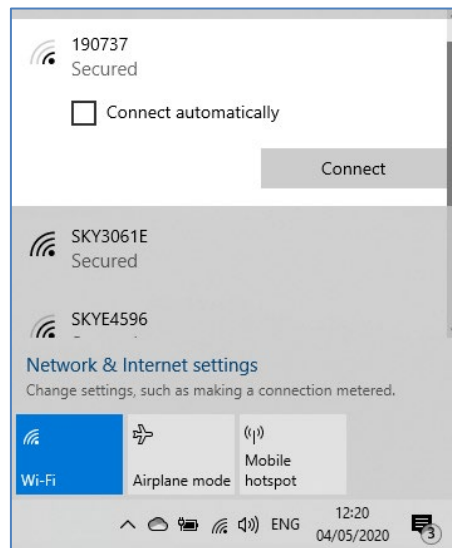


Figure 31 FiX1 recovery mode SSID in the Windows Wi-Fi manager

The Wi-Fi access point SSID is the serial number of the FiX1. In the case above, this is 190737. Select the appropriate entry in the list of Wi-Fi networks and click **Connect** to connect to the FiX1.

The Wi-Fi connections dialog requests a network security key.

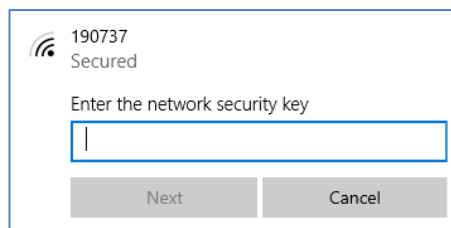


Figure 32 Enter the recovery mode security key

Enter: **6065645028**. Click **Next**. Your PC connects to the FiX1.

Open your web browser and enter the address: **<http://fix1.carlsonsw.com>**

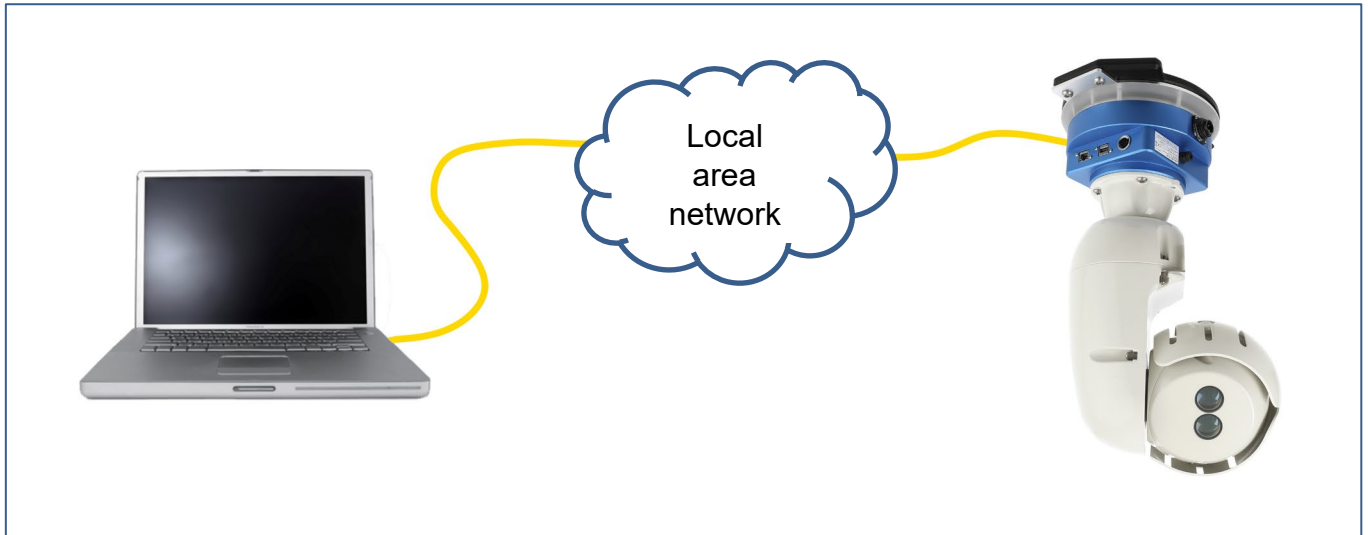
The FiX1 login screen appears. Enter the default username and password. Click **LOGIN** to access the web application.

Navigate to the **Network setup options** to configure the settings as required. After making any changes, click **Apply network settings**. As soon as the new settings are applied, the unit will reconfigure the network interfaces and exit from recovery mode. If the newly configured settings still do not provide connectivity, the FiX1 returns to the rescue mode after a few minutes.

## 6.4 Connection options

### 6.4.1 Wired ethernet connection

A wired Ethernet connection is the recommended setup for the FiX1.



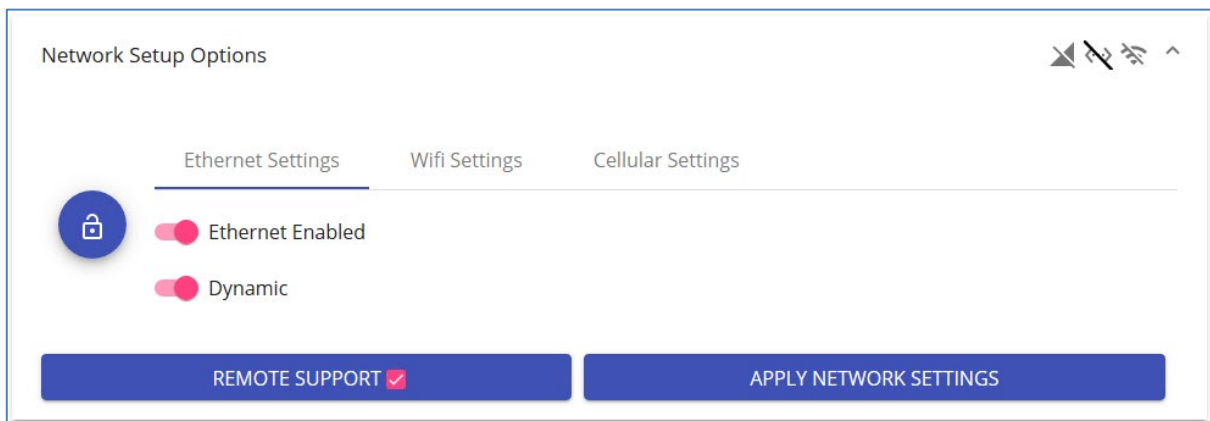
*Figure 33 Wired Ethernet connection*

Run an Ethernet cable of suitable length from the FiX1 to the nearest network connection point.

Decide whether you wish to allocate to the FiX1 a 'fixed' or 'dynamic' IP address.

#### 6.4.1.1 Dynamic IP address

To use a dynamic IP address, in the **Network setup options > Ethernet settings**, set the switches to **Ethernet enabled** and **Dynamic**.



*Figure 34 Network setup options > Ethernet settings > Dynamic IP address*

An IP address will be automatically assigned to the FiX1 when it is connected to a DHCP server, in the same way that a PC is assigned an IP address when it is connected to a company's network.

When the FiX1 is connected to a network, find the IP address of the system by using a tool such as MAC Scanner (see section 5.8.1). Enter this IP address into your web browser.

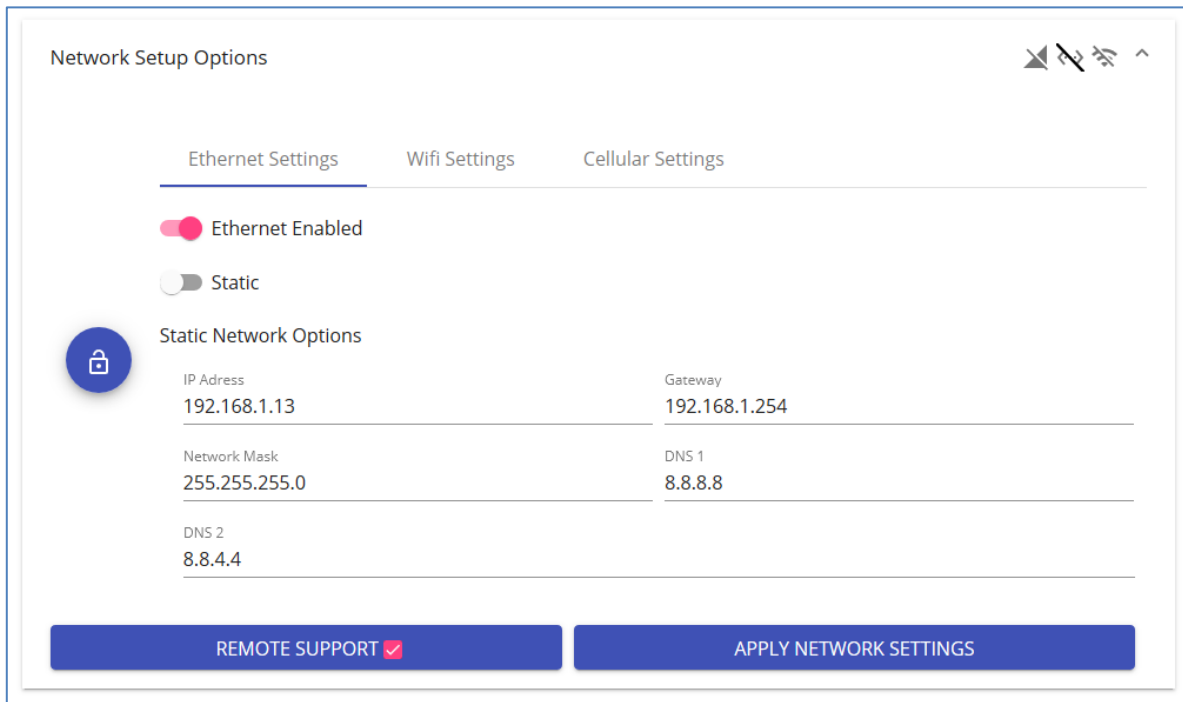
With **Dynamic** set in the FiX1 web application, you may choose to set your network router to reserve a fixed IP

address which is then permanently allocated to the FiX1. Be aware that without this fixed, allocated IP address, the IP address of the FiX1 may, on occasion, be changed automatically by your network router.

#### 6.4.1.2 Static IP address

To use a static IP address, in the **Network setup options > Ethernet settings**, set the switches to **Ethernet enabled** and **Static**.

Fill in the **Static network options**. Consult your IT department for advice on these settings.



The screenshot shows the 'Network Setup Options' window with three tabs: 'Ethernet Settings', 'Wifi Settings', and 'Cellular Settings'. The 'Ethernet Settings' tab is active. It features a toggle switch for 'Ethernet Enabled' which is turned on (pink). Below it is a toggle switch for 'Static' which is also turned on (grey). Under the 'Static' toggle is a section titled 'Static Network Options' with a lock icon. This section contains input fields for 'IP Address' (192.168.1.13), 'Gateway' (192.168.1.254), 'Network Mask' (255.255.255.0), 'DNS 1' (8.8.8.8), and 'DNS 2' (8.8.4.4). At the bottom of the window are two buttons: 'REMOTE SUPPORT' with a checkmark icon and 'APPLY NETWORK SETTINGS'.

*Figure 35 Network setup options > Ethernet settings > Static IP address*

Enter the selected IP address into your web browser.

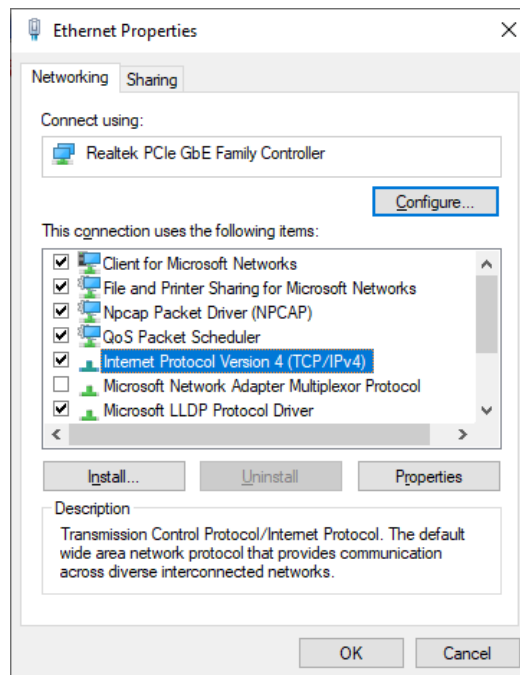
With a static IP address set, you can also connect the FiX1 directly to your PC when the PC is not connected to any network. Connect an Ethernet cable between the FiX1 and your PC.

On your PC go to **Settings > Network and Internet > Change adaptor options**. Right-click on **Ethernet > Properties**.

The **Ethernet properties window** opens.

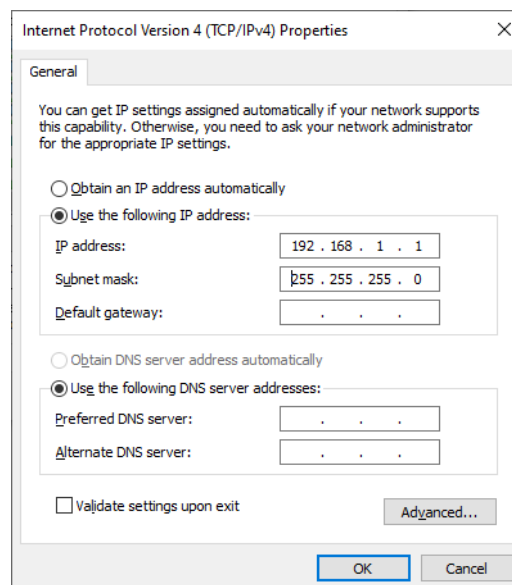


++++



*Figure 36 The Ethernet properties window*

Double click **Internet Protocol Version 4 (TCP/IPv4)**. The **Internet Protocol Version 4 (TCP/IPv4) Properties** window opens.



*Figure 37 The Internet Protocol Version 4 (TCP/IPv4) Properties window*

Note: before changing any settings in this window, make a note of how they are currently configured.

Select **Use the following IP address**.

Enter a fixed IP address for your PC. The entered IP address should be the same as that of the FiX1, other than

the last digit(s). In the example above, the FiX1 was **192.168.1.7** so the PC is being set to **192.168.1.1**.

Set the Subnet mask to **255.255.255.0**. Click **OK**.

Your computer is now set on the same network as the FiX1. You will lose connection to any other network to which you were previously connected.

Open a web browser on your PC and enter **192.168.1.7** into the address bar. The FiX1 UI appears.

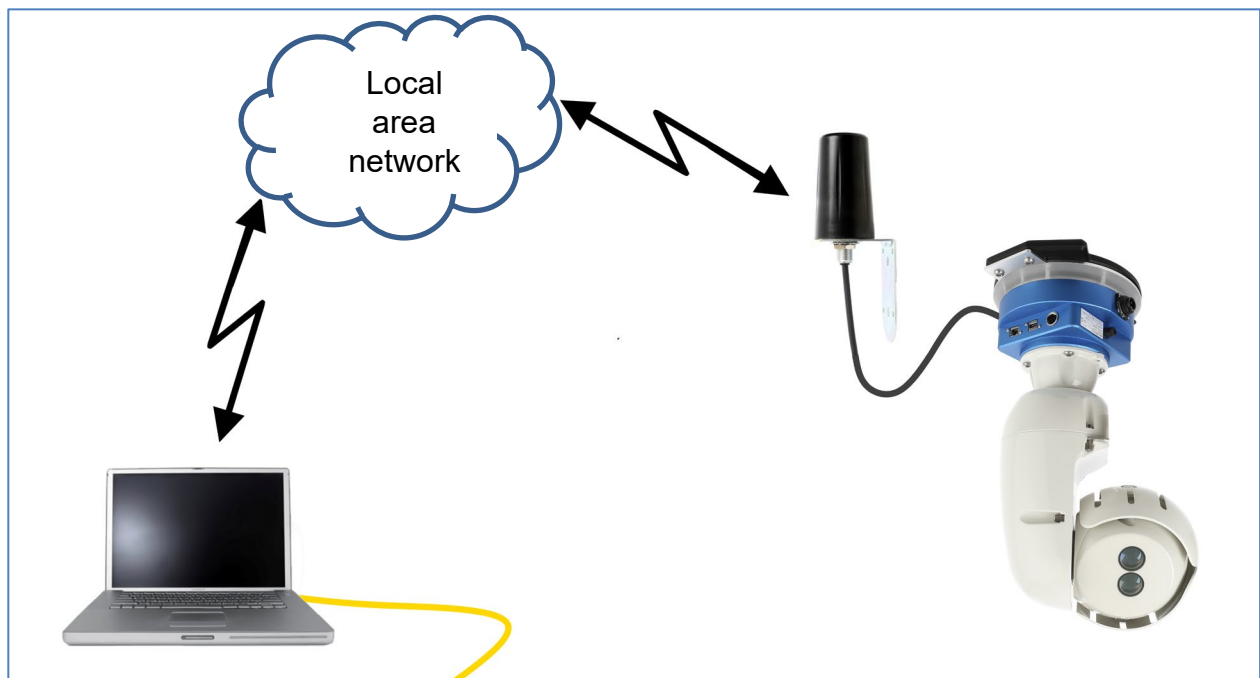
After finishing with the FiX1, return to the **Internet Protocol Version 4 (TCP/IPv4) Properties** window and return your PC's network settings to their initial state.

## 6.4.2 Wi-Fi connection

As an alternative to connecting to a network with Ethernet cable a Wi-Fi connection is also available. The connection can be set as an access point mode or client mode.

### 6.4.2.1 Wi-Fi client mode

Switch the FiX1 to Wi-Fi client mode to enable the FiX1 to connect to a network Wi-Fi access point.



*Figure 38 Wi-Fi client mode*

Connect one of the supplied antennae to the FiX1's Wi-Fi antenna connector. Ensure the antenna is within range of a Wi-Fi access point by testing the connection with a PC or mobile phone held at the antenna's location.

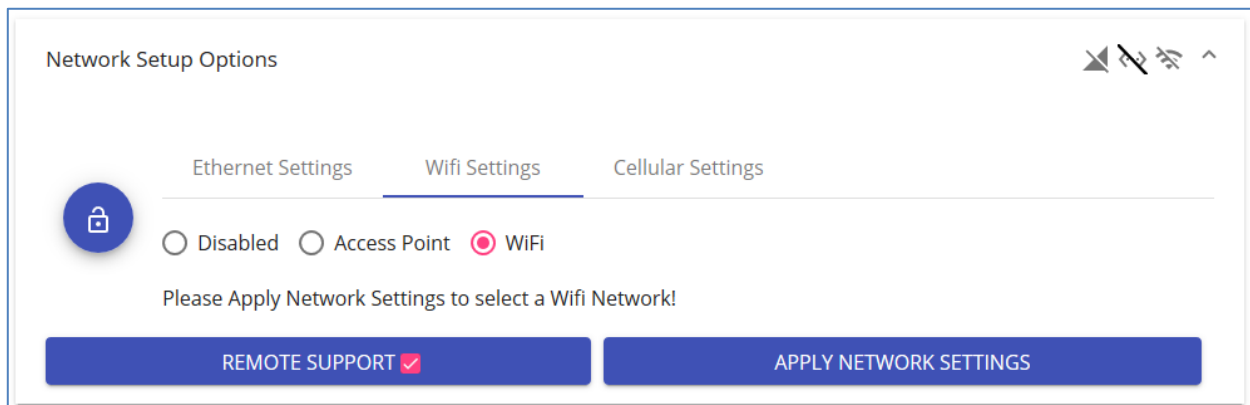


Figure 39 Network setup options > Wi-Fi Settings

To connect wirelessly to a network, in **Network setup options > Wi-Fi settings**, set the radio button to **Wi-Fi**. Click **Apply Network Settings**.

Allow time for the FiX1 to search for networks. The local networks appear in the **Available networks** list. Click the network to which you wish to connect.

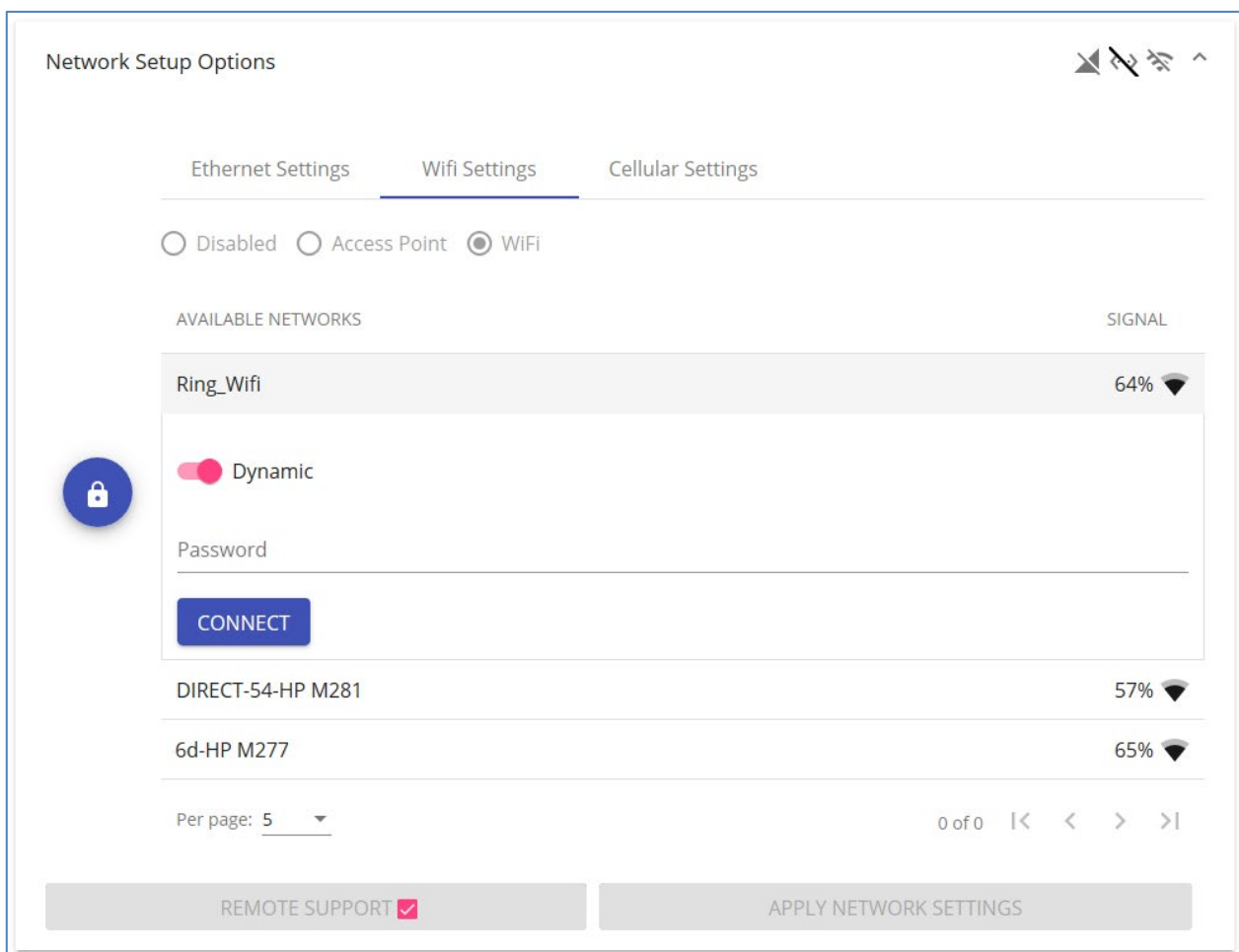
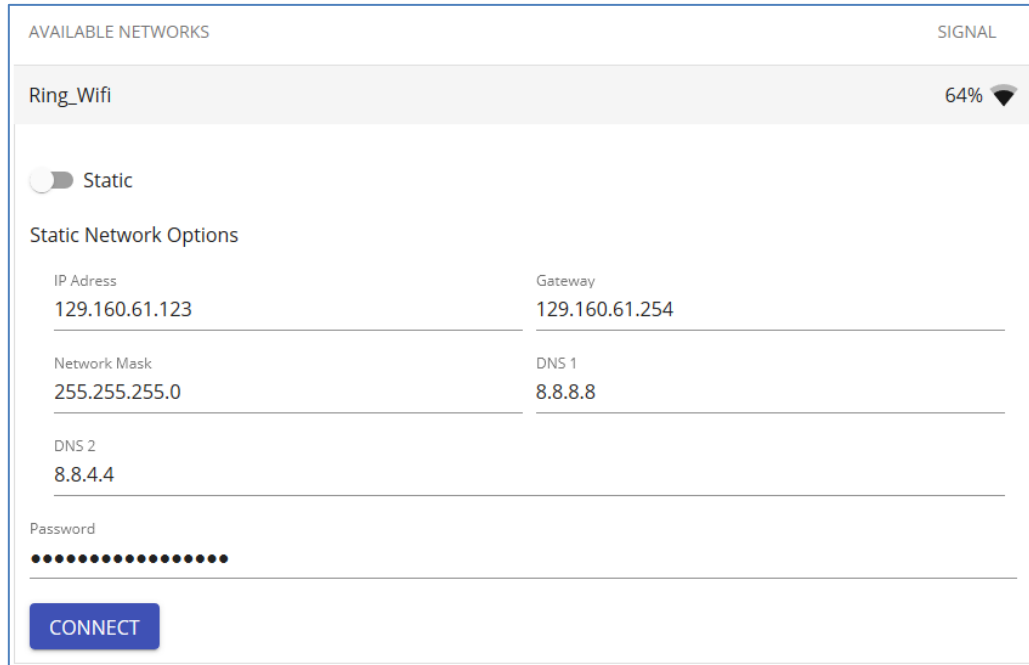


Figure 40 Network setup options > Wi-Fi Settings > Available networks > Dynamic

To establish a dynamic IP address, set the network connection switch to **Dynamic**.

Enter the network password and click **Connect**. Your network will assign an IP address to the FiX1.

To establish a fixed IP address, set the network connection switch to **Static**. Fill in the **Static network options** as appropriate. Consult your IT department for advice on these settings.



The screenshot shows the 'AVAILABLE NETWORKS' section with 'Ring\_Wifi' selected and a signal strength of 64%. Below this, the 'Static' toggle is turned on. The 'Static Network Options' section contains the following fields:

Field	Value
IP Address	129.160.61.123
Gateway	129.160.61.254
Network Mask	255.255.255.0
DNS 1	8.8.8.8
DNS 2	8.8.4.4
Password	••••••••••••••••

A blue 'CONNECT' button is located at the bottom left of the form.

Figure 41 Network setup options > Wi-Fi Settings > Available networks > Static

#### 6.4.2.2 Wi-Fi access point mode

Switch the FiX1 to access point mode to enable a FiX1 to act as a Wi-Fi access point. Mobile devices are then able to connect directly to the FiX1.

When switched to access point mode, the FiX1 is also connected to the local network via an Ethernet cable.

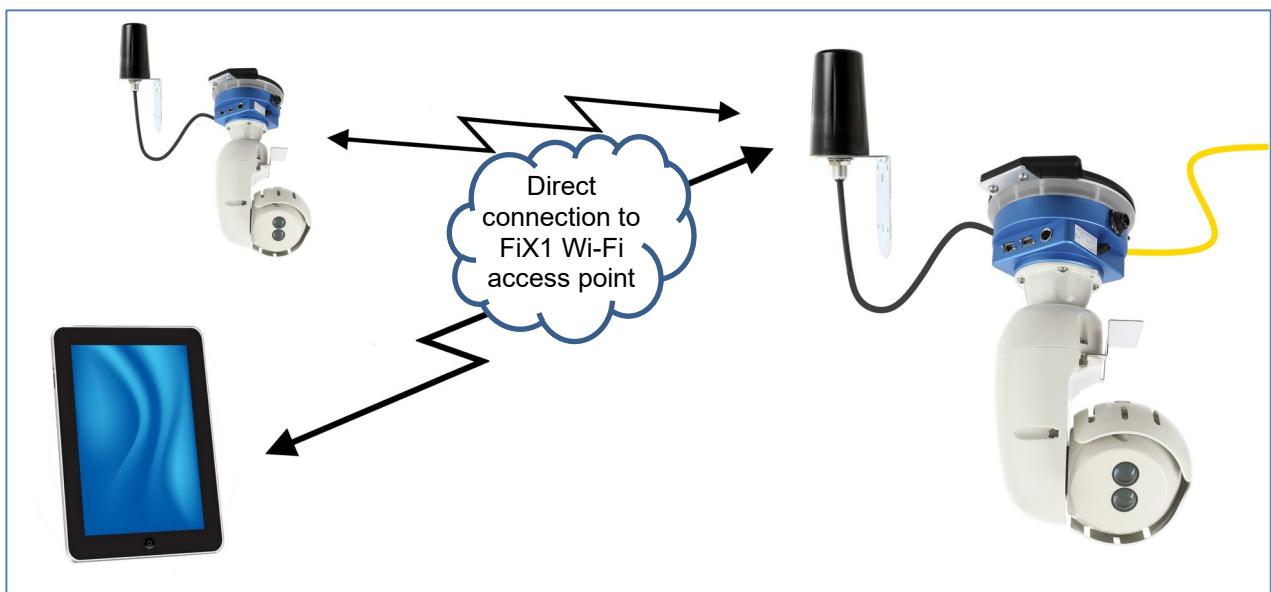
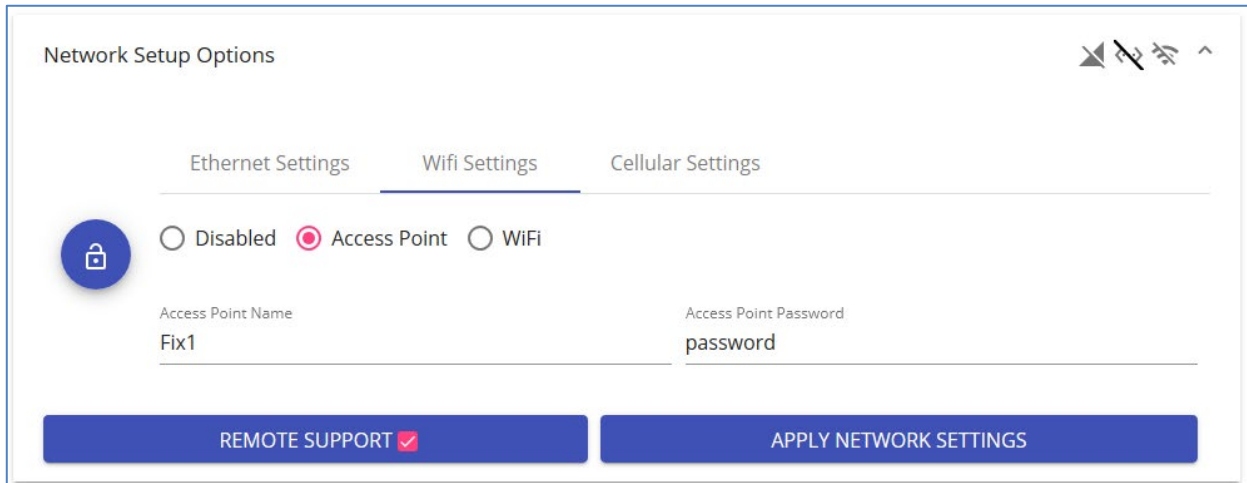


Figure 42 Connection with a Wi-Fi access point

Connect one of the supplied antennae to the FiX1's Wi-Fi antenna connector. Your Wi-Fi enabled device must be within Wi-Fi range of the antenna.

To use the Wi-Fi access point mode, in the **Network setup options > Wi-Fi settings**, set the switches to **Wi-Fi enabled** and **Access point enabled**.



*Figure 43 Network setup options > Wi-Fi settings > Access point mode*

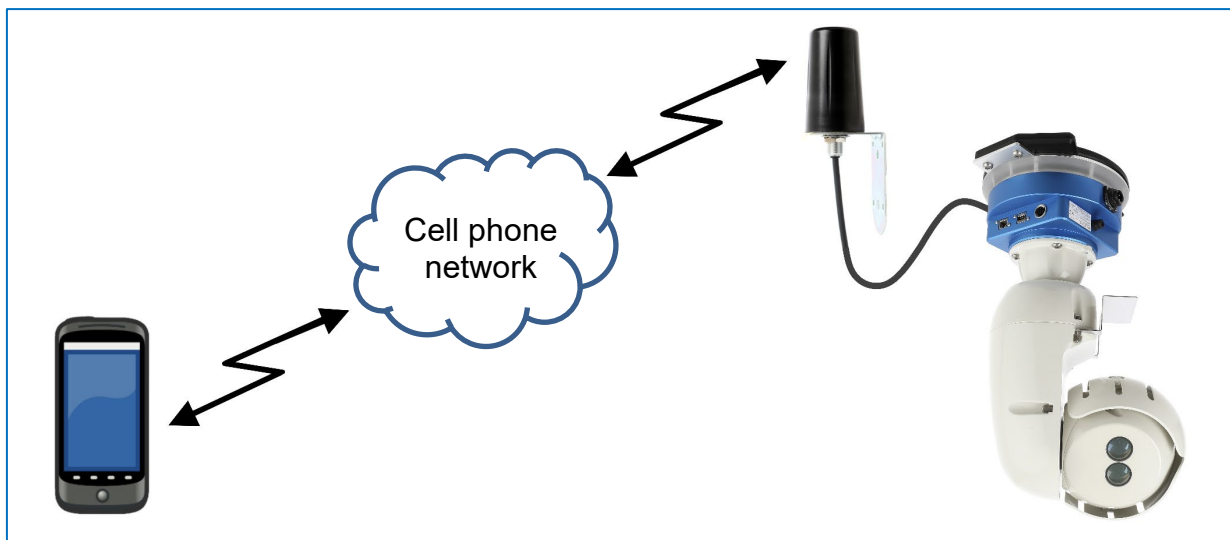
In the **Access Point Name** field, enter a name for the Wi-Fi access point. This is the SSID which will appear in the Windows Wi-Fi manager networks list.

In the Access Point Password field, enter a password. This will be required when any new device connects to the FiX1 access point.

### 6.4.3 Cell connection

The FiX1 incorporates a cell phone SIM card appropriate for your region. This enables you to connect to the FiX1 through the cell phone network. This sets up a connection completely independent of the site network.

A cell connection may be useful if the FiX1 is located in a remote facility without any available network connection.



*Figure 44 Connection using the cell phone network*

Connect one of the supplied antennae to the FiX1's Cell antenna connector. Ensure the antenna is within range of a cell phone network by testing the connection with a mobile phone held at the antenna's location.

You must supply a SIM card for your local phone network. The end user is responsible for all phone charges associated with the SIM card, as well as all admin and contact with the network provider.

With the FiX1 sat upright, the SIM card sits in the lower card slot. The SD card sits above it.

The SIM card slot directly accepts a micro-SIM card. If you have a nano SIM card, insert the card into an adaptor to enable it to fit in the FiX1 card slot.



*Figure 45 Insert a SIM card into the lower card slot*

To use the Cell connection, in the **Network setup options > Cellular settings**, tick the **Enabled** check box.

Enter the APN of your cell phone provider in the **Network Provider APN** field.

The **Cell status** field indicates the status of the cell phone connection.

The **Modem Info** fields display the modem installed in your FiX1 unit. Note that different models of are installed depending on your global region as per the table below.

Modem Model	Region covered
TOBY-L200	North America
TOBY-L210	Europe, Middle East, Africa & Asia
TOBY-L220	Japan
TOBY-L280	Asia Pacific and South America

Network Setup Options

Ethernet Settings

Wifi Settings

Cellular Settings

☒ Enabled

Network Provider APN

cellStatus  
registered

☒ Dynamic

modemInfo

Firmware	IMEI
15.63	358503061050523
Manufacturer	Model
u-blox	TOBY-L280
Model Full	Sim Number
MPCI-L280-03S-00	8944110068136042541
External IP Address	

REMOTE SUPPORT ☒

APPLY NETWORK SETTINGS

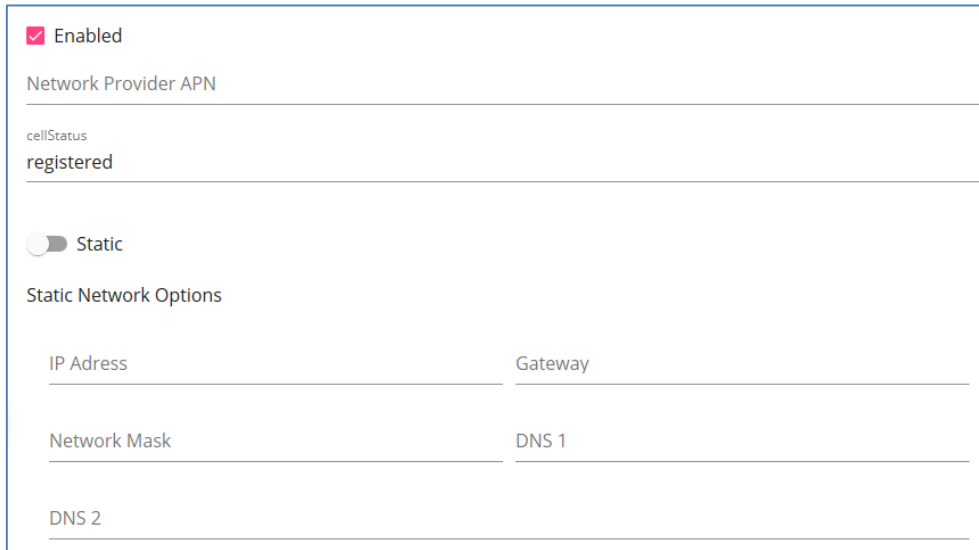
Figure 46 Network Setup Options > Cellular Settings > Dynamic

#### 6.4.3.1 Dynamic IP address

To use a dynamic IP address, in the **Network setup options > Cellular Settings**, set the mode switch to **Dynamic**. An IP address will be automatically assigned to the FiX1 by the cell phone network.

### 6.4.3.2 Fixed IP address

To use a static IP address, in the **Network setup options > Cellular Settings**, set the mode switch to **Static**.



☒ Enabled

Network Provider APN

cellStatus  
registered

☐ Static

Static Network Options

IP Address

Gateway

Network Mask

DNS 1

DNS 2

*Figure 47 Network Setup Options > Cellular settings > Static*

Fill in the **Static network options**. Consult your IT department or cell phone service provider for advice on these settings.

## 6.5 Hub-and-spoke installations

An installation combining more than one FiX1 unit operating together is a hub-and-spoke installation. In such a setup, every FiX1 unit must be connected to the same network.

One unit is designated the 'hub' and all other units are the 'spokes'. The hub is provisioned with a list of IP address for all the spokes in the installation (see section 7.5.6). This enables communications within the FiX1 network.

During installation, each unit must be individually configured to set up its specific scan/calibration/coordinate parameters.

To ensure stable operation, all units in a hub and spoke installation should be connected to the same network by means of an Ethernet cable.

During standard operations, the operator communicates just with the hub. The base file and scanning schedule are configured only in the hub.

A scan request is sent to the hub. The hub sends a scan command to the spokes, together with an empty grid. Each spoke runs a scan, fills the grid with elevations and returns the grid to the hub. The hub consolidates data from all FiX1 units in the network, cleans the data and computes a volume.

A schematic view of the Hub-and-spoke communications is shown in Figure 48.

If the hub fails to send or receive a message from a spoke, it throws a warning but continues with the scan procedure.



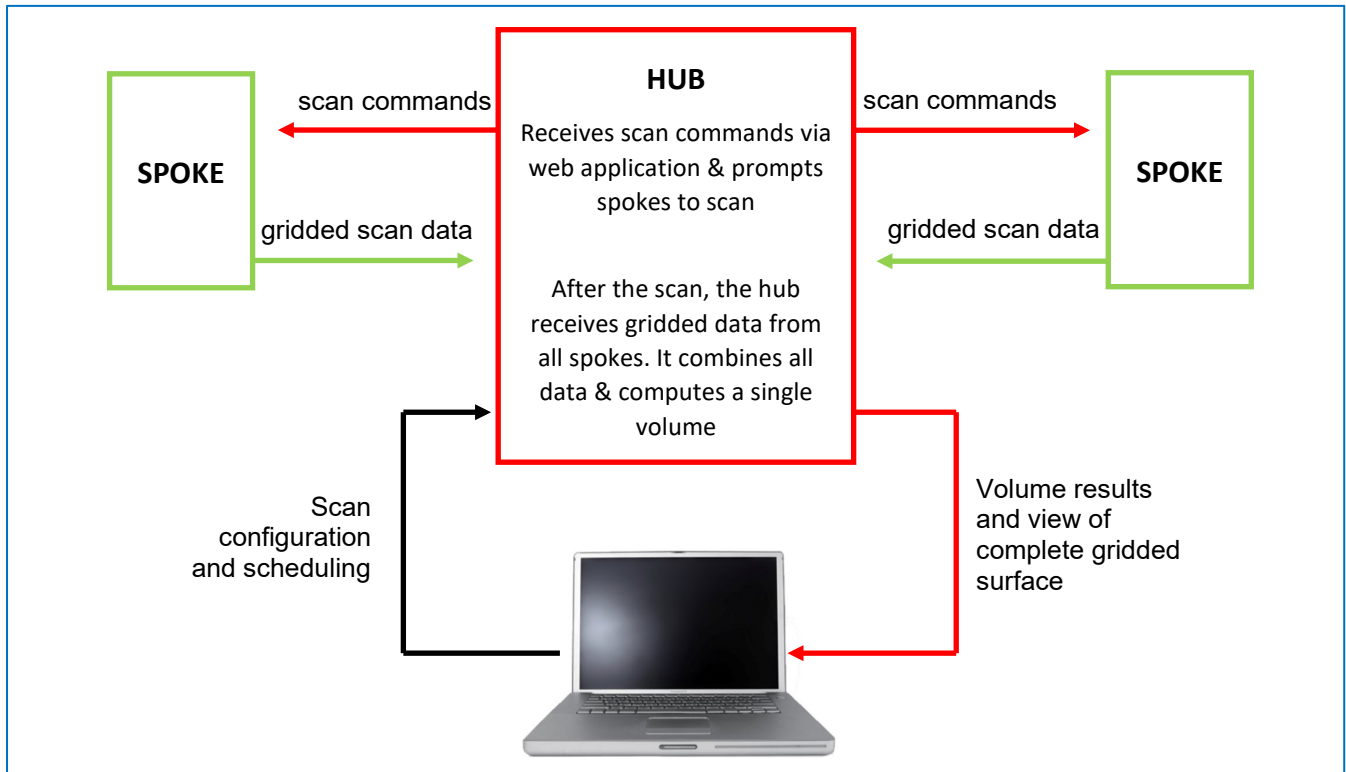


Figure 48 Communications between the user and three FiX1 units in a hub-and-spoke installation

## 6.6 Remote support

A **Remote Support** check box is located in the Network setup options page. When ticked, this function allows Carlson to remotely support the FiX1, both through access to the Web UI, and through direct SSH access to the FiX1 computer.

SSH or Secure Shell, is a remote administration protocol that allows users to control and modify their remote servers over the internet. The service uses cryptographic techniques to ensure that all communications to and from the remote server happen in an encrypted manner.

With the **Remote Support** check box ticked, the following 'reverse tunnelling' process is enabled:

1. Whenever the FiX1 is connected to a network with access to the internet it reaches out to Carlson's server. The FiX1 broadcasts its own name and status, and it requests two unique ports from Carlson's server: one for SSH connection and one for HTTP. This action is performed once every five minutes.
2. When these ports have been established, and a 'tunnel' created, the FiX1 makes an outgoing SSH connection to Carlson's server.
3. The FiX1 forms two reverse SSH connections using the two ports given in the first step. This allows Carlson to contact the FiX1 using SSH and HTTP.

Network administrators who do not want the reverse tunnelling process to take place over their network should untick the **Remote Support** check box.

## 7 Volume computations

The FiX1 volume computations all take place onboard the unit. For most users the system is a 'black-box' which automatically produces the required deliverable: a volume or set of volumes.

However, during the FiX1 installation process the volume must be verified and an understanding of the internal processing and potential limitations of the FiX1 system are necessary to understand and optimise the results.

### 7.1 Base surface

The base surface defines the extent over which volumetric computations are made. Any data collected beyond the X and Y coordinates of the base surface is discarded prior to the automated computations.

The base surface effectively acts as a 'cookie-cutter' to the scanned data. The outline of the base is projected upwards and everything between the base surface and scanned (or elevation) surface is counted as the 'fill' volume.

The geo-referencing of the FiX1 with respect to the base surface is crucial. If the scanned data and resulting elevation surface are incorrectly positioned or orientated the volume results will be incorrect.

The base surface is contained in a single TIN or DXF file, but may consist of multiple, disconnected surfaces if required.

### 7.2 Scan coverage

The scan from the FiX1 must cover the entire area of interest, encompassing all sides of the stockpile(s) which are to be measured. If the positioning of the FiX1 with respect to the stockpiles means that part of a stockpile is obscured, then the FiX1 has to make the volume computation using only the data available to it. This means that smoothing is used to fill any holes join up areas with genuine data. This should be avoided wherever possible by carefully planning the location at which the FiX1 is mounted and, if necessary, using additional FiX1 units to ensure complete coverage.

Consider what the laser can and cannot see, and also what it will and will not be able to see when the stockpiles are at their maximum height.

Some sites may have personnel, vehicles or machinery passing through or stopping during normal operations. The sequence above may filter out some effects of these features, but ultimately the optimum results will be achieved by directly scanning the surface of the stockpile. Some suggestions for ensuring this are:

- Schedule scans for times when there will be no other work going on onsite.
- Manually run scans when you can see there are no obstructions.
- Run more regular scans so that any anomaly - like a massively different volume in one scan - will be less significant & drowned out by more consistent, correct data.
- Run a scan set to 720° horizontal coverage instead of 360°. In this case the unit will scan the area twice (2 x 360°) and all collected data is pulled into the same grid. Since the lowest point measured in each grid cell is used to create the elevation surface, the hope is that the obstruction was not present for one of the sweeps, and so the surface is measured, and true heights are collected, at least once. This will help if there are people or vehicles moving around and stopping briefly.

### 7.3 Processing

The area above the base surface is broken into a grid. The number of grid cells is defined by the **Grid cells** option

in **Settings > Calculation > Grid cells**: see section 7.5.1.6.

As a scan is in progress, collected data is allocated to the grid cells which have been generated.

Each grid cell is allocated the Z value of the lowest point within that cell. This helps to reject spurious points: perhaps where dust, steam or moving machinery have intercepted the laser.

The user-entered **Angle of repose** (see section 7.5.1.7) is queried and any cells which define a slope beyond this value are rejected. Again, this helps to reject spurious data from foreign objects in the area of interest. For example, if there is a scoop left in the middle of the pile, or if spurious points are gathered from dust in the air, the surface formed from these points will have sides that are steeper than the angle of repose and will be discarded.

Any holes in the grid are filled using averaging based on smoothing. Ideally there will be as few holes as possible in the grid. The main way of ensuring this is through careful positioning of the FiX1.

This finished grid forms the elevation surface, which is then compared to the base surface, to compute a volume.

The final volume consists of:

- a 'fill' volume: the difference between the elevation surface and base surface in areas where the elevation surface is above the base surface.
- a 'cut' volume: difference between the elevation surface and base surface in areas where the elevation surface is lower than the base surface. This will usually be zero as the stockpiled material will be above the floor as defined in the base surface.
- a 'net' volume: the final result which is the fill volume minus the cut volume.

## 7.4 Areas of Measurement

The base surface can be sub-divided into smaller regions, with separate volumes reported for each of these regions. These **Areas of Measurement** may be required if, for example, different grades of material are being stored in different parts of the same warehouse and volume reports are required for each material.

A PLN file with any number of named polylines enclosing these regions is uploaded to the FiX1 (see section 9.6.2). The polylines must be located within the bounds of the base surface. Volumes for each named area are displayed on the PDF report and on the FiX1 **Scan list**.

## 7.5 Hub-and-spoke installations

In a hub-and-spoke installation with multiple units connected to a network, all communications with the installation are conducted through the FiX1 which has been designated as the hub.

When a scan is activated, the hub sends a scan command to the spokes, together with an empty grid. Each spoke runs a scan, fills the grid with elevations and returns the grid to the hub. The hub consolidates data from all FiX1 units in the network, cleans the data and computes a single volume (or single set of volumes if different **Areas of Measurement** are being used) from the resulting elevation surface.

## 7.6 Verification

For verification of the volume, as well as for troubleshooting and QC purposes, data from each scan is available for download. The main time this is necessary will be during installation and initial system setup and georeferencing.

- The constructed elevation surface is available for download as a GRD file. In hub-and-spoke systems, this is available from the hub.

- The uploaded base surface can be downloaded as a TIN file. In hub-and-spoke systems, this is available from the hub.
- The raw point cloud is available as a LAS file. In hub-and-spoke systems, these files are held on each individual unit, whether it be a hub or spoke.

## **FIX1 WEB UI**

## 8 FiX1 web application – introduction

All the software required for basic control of a FiX1 is contained on the unit itself in the form of a web application. This application is accessible via a web browser. Chrome, Firefox, Opera and Safari are all fully supported. No other software is required to operate the FiX1 system.

Access the FiX1 web application by entering the IP address of the unit in a web browser.

If the FiX1 is on a company network, then any device on that network can have access to the unit.

Additional functionality and management capabilities for multiple FiX1 installations are available in **Site Ops** which is a cloud-based software.

### 8.1 Remote updates and support

The web application software is being constantly updated with improvements and new features. Updates to this software can be remotely distributed from Carlson to any FiX1 on a network connected to the world wide web. If a FiX1 unit is on a network which has access to the internet, then the FiX1 can be configured to automatically receive regular updates whenever they become available.

The FiX1 checks daily for software and firmware and downloads any new version when available.

Software updates are then installed automatically.

If firmware updates have been downloaded, the FiX1 must be rebooted to allow the firmware update to take place. A regular, automatic reboot can be arranged in the **Schedule** page to ensure the process is fully automatic.

Options are available to turn off automatic updates and to allow beta versions to be installed. See section 7.5.2.

### 8.2 User access

User can log into a FiX1 as a user or as an administrator. An administrator has full control over all aspects of the FiX1 setup and configuration. A user has access to standard day-to-day functionality. It is recommended that most workers accessing a FiX1 should be restricted to user access to reduce the chances for conflict and accidental changes to a system.

#### 8.2.1 Admin access

For full administrator access enter the login details as below:

- Username: **admin**
- Password: **seem british mile**

Click **LOGIN** to access the web application.

Administrator access gives full control over all functionality described in this manual.

#### 8.2.2 User Access

For basic user access enter the login details as below:

- Username: **fix1\_user**
- Password: **carlson123**

Click **LOGIN** to access the web application.

A user has access to:

- Manual scan control (start / stop scan)
- The scan list / scan graph
- All downloads for each scan
- Schedule (read only)
- Scanner controls
- Information tab

All other functionality is hidden for a user.

### 8.3 Web application UI

The first time you connect to a given FiX1, the login screen is encountered.

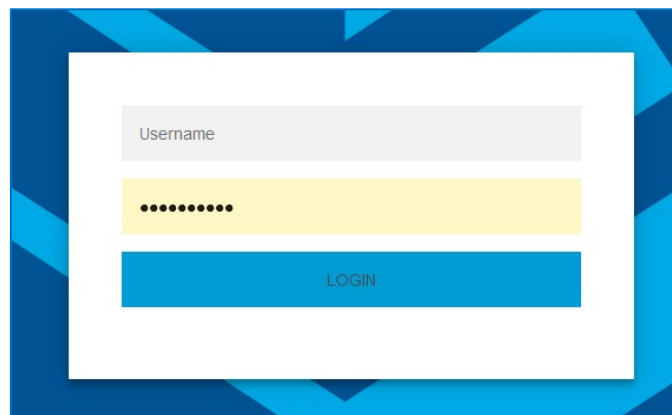


Figure 49 Log-in screen

Enter the username and password as per your access status. This manual assumes you have administrator access to the FiX1.

Entering the web application, a title bar is visible along the top of the screen.

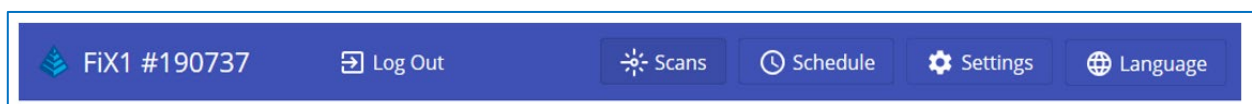


Figure 50 Title bar

The title bar incorporates:

- The serial number of the FiX1 to which you are currently connected.
- **Log Out**: click to log out of the web application.
- **Scans**: the default home page outlining the scan history and last computed volume. See section 7.3.
- **Schedule**: to pre-arrange scans using a calendar. See section 7.4.

- **Settings:** provides configuration tools to setup scanner operational parameters. See section 7.5.
- **Language:** switch between multiple translations of the web application. See section 7.6.

Click one of these buttons to access different areas of the web application. The **Scan** page is the home page and is encountered when logging in to the web application.



## 9 FiX1 Web application – Scans

The **Scan** page displays a history of recent scans, the last recorded volume and the scan tool for requesting an immediate scan.

### 9.1 Scanning

FiX1 scans can be scheduled in advance through the **Schedule** page. You can also start a scan manually from the **Scan** page.

If any scans have been scheduled, the **Next Scan** frame shows the next scan that has been scheduled.



Next Scan

No scan scheduled

■ STOP

▶ MANUAL START

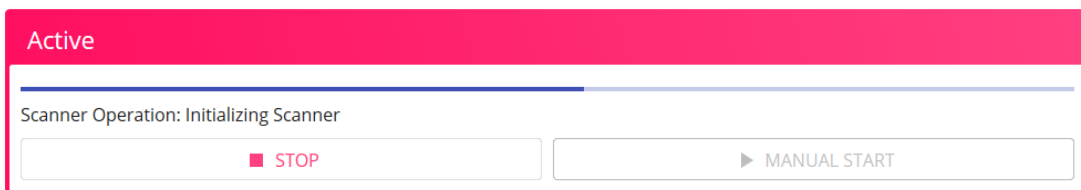
If no scans are currently running, press **Manual Start** to immediately start a scan.

The **Stop** button becomes active. Press **Stop** to cancel the scan at any point in the scanning process.

The **Next Scan** frame turns red and shows the title: **Active**.

Before the scan begins, the FiX1 progresses through an initialisation routine.

The **Active** frame displays: **Scanner Operation: Initialising Scanner**.



Active

Scanner Operation: Initializing Scanner

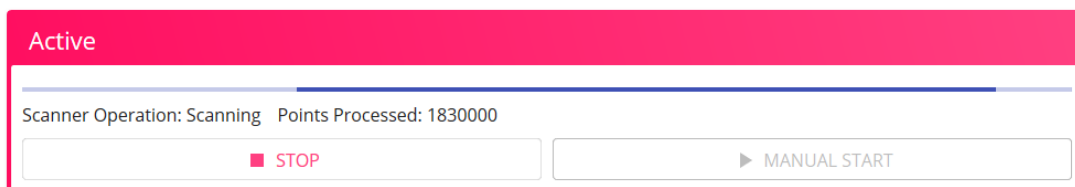
■ STOP

▶ MANUAL START

After initialisation, the scan begins.

The **Active** frame displays: **Scanner Operation: Scanning**.

As the scan progresses, the number of points that have been collected is displayed. For example: **Point Processed: 1820000**.



Active

Scanner Operation: Scanning Points Processed: 1830000

■ STOP

▶ MANUAL START

On completion of the scan, the FiX1 processes all collected data, creates a gridded surface and computes a volume.

During processing, the **Active** frame displays: **Scanner Operation: Creating Point Visualisation**.



On completion of the processing, the completed scan is added to the **Scan list** and **Scan graph**.

## 9.2 Scan list

The **Scan list** shows, in tabular form, the most recent scans completed on the FiX1.


Scan History 				
#	Time Start	Run Time		Volume
6	11/20/20, 12:59 PM	1h11m36s	All	31,252 Cubic Meter
5 *	11/20/20, 3:16 PM	17m5s	All	31,300 Cubic Meter
5	11/20/20, 10:41 AM	1h9m38s	All	31,339 Cubic Meter
4	11/19/20, 11:57 AM	1h52m15s	All	35,789 Cubic Meter
Per page: 5 <span>▼</span> <span style="float: right;">1 - 5 of 11  &lt; &lt; &gt; &gt; </span>				

Figure 51 Scan list

In the top right of the **Scan list** is an icon. Click the icon to toggle between the **Scan list** and the **Scan graph** (see section 7.7).

As more scans are run, the list of scans retained by the FiX1 grows. At the bottom left of the **Scan list**, use the **Per page** drop down tool to select the number of scans to be shown on each page.

Use the forward and back controls on the bottom right of the **Scan list** to move back and forwards through the pages of scans.

Columns in the **Scan list** show:

- **Scan number:** a sequential ID number. An asterisk after the id number indicates that this entry in the list is a reprocessed scan. The ID of the reprocessed scan is otherwise the same as that of the original scan.
- **Time start:** the time and date that the scan was started.
- **Run time:** the duration of the scan in minutes and seconds.
- **Volume:** the computed volume. To change this column to display weight instead of volume, change the appropriate setting in the **Settings > Units** page (see section 9.1).

Click on a scan to reveal options for each scan.



Figure 52 Scan buttons

### 9.2.1 View

Click **View** to open the point cloud for viewing in the web browser. See section 8 for further details.

### 9.2.2 Download

Click **Download** to access a sub menu which lists the downloads available for each scan.

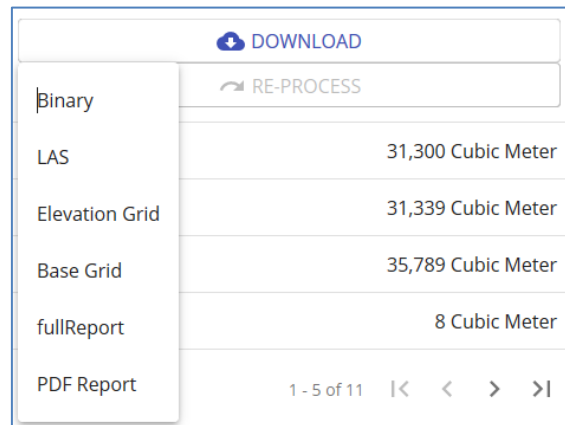
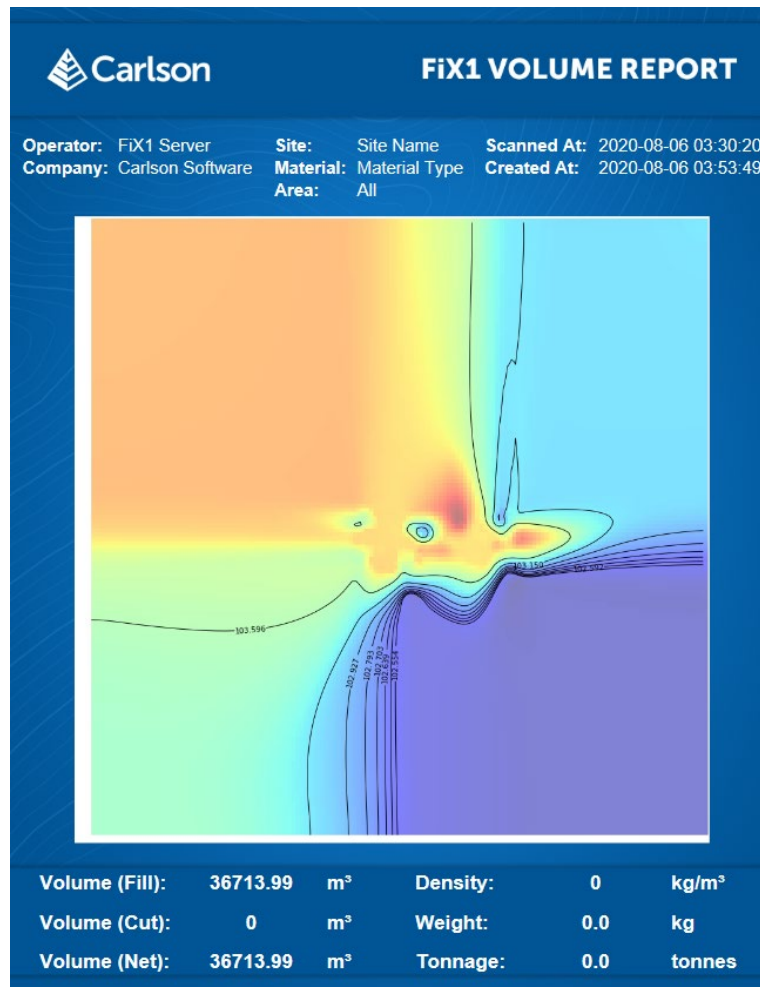


Figure 53 Download options

- **Binary:** includes all raw data, without calibration adjustments or filtering. Open in Carlson's P3D for troubleshooting and data analysis.
- **LAS:** industry standard LAS format. Point cloud with calibration adjustments. This file is always downloaded in metric units.
- **Elevation grid:** data used to create the surface for volume computations. The GRID dataset is created by:
  - Applying calibration adjustments to the point cloud
  - Break the area into grid cells (using the **Grid options** settings: see section 7.5.1.6)
  - Take the elevation of the lowest point in the grid cell
  - Filter the data with the **Angle of repose** setting (see section 7.5.1.7)
  - Fill holes using averaging based on smoothing algorithms
  - In a hub-and-spoke system, combine the surfaces from each individual FiX1
  - Re-filter the combined surface.
- **Base grid:** the user-uploaded base surface in TIN format. This is always downloaded in metric, even if a

surface in imperial units was uploaded.

- **Full report:** a full report for troubleshooting and analysis including information about all parameters used to run or reprocess the scan.
- **PDF report:** a full report in PDF format.



*Figure 54 PDF report*

The PDF report includes:

- FiX1 serial number(s)
- Company name
- Site name
- Date and time of scan
- Contour map of the scanned area
- Volume (Fill): difference between the elevation surface and base surface where the elevation surface is above the base surface.
- Volume (Cut): difference between the elevation surface and base surface where the base surface is above the elevation surface.

- Volume (Net): equal to the fill volume minus the cut volume.
- Density
- Weight
- Tonnage

### 9.2.3 Delete

Click **Delete** to delete the selected scan. The process takes a few seconds, during which a message appears: **Deleting scan**.

The scan is permanently removed from the FiX1 and from the **Scan list**.

### 9.2.4 Reprocess

When any scan is run, the resulting point cloud, gridded surface and volume are created with reference to the parameters in the **Settings > Calculation** page (see section 7.5).

In some situations, you may wish to recompute the volume using different parameters, for example a different base surface or a different angle of repose.

In this case, first change the appropriate settings in the **Calculation** page. Then, from the **Scan list**, select a scan and click **Reprocess**.

The **Next Scan** frame will change to **Active**, replicating the processes displayed during a standard scan. When the reprocessing is complete, the reprocessed scan appears in the **Scan list** above the original scan. It is displayed with the same scan ID but is differentiated with an asterisk.

You can view, download or delete the reprocessed scan as with any normal scan. However, the reprocessed scan cannot itself be reprocessed. Return to the original scan if further reprocessing is required.

## 9.3 Scan graph

The **Scan graph** shows, in graphical form, the computed volumes of the most recent scans completed on the FiX1.

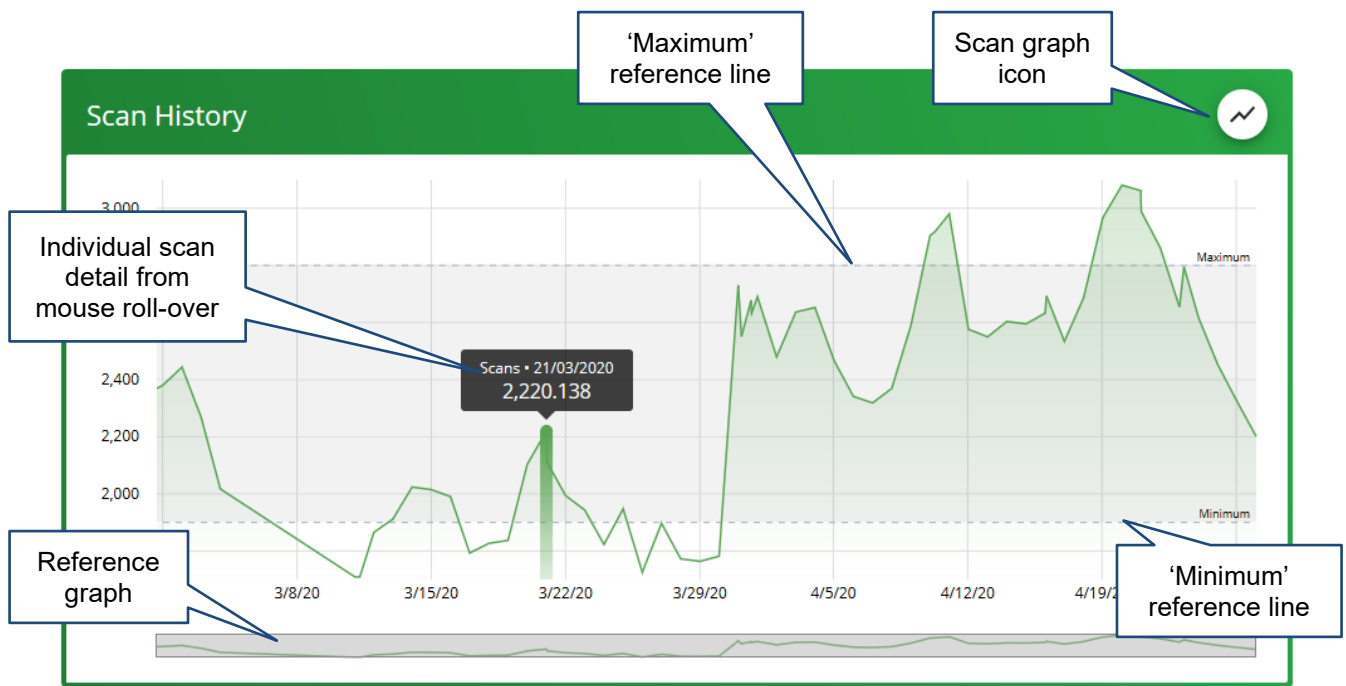


Figure 55 Scan graph

In the top right of the **Scan list** is an icon. Click the icon to toggle between the **Scan list** and the **Scan graph** (see section 7.3.2).

To change the **Scan graph** to display weight instead of volume, change the appropriate setting in the **Settings > Reporting** page (see section 7.5.3).

The Y-axis displays computed volumes (or weights if that option is selected) and the X-axis displays the date of the scans.

Run your mouse pointer over the graph to view details of specific scans on the graph.

Beneath the main graph is a reference graph. Drag a window over a section of the reference graph to zoom the main graph into a certain time period.

Maximum and minimum guidelines can be added to the graph. Enter the appropriate setting in the **Settings > Reporting** page (see section 7.5.3).

## 10 FiX1 web application – Schedule

Scans can be scheduled in advance, either individually, or on a regular, recurring basis.

The **Schedule** page displays a calendar detaining all scheduled scans.

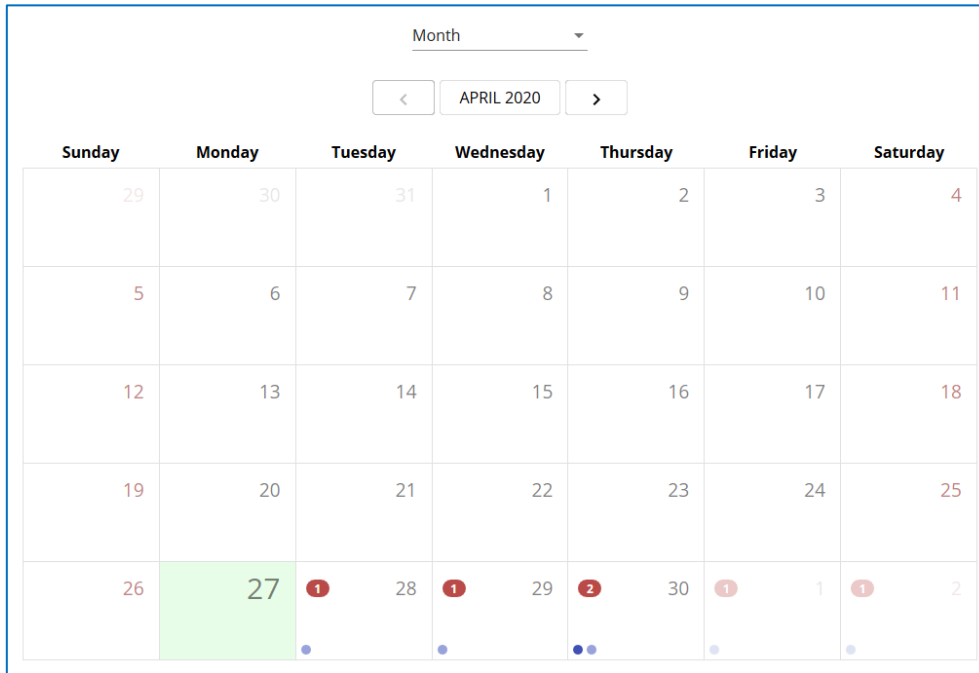


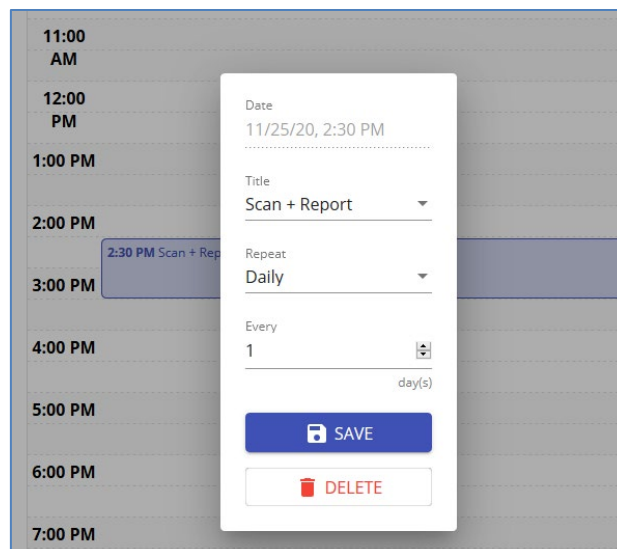
Figure 56 Schedule

Use the drop-down list at the top of the page to choose whether the calendar is displayed by **Month**, **Week** or **Day**.

Today's date is displayed beneath the drop-down list.

In the **Month** view, days where a scan has been scheduled are highlighted in red. Click on a day to add, delete or edit scheduled scans.

In the **Day** and **Week** views, times are listed down the page in half-hour divisions. Click in a division to schedule a scan. Alternatively, click on an existing scan to delete or edit the scan.



A scheduling dialog appears. Listed are:

- **Date:** the selected date and time
- **Title:** determines whether the schedule is for a **Scan**, a **Report**, a **Scan + Report**, or for a **Weekly Reboot**. A weekly reboot ensures that any firmware and software updates are loaded.
- **Repeat:** from the drop-down list select the basis on which the scheduled action should be repeated: **Never** (if this scan is a one-off scan), **Monthly**, **Weekly**, **Daily** or **Hourly**.
- **Every:** select how regularly the scan should be carried out. For example, every 3 days, or every 2 hours.
- **Save:** save the scheduled scan to the calendar.
- **Delete:** remove the scheduled scan from the calendar.

When the time of a scheduled scan arrives, the scan starts automatically if the FiX1 is powered on.

If you connect to the web application during a scheduled scan you will see the **Active** frame on the **Scan** page displaying the current scan status.

A scheduled scan can be manually stopped using the **Stop** button on the **Scan** page.



## 11 FiX1 web application – Settings

The settings screen contains all parameters for configuring the setup and manner of operation of the FiX1.

After the FiX1 has been fully installed and is working to the satisfaction of the customer, the end user should rarely have to enter the **Settings** page.

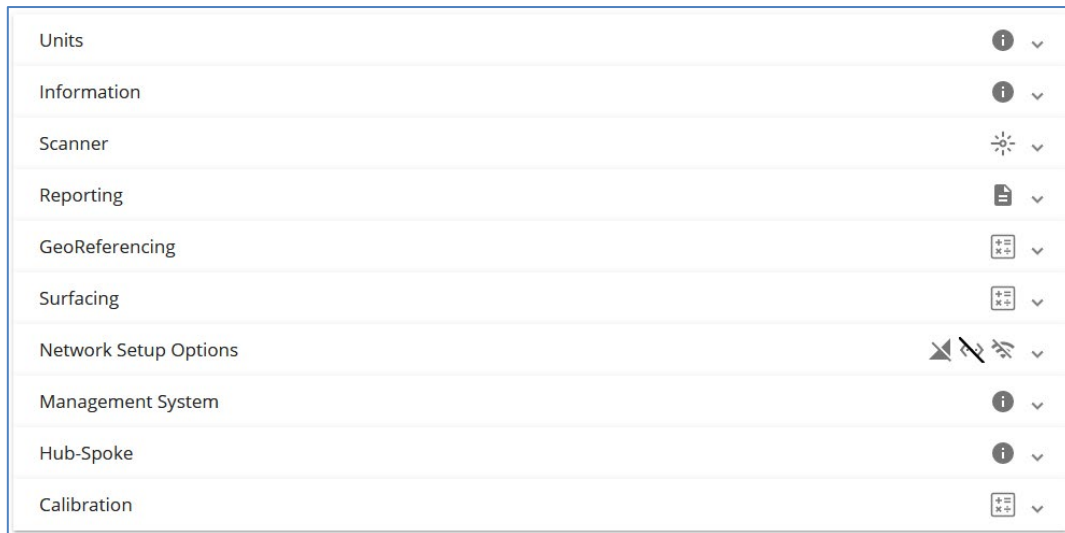


Figure 57 Settings

Some values are protected with a blue padlock symbol. In this case, click the appropriate padlock button to enable the value to be edited. Click the padlock button again to confirm the entered value.



Figure 58 Padlock button

The sections in the **Settings** page are outlined below.

### 11.1 Units

The **Units** section allows definition of the units of measurement in the FiX1 web application. The selections determine the units in which values displayed and reported.

The selections also determine the default units for data input. However, each input field has the option to enter values in units other than those selected in the **Units** section. In this case the input values are converted to the units selected in the **Units** section.

Units
i ^

**Measurements**

Volume Units  
Cubic Meter

Weight Units  
Kg

Length Units  
Meter

Reporting Units  
Volume

**Weight computation**

Density  
0.25

Kg/Cubic Meter

Figure 59 Settings > Units

Available for selection are:

- **Volume units:** Cubic meter, Cubic foot, or Cubic yard.
- **Weight units:** Kg, Lbs, Ton (2,000 lbs), or Tonne (metric ton of 1,000 kgs)
- **Length units:** Meter; Feet, or US-Feet.
- **Reporting units:** select whether reports display the **Volume** or the **Weight** of the stockpiled material. If weight is selected, enter a density value in **Weight computation**.
- **Weight Computation:** to enable a weight to be computed, enter the known density of the stockpiled material.

The **Density** is used to convert from volume using the formula  $Weight = Volume \times Density$ .

## 11.2 Information

The Information section contains details of the current status of the FiX1 unit.

Information

Unit Information

Temperature

26° C, 79° F

Average CPU Usage

0.00, 0.04, 0.08

Uptime

4 hours, 53 minutes

RESTART

Update Settings

☐ Use Beta Version
 

Update Available

☐ Automatic Update
 

a201ea9

Target Version

APPLY

Software Versions

Server Version

2.1.5

Base Version

Base Version 4.7

Head Version

FiX1 Head Application V7.6.11.1

Pan Version

PAN Firmware Version - 0x0505000f

Tilt Version

TILT Firmware Version - 0x00090006

Kernel Version

Linux 190737 4.9.88-10182-gec7d7d8ccb49-dirty #1 SMP PREEMPT Wed May 27 12:38:34 EDT 2020 armv7l GNU/Linux

Figure 60 Settings > Information

The **Information** section displays information used for troubleshooting and maintenance.

- **Temperature:** the current temperature inside the FiX1 base
- **Average CPU usage:** displays the CPU load average over 1/10/15 minutes.
- **Uptime:** time since the FiX1 was last powered on.
- **Restart:** reboot the FiX1.

The **Information** section also provides details of the FiX1 web application software version and updating options. The web application software is being constantly updated with improvements and new features. Updates to the software can be remotely distributed from Carlson to any FiX1 on a network which has access to the world wide web. A FiX1 can be configured to automatically receive regular updates whenever they become available.

- **Use Beta Version:** tick the check box if you wish to use software updates that are still labelled as Beta versions. This is unticked by default and should be left in this state unless advised otherwise by Carlson.
- **Automatic update:** tick the check box if you wish the FiX1 to receive automatic software and firmware updates. A message to the right of this control indicates whether an update is currently available.

A software update occurs when a new update is available and the FiX1 is connected to a network with access to the world wide web. The FiX1 checks every day whether a software update is available.

The FiX1 checks on boot up whether a firmware update is available. A regular reboot can be entered in the schedule – for example once a week – to ensure that the firmware is always up to date.

- **Software Versions:** the current software and firmware versions used by the FiX1.

## 11.3 Scanner

When the FiX1 is scanning, the body of the FiX1 rotates horizontally at a relatively slow speed, while at the same time the laser head rotates vertically at a higher speed. The laser itself is firing constantly at a pre-determined rate.

The result is a pattern of radial scan lines drawn beneath the FiX1.

The **Scanner** section allows you to adjust the density of the angle between the radial lines, the density of the points along the lines and the extent of the ground that the lines cover.

The optimum settings should be determined when the system is installed. They should be configured to ensure that the point cloud is of sufficient density to produce a reliable volume. Be aware that if the point cloud is needlessly dense, each scan will take longer to complete and the amount of data being stored on each unit will be higher.

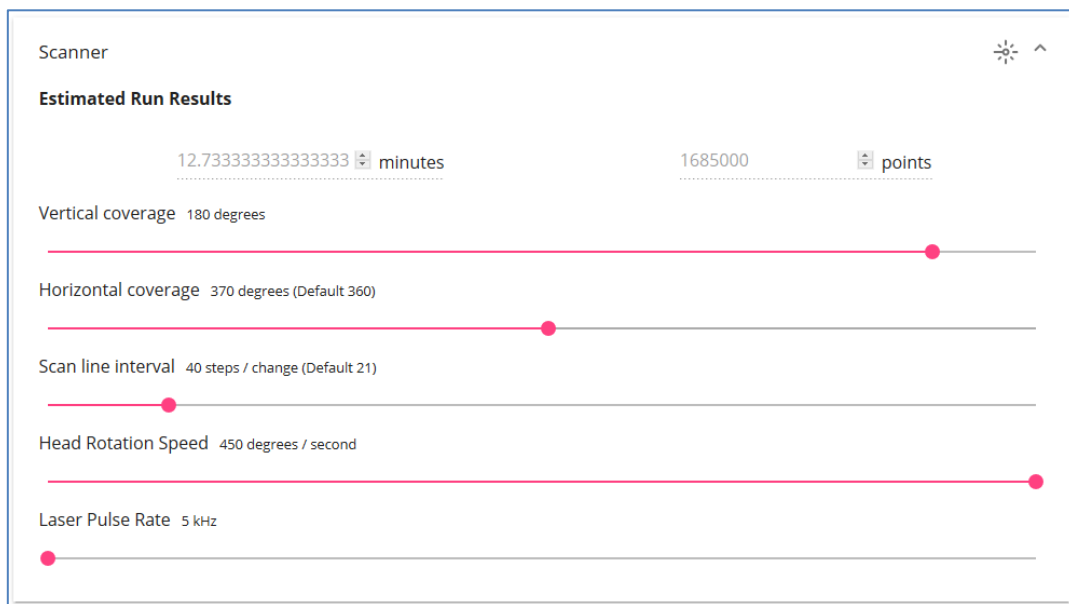


Figure 61 Settings > Scanner

The controls are listed below.

### 11.3.1 Estimated Run Results

Adjusting the settings in the **Scanner** section changes the duration of each scan, as well as the number of points that will be collected. Usually, the larger the area that each FiX1 needs to cover, the longer the scan duration will tend to be, and the more points will be required. This will ensure a sufficient density of points over the area of interest.

As you change the **Scanner** settings, the **Estimated run results** change automatically, giving an approximation of the time to complete the scan and the final number of points that will be collected.

### 11.3.2 Vertical coverage

The **Vertical coverage** slider determines the vertical extents of the scan. 180° vertical coverage would survey everything up to a horizontal plane from the FiX1. The drawing to the right shows a 70° angle. The selected angle should ensure that the whole area of interest is included in each scan.

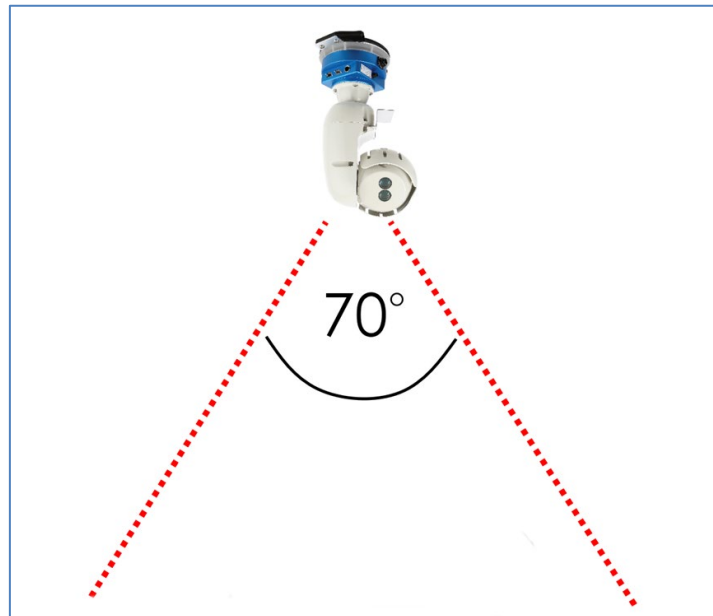


Figure 62 Vertical scan coverage

### 11.3.3 Horizontal coverage

The **Horizontal coverage** slider determines the horizontal extents of the scan. Once the FiX1 is installed this will almost always be 360° to ensure full coverage of the area beneath the FiX1



Figure 63 Horizontal scan coverage

### 11.3.4 Scan line interval

The **Scan line interval** slider determines the distance between each radial line that is scanned. In effect, this controls the speed that the FiX1 is turning horizontally in relation to the vertical spin of the laser head.

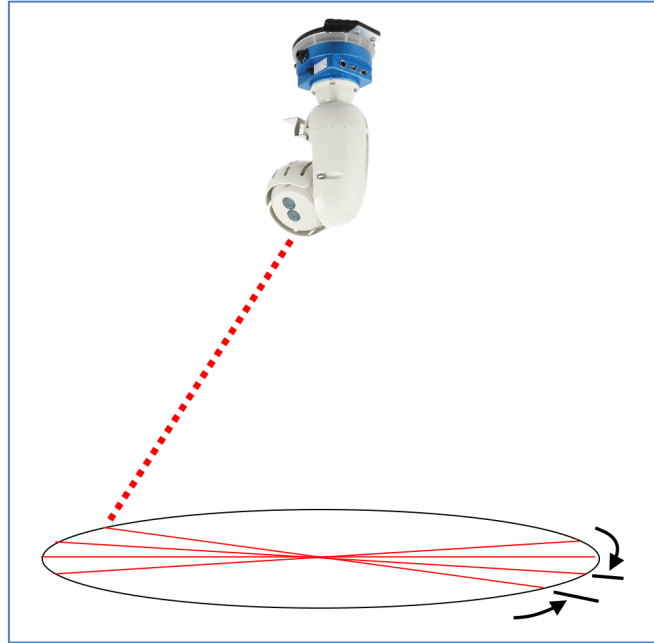


Figure 64 Scan line interval

### 11.3.5 Head rotation speed

The **Head rotation speed** slider determines the speed of vertical rotation of the laser head. Given that the laser is firing at a fixed rate as the head is turning, for larger scan areas the rotation speed may be slowed to ensure sufficient point density at longer distances.

Together with the **Laser pulse rate**, the **Head rotation speed** determines the density of points along each radial scan line.



Figure 65 Head rotation rate speed

### 11.3.6 Laser pulse rate

The **Laser pulse rate** slider determines the speed at which the laser is firing as the head turns. Usually this setting is left at the minimum value of 5,000 Hz (5,000 measurements per second). However, for larger scan areas, this value may be increased to ensure sufficient point density at longer distances. The maximum setting is 15,000 Hz.

Together with the **Head rotation** rate, the **Laser pulse rate** determines the density of points along each radial scan line.

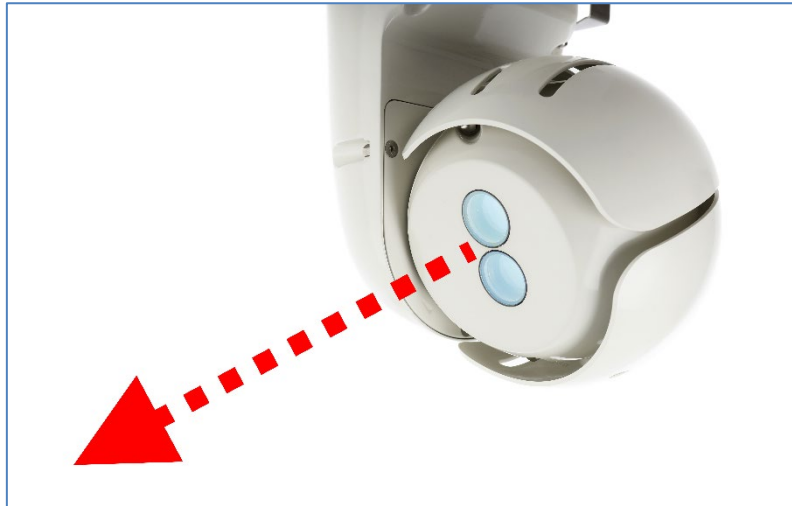


Figure 66 Laser rate

## 11.4 Reporting

The **Reporting** section provides tools to configure the way scan results are displayed in the **Scan list**, the **Scan graph** and in PDF reports. It also enables you to setup email addresses to which reports are dispatched.

Reporting

Reporting Triggers

Reporting Options

SMTP Settings

Email Alert Users

Email	Scheduled	Alert	Actions
workman@acme_quarries.com	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

ADD USER

TEST ALERTS

<

East pile 8mm

North pile FDC

Waste YR/45

>

Threshold Alert

Maximum

35000

Cubic Meter

Minimum

15000

Cubic Meter

Change Alert

Delta

100

Cubic Meter

APPLY

Figure 67 Settings > Reporting > Reporting Triggers

### 11.4.1 Email alert users

Reports can be sent out to defined email addresses after every scheduled scan or after thresholds are triggered.

To add an email address, click **Add user**. Enter the email address in the **Email** field. Click **Add user** again to add subsequent email addresses.

For each email address, define when a report should be sent:

- Tick the **Scheduled** check box to receive a report after every scheduled scan.
- Tick the **Alert** check box to receive a report whenever the user-defined **Threshold alerts** are met, or the **Change alert** is exceeded.

Click the dustbin icon to delete an email address from the **Email alert users** list.

Click **Test alerts** to check that the email addresses are set up correctly. A test message is sent to each address listed.

By default, email alerts are sent from **support@carlsonsw.com**. To setup emails from a customised address, use the **SMTP settings** (see section 11.4.5).

### 11.4.2 Threshold alert

After a scan is completed and a new volume computed, if a user defined **Maximum** value is exceeded or the **Minimum** value not reached, an email report is sent out to the listed email addresses.

Enter **Maximum** and **Minimum** values according to your site's reporting requirements.

Maximum and minimum guidelines appear on the **Scan graph**, helping to highlight values which are beyond an acceptable range.

The thresholds relate to volume or weight, depending on the **Reporting units** selected in the **Units** section (see section 9.1).

If a \*.PLN file is selected to delineate **Areas of Measurement** (see section 11.6.2), different thresholds can be defined for each specified area. Select the tab associated with an area then enter the threshold required for that area.



The screenshot shows a web interface with three tabs: 'East pile 8mm', 'North pile FDC', and 'Waste YR/45'. The 'East pile 8mm' tab is selected. Below the tabs, there are two sections: 'Threshold Alert' and 'Change Alert'. Under 'Threshold Alert', there are two rows: 'Maximum' with a value of 35000 and 'Minimum' with a value of 15000. Both rows have a dropdown menu set to 'Cubic Meter'. Under 'Change Alert', there is one row: 'Delta' with a value of 100, also with a dropdown menu set to 'Cubic Meter'.

Figure 68 Tabs showing customised alerts for each Area of Measurement

### 11.4.3 Change alert

Email reports can be triggered if the volume or weight changes more than a user-defined amount. Under the **Change Alert** title, enter a **Delta** value.



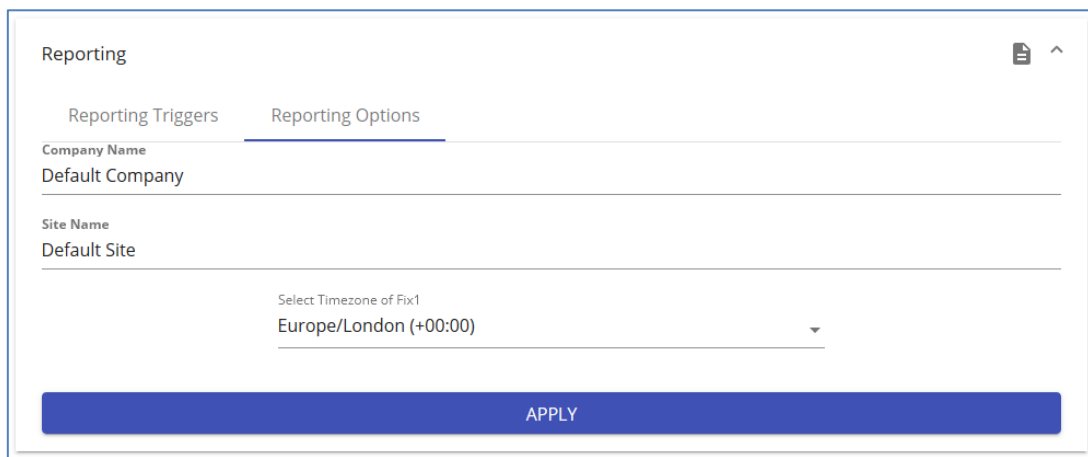
The **Change alert** relates to volume or weight, depending on the **Reporting units** selected in the **Units** section (see section 9.1).

After a scan is completed and a new volume computed, if the result differs from the preceding result by more than the entered value, an email report is sent out to the listed email addresses.

If a \*.PLN file is selected to delineate **Areas of Measurement** (see section 11.6.2), different change alerts can be defined for each specified area. Select the tab associated with an area then enter the change alert required for that area.

### 11.4.4 Reporting Options

Select the **Reporting Options** tab to define variables for the PDF reports.

The screenshot shows a web interface for configuring reporting options. At the top, there's a 'Reporting' header with a document icon and an expand/collapse arrow. Below this are two tabs: 'Reporting Triggers' and 'Reporting Options', with the latter being the active tab. The form contains three input fields: 'Company Name' with 'Default Company' entered, 'Site Name' with 'Default Site' entered, and a dropdown menu for 'Select Timezone of Fix1' currently set to 'Europe/London (+00:00)'. At the bottom of the form is a large blue button labeled 'APPLY'.

*Figure 69 Settings > Reporting > Reporting Options*

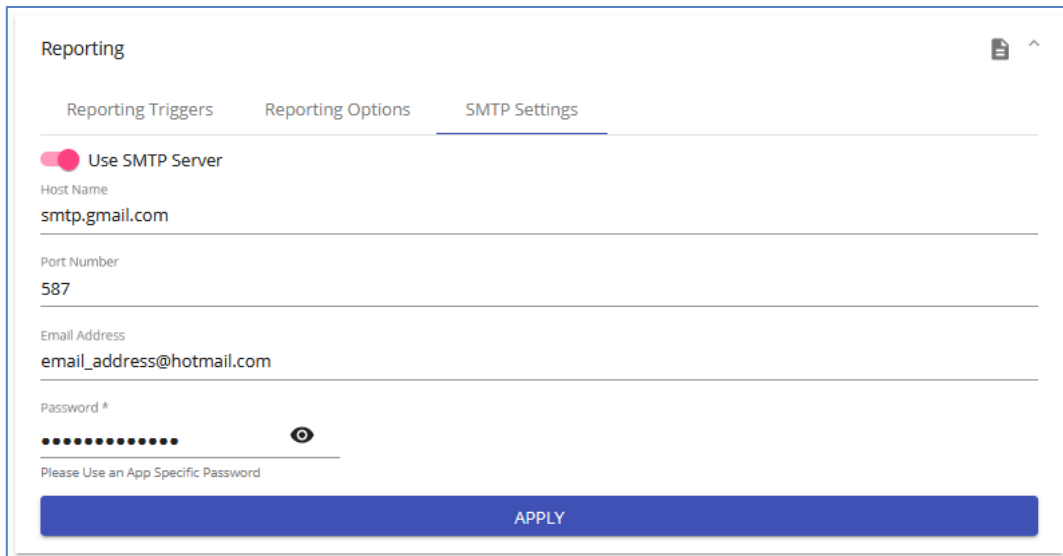
The PDF report include heading fields which are defined in the **Reporting Options** section.

As appropriate, enter:

- **Company Name**
- **Site Name**
- **Time zone** in which the FiX1 is located.

### 11.4.5 SMTP Settings

Select the **SMTP Settings** tab to customise the email account from which reports are sent.



Reporting

Reporting Triggers Reporting Options SMTP Settings

☒ Use SMTP Server

Host Name  
smtp.gmail.com

Port Number  
587

Email Address  
email\_address@hotmail.com

Password \*

.....

Please Use an App Specific Password

APPLY

*Figure 70 Reporting > SMTP Settings*

Turn OFF the **Use SMTP Server** switch to use the default email account. Reports are sent from support@carlsonsw.com.

Turn ON the **Use SMTP Server** switch to customise the 'From' email account.

Enter all fields to enable the SMTP configuration:

- Host name: your email provider's SMTP server address.
- Port number: your email provider's SMTP port number.
- Email address: the address that the emailed reports will originate from.
- Password: the password for the entered email address.

Click **Apply** to confirm all settings.

Note that you may need to configure some security settings in your email account to allow the SMTP settings to be used by the FiX1.

## 11.5 Geo-referencing

After the FiX1 mounting plate has been installed in its permanent location, and before the FiX1 unit is attached, the mounting plate is surveyed in using the site coordinate system. This must be the same coordinate system as that used to position the **Bottom surface** which is used as the base for volumetric computations (see section 7.5.1.4 below).

GeoReferencing

Mounting Plate Location

X

2000.51

Meter

Y

3007.48

Meter

Z

103.33

Meter

Mounting Plate Orientation

Azimuth Offset

-14.8

Degrees

Roll Offset

0

Degrees

Pitch Offset

0

Degrees

Mounting Plate Orientation

Mounting Plate Up

Figure 71 Settings > Geo-referencing

### 11.5.1 Mounting plate location

Establish coordinates of the centre of the etched cross on the mounting plate (see section 3.2).

Enter these coordinates in **the Mounting plate location X,Y,Z** fields.

All collected scan data is automatically adjusted to account for the offset between this entered coordinate on the mounting plate and the scan origin, which is at the intersection of the horizontal and vertical axes.

### 11.5.2 Mounting plate orientation

The **mounting plate orientation** fields define the horizontal and vertical orientation of the FiX1 system.

- **Azimuth offset:** the horizontal orientation of the mounting plate in your local coordinate system. Survey the heading of the central groove of the mounting plate to establish the orientation of the FiX1 (see section 5.4).

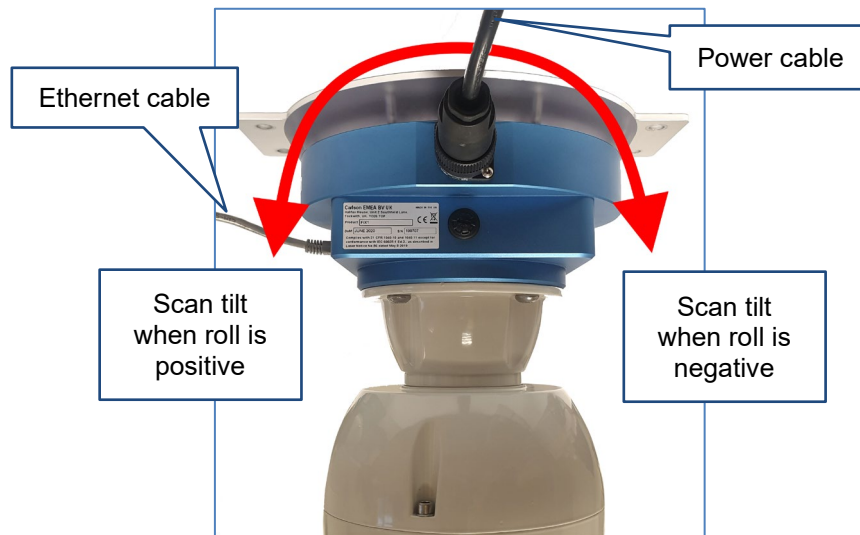
Figure 72 Azimuth of the mounting plate for a hanging FiX1 – seen from above (left) and looking up from below(right)

In Figure 70, note the relative positions of the power connector and Ethernet connector in relation to the direction surveyed.

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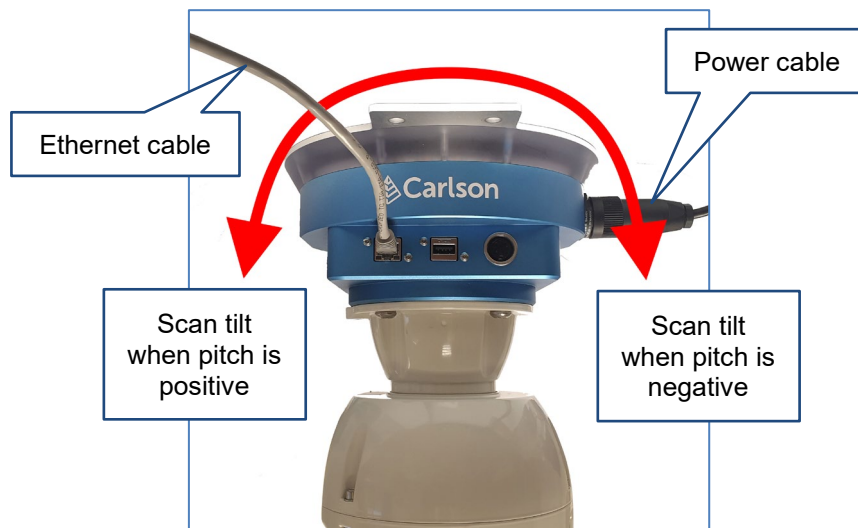
Currently there is an additional offset of around  $74^\circ$  which must be added to the entered heading. Contact Carlson for the exact value for your FiX1 unit.

- **Roll offset:** the mounting plate roll inclination, offset from horizontal. The roll is related to the FiX1 hardware (see Figure 71)



*Figure 73 Roll offset in relation to the FiX1 hardware*

- **Pitch offset:** the mounting plate pitch inclination, offset from horizontal. The roll is related to the FiX1 hardware (see Figure 72)



*Figure 74 Pitch offset in relation to the FiX1 hardware*

- **Mounting plate orientation:** determines whether the FiX1 is mounted hanging down or upright.

For most applications the FiX1 is installed hanging down. In this case the **Mounting plate orientation** switch should read **Base plate up**. If the FiX1 is installed upright, the switch should read **Mounting plate down**.



Figure 75 Mounting plate up (left), mounting plate down (right)

## 11.6 Surfacing

In order to compute a volume, each scan is smoothed and filtered, then an elevation surface is generated. This elevation surface is compared to a base surface, uploaded by the user, which defines the floor level. The **Surfacing** section deals with establishing these surfaces and the boundaries of the volume computations.

Surfacing

Surfacing Settings

Base Surface

Selected Surface

surveyed base.tin (Meters)

UPLOAD (METER)

DOWNLOAD

DELETE

Top Surface

Selected Surface

1m beneath roof struts.tin (Meters)

UPLOAD (METER)

DOWNLOAD

DELETE

Areas Of Measurement

Area Lines

Areas in PLN File

All

UPLOAD (METER)

DOWNLOAD

DELETE

Volume Calculation Parameters

Cells on X Axis

200 Cells (Default 150)

Cells on Y Axis

200 Cells (Default 150)

Clip Points Below Surface

Angle of Repose

65

Degrees

Figure 76 Settings > Surfacing

### 11.6.1 Base surface

The **Base surface** controls control the base surface being used for volume computations. This surface defines the horizontal extents over which a volume is computed and the vertical base level to which all volumes are computed.

Surfaces must be prepared in external software. The web application accepts Carlson TIN files, or DXF surface files. Uploaded DXF files are converted to TIN format for use onboard the FiX1.

The surface must be geo-referenced on the same coordinate system as that used to survey in the **Base Plate Coordinates** (see section 5.4 above).

The Base surface may be derived from design files for the site, from a historic survey of the floor level or from a new scan of the site. It is essential that the surface be as far as possible, a close representation of the survey of the solid ground or structure underneath the stockpiles to be measured by the FiX1.

- Click **Upload** to upload a base surface to the FiX1. A **File upload** dialog appears. Select the appropriate TIN or DXF surface file from your computer and click **Open**.

The file is uploaded to the FiX1. This may take a few minutes depending on the size of the file. When it is complete, the uploaded file appears in the **Base surface** drop down list.

- To download a surface from the FiX1, first select the appropriate surface file from the **Base surface** drop down list. Then click **Download**.

The selected file is downloaded to your computer.

- To delete a surface from the FiX1, first select the appropriate surface file from the **Base surface** drop down list. Then click **Delete**.

The selected file is deleted from the FiX1.

- The **Base surface** drop down list displays all surface files that have been uploaded to the FiX1. Select a surface file from the list.

The surface file which has been selected and is currently displayed is the **Base surface** currently in use. This will be used for volumetric computations on subsequent new or reprocessed scans.

If no base surface is selected from the list, no volume is computed after a scan.

Alternatively, select a file from the list before using the **Download** or **Delete** buttons.

### 11.6.2 Top Surface

Using a **Top surface** is a way of masking points above the stockpile which may accidentally be used in the computed elevation surface.

During a scan, as well as collecting data from the stockpile, the FiX1 may also collect points from the roof of a facility, from conveyors, scoops or other infrastructure located above the targeted area. Usually these points are filtered out, as only the lowest point in any grid square is used to compute the elevation surface, and the lowest point will usually be on the stockpile. However, in some cases, small areas of a stockpile may be hidden from the laser and therefore appear as blank 'shadows' in the scan. When this happens, points picked up in the roof of a facility above the blank area may be taken as the lowest point in that particular grid square. Note that the **Angle of repose** value may successfully filter out such points (see section 11.6.4).

To ensure that points from above the stockpile are never included in the creation of an elevation surface, a top surface can be used to mask out all machinery & infrastructure above a certain elevation.

The top surface should be elevated enough so that it is above the highest level that the stockpile might reach.

The top surface can be carefully constructed to match the shape of the roof, for example: domed, arched or customised to account for other machinery and infrastructure.

The top surface should be constructed so that it overlaps the base surface on all sides.

Use of a top surface is optional.

- Click **Upload** to upload a top surface to the FiX1. A **File upload** dialog appears. Select the appropriate TIN or DXF surface file from your computer and click **Open**.

The file is uploaded to the FiX1. This may take a few minutes depending on the size of the file. When it is complete, the uploaded file appears in the **Top surface** drop down list.

- To download a surface from the FiX1, first select the appropriate surface file from the **Top surface** drop down list. Then click **Download**.

The selected file is downloaded to your computer.

- To delete a surface from the FiX1, first select the appropriate surface file from the **Top surface** drop down list. Then click **Delete**.

The selected file is deleted from the FiX1.

- The **Top surface** drop down list displays all surface files that have been uploaded to the FiX1. Select a surface file from the list.

The surface file which has been selected and is currently displayed is the **Top surface** currently in use. This will be used for volumetric computations on subsequent new or reprocessed scans.

Alternatively, select a file from the list before using the **Download** or **Delete** buttons.

If no top surface is required, select a blank entry from the **Top surface** drop down list.

### 11.6.3 Areas of measurement

By default, one volume is returned each time a FiX1 (or a hub-and-spoke group) completes a scan.

To separate the scanned area into separate regions, use the **Areas of measurement** function. A volume is computed independently for each region.

The regions must be delineated by polylines. A single file can hold any number of polylines. The polyline must be prepared in external software. The web application currently accepts just Carlson PLN files.

The polyline must be geo-referenced on the same coordinate system as that used to survey in the **Base Plate Coordinates** (see section 5.4 above).

The polylines may be derived from design files for the site, from a dedicated survey, or from FiX1 data. The height (Z) value of each point along the polyline is ignored for the purposes of the establishment of the regions.

Each polyline in the file must have at least three vertexes. If the polyline is not closed, the FiX1 will close it by automatically.

Name each polyline after the region that it encloses.

UPLOAD

DOWNLOAD

DELETE

**Areas Of Measurement**

areaLines

34E\_Barn2.pln

**Areas in PLN File**

central sector

south sector

west sector

east sector

UPLOAD

DOWNLOAD

DELETE

*Figure 77 Areas of measurement section with a PLN file selected*

To use a PLN file, hit the **Upload** button and select the appropriate file.

All named regions within the PLN file are displayed

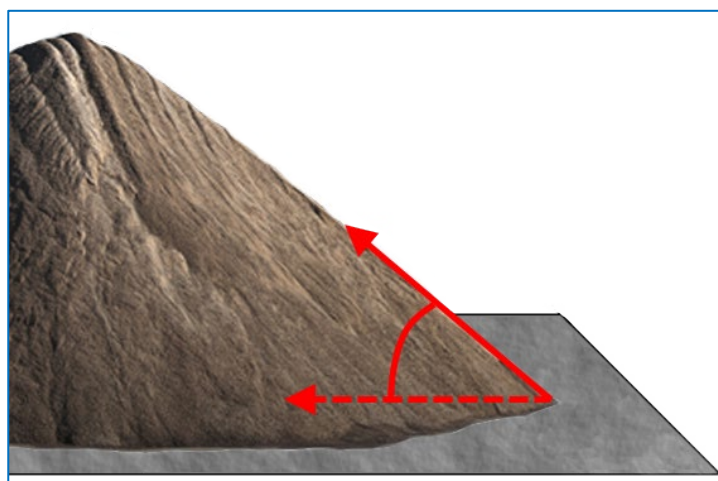
In the **Scan list**, a volume is reported for each region in the PLN file.

#### 11.6.4 Volume calculation parameters

- **Cells on X Axis / Cells on Y Axis:** The FiX1 generates a grid over the base surface. As the scan progresses, each scanned point within the limits of the base surface is assigned to one of the grid cells. The gridded data is then used to create an elevation surface which in turn is used to compute a volume.

Use the **Cells on X axis / Cells on Y axis** sliders to determine the number of grid cells contained in the grid.

- **Angle of repose:** The angle of repose of a material is the steepest angle of inclination that the material can be piled without slumping. This value is used during the creation of the elevation surface to help filter out spurious data. Any data suggesting a pile steeper than the entered angle is considered to not be representing data collected by direct observation to the stockpile.



*Figure 78 Angle of repose*

Enter the **Angle of repose** for the material which the FiX1 is targeting. If there are multiple materials in the area of interest, enter the largest (steepest) angle of repose of the different materials.



- **Clip points below surface:** turn this switch ON to mask all points below the base surface. This may be desirable if there are puddles around the work site which are causing reflected scan points to appear below the floor level. These low points may be included in the creation of an elevation surface, distorting the volume computation.

Turn the switch OFF to ensure all points are taken into account during the creation of the elevation surface. This enables the computation of a 'cut' volume which appears in the Full report.

## 11.7 Network setup options

The **Network setup options** allows you to configure the way that you connect to the FiX1 unit. See section 5.8 for more information on the different connection options.

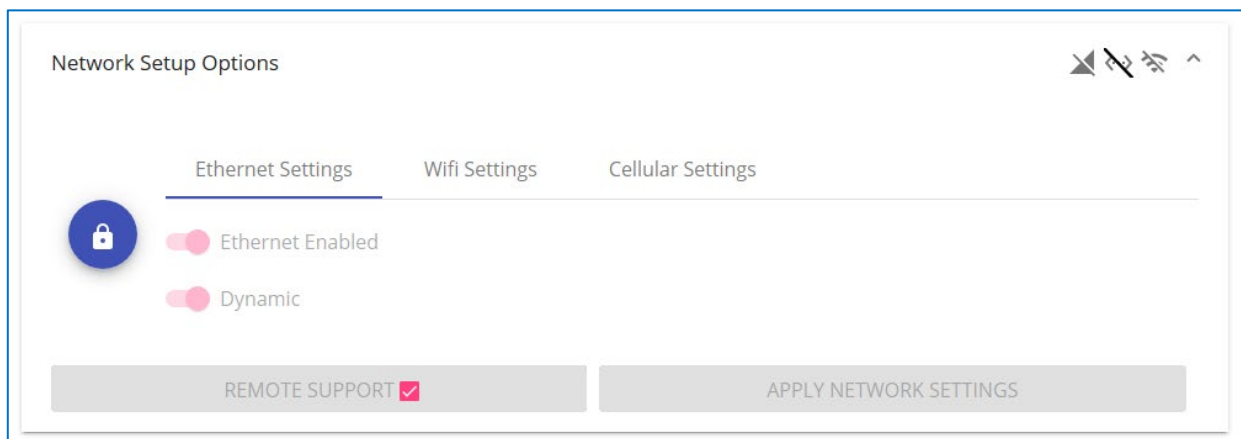


Figure 79 Network setup options

The **Network setup options** are locked to avoid accidental alterations of the settings, which could cause the FiX1 to lose connection.

Click the padlock button to unlock this section of the web application.

After making any changes click **Apply network settings** to confirm and activate any changes that have been made.

Note, take great care when entering any new configuration of network settings. Incorrect entries may cause connection to the FiX1 to be lost. In this case, you may need to use the recovery mode to re-establish contact with the FiX1 (see section 5.8.2).

There are three tabbed sections. **Ethernet settings**, **Wi-Fi settings** and **Cellular settings**.

At the bottom of each tab is a **Remote Support** check box. Tick this check box to allow Carlson to remotely support the FiX1. See section 6.6 for further information.

### 11.7.1 Ethernet settings

To turn on an Ethernet connection, in the **Ethernet settings** select **Ethernet enabled**.

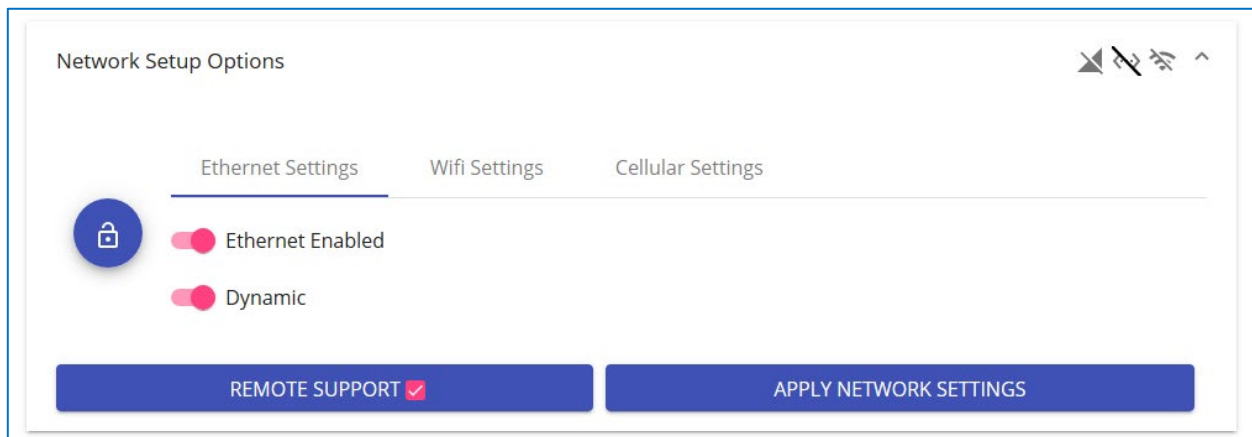


Figure 80 Ethernet activated, Dynamic IP

To activate a dynamic IP address, select **Dynamic**.

The FiX1 is assigned a dynamic IP address when it is connected to a network with a DHCP server. You may need to use a tool such as MAC Scanner to identify the assigned IP address (see section 6.2).

To activate a fixed IP address, select **Static**.

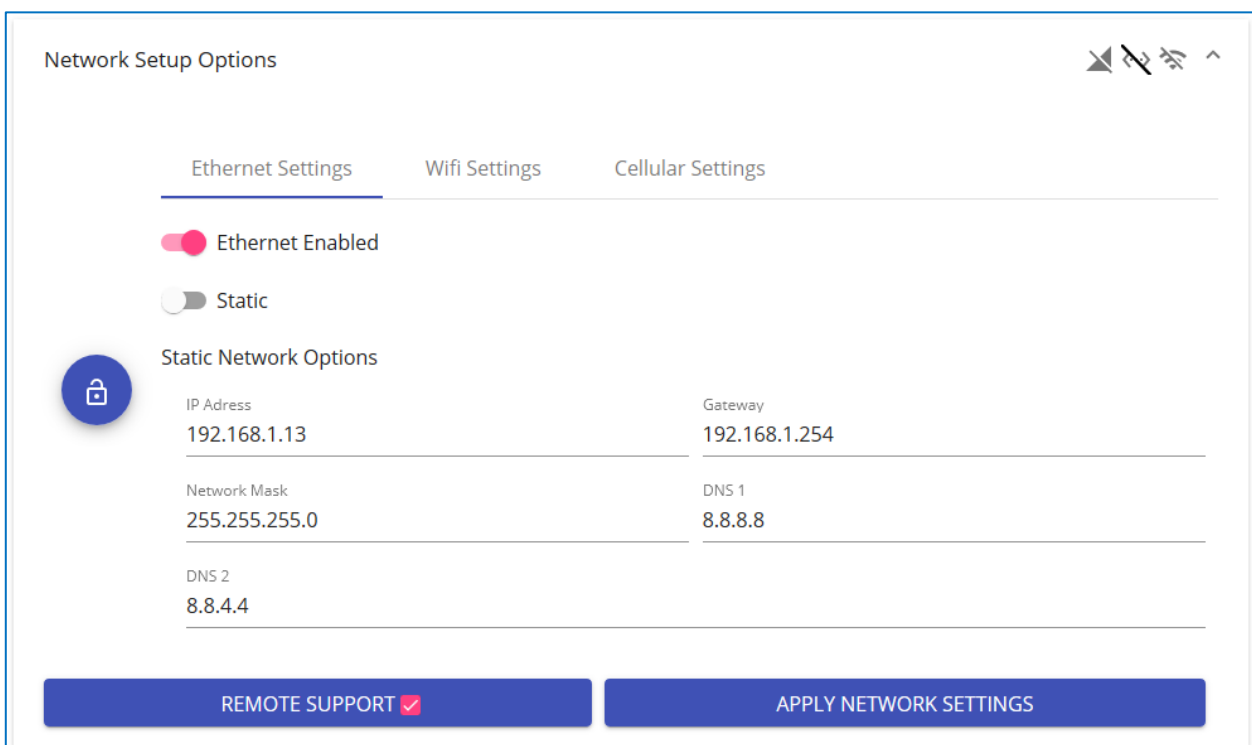


Figure 81 Ethernet options, Static IP

Enter appropriate values which allow the FiX1 to connect to your network.

- IP address
- Gateway
- Network mask

- DNS1
- DNS1

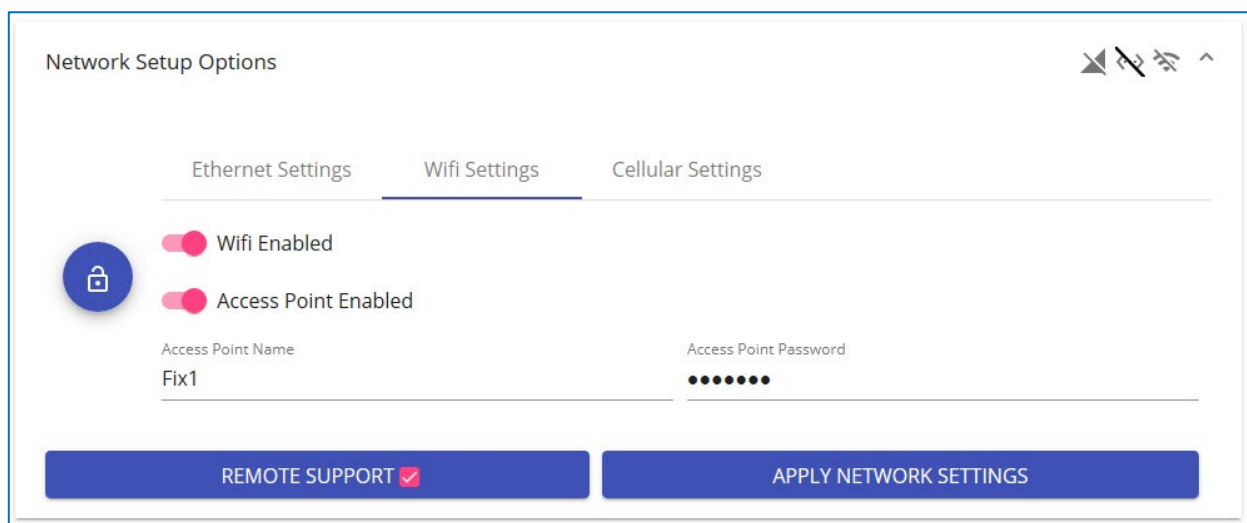
Consult your IT department for advice on the values to enter for each of these fields.

Click **Apply network settings** to activate any changes.

The IP address – fixed or dynamic – can be entered into the address bar of a web browser to access the FiX1 web application.

## 11.7.2 Wi-Fi settings

To turn on a Wi-Fi connection, in the **Wi-Fi settings** select **Wi-Fi enabled**.



*Figure 82 Wi-fi enabled, Access point mode*

To use the Wi-Fi access point mode, select **Access point enabled**.

Enter an **Access point name**. This is the SSID that appears in the Windows Wi-Fi manager.

Enter an **Access point** password. After selecting the appropriate SSID, enter the password into the Windows Wi-Fi manager when a security key is requested.

Click **Apply network settings** to activate any changes.

To use the Wi-Fi client mode, select **Use Wi-Fi connection**.

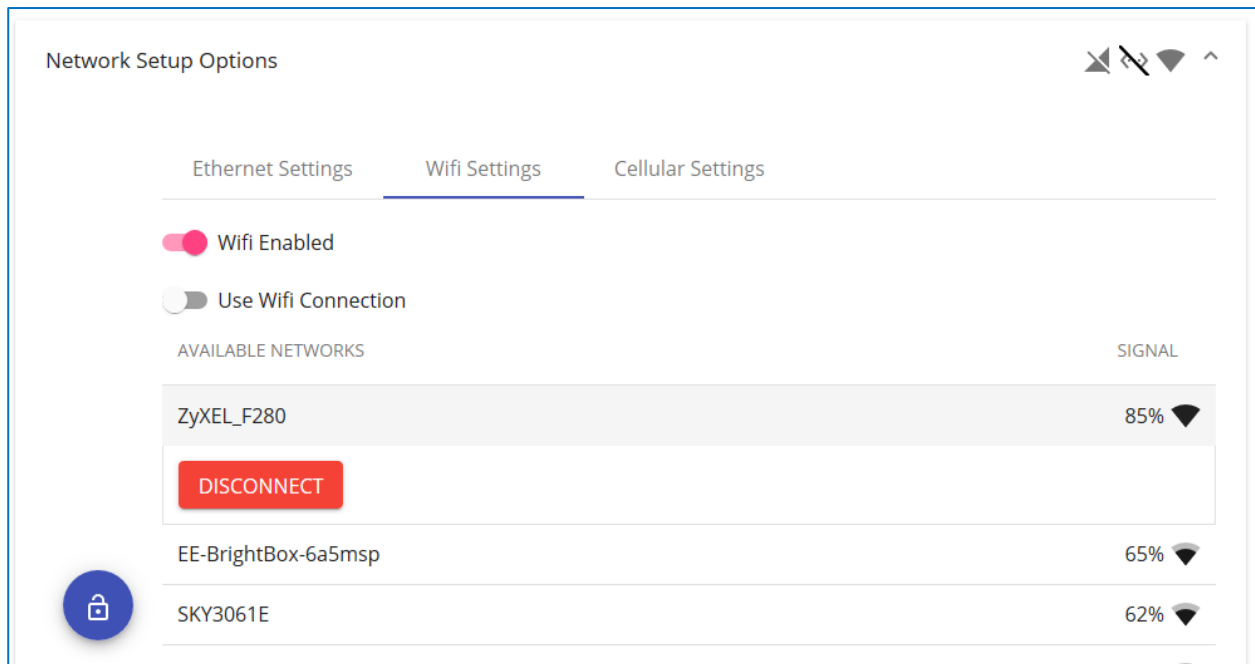


Figure 83 Wi-Fi enabled, client mode

All available networks within range of the FiX1's Wi-Fi antenna appear in the **Available networks** list. Click the network to which you wish to connect.

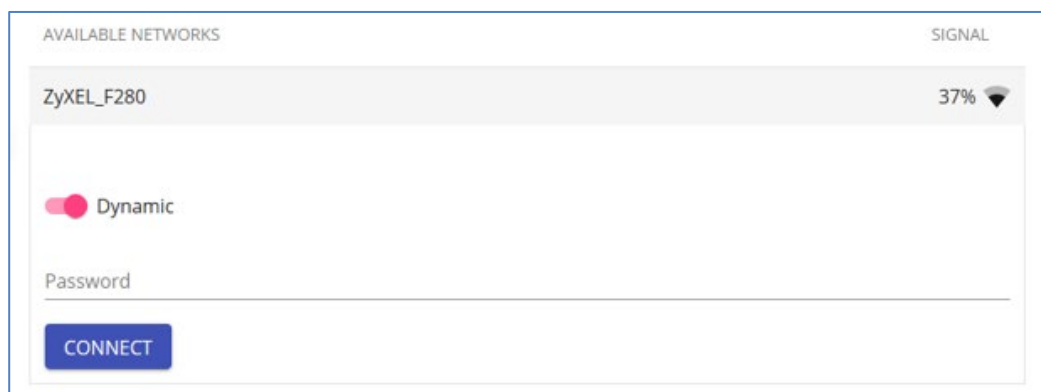


Figure 84 Connecting to a Wi-Fi network

To activate a dynamic IP address, select **Dynamic**.

Enter the network password and click **Connect**.

The FiX1 is assigned a dynamic IP address when it connects to the network. You may need to use a tool such as MAC Scanner to identify the assigned IP address (see section 6.2).

To activate a fixed IP address, select **Static**.

Enter appropriate values which allow the FiX1 to connect to your network.

- IP address
- Gateway
- Network mask

- DNS1
- DNS1

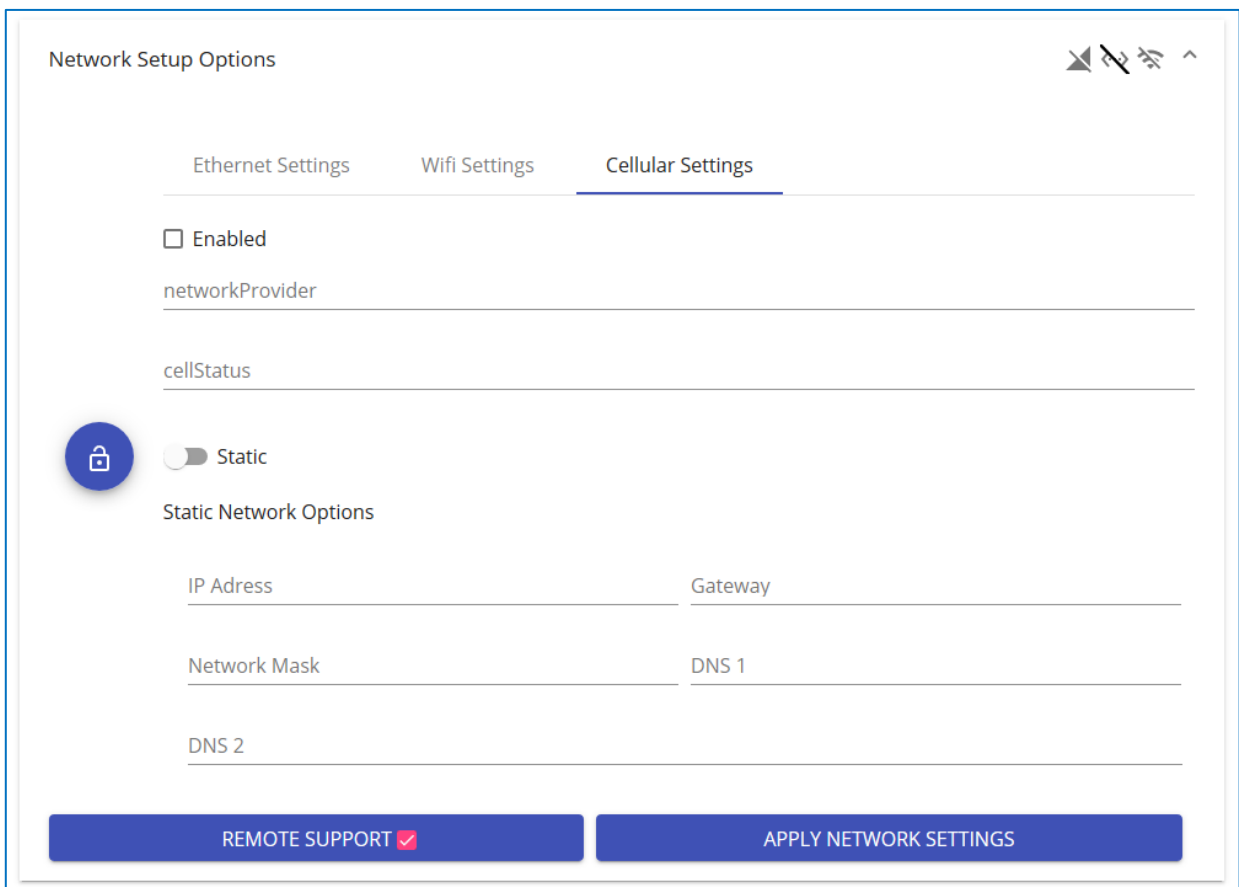
Consult your IT department for advice on the values to enter for each of these fields.

Click **Apply network settings** to activate any changes.

The IP address – fixed or dynamic – can be entered into the address bar of a web browser to access the FiX1 web application.

### 11.7.3 Cellular settings

To activate a cell phone connection, in the **Cellular settings** select **Enabled**.



The screenshot shows the 'Network Setup Options' dialog box with the 'Cellular Settings' tab selected. The 'Enabled' checkbox is unchecked. Below it are input fields for 'networkProvider' and 'cellStatus'. A blue circular icon with a lock symbol is next to a 'Static' toggle switch, which is currently turned off. Under 'Static Network Options', there are input fields for 'IP Address', 'Gateway', 'Network Mask', 'DNS 1', and 'DNS 2'. At the bottom, there are two blue buttons: 'REMOTE SUPPORT' with a red checkmark icon, and 'APPLY NETWORK SETTINGS'.

Figure 85 Cellular settings

## 11.8 Management system

Select **Management system** to visit **Carlson OPS**. **Carlson OPS** provides an interface to manage multiple FiX1 systems in various geographic locations.

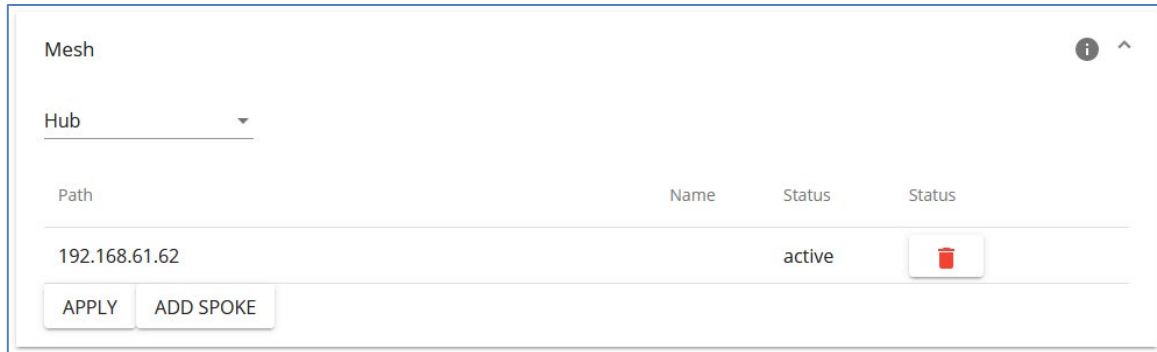
## 11.9 Hub-spoke

To set up a hub-and-spoke installation, select one unit to act as the hub and open the web application of this FiX1. Click **Mesh** and in the drop-down list select **Hub**.

All spokes in the system must be added to the list. Identify the IP addresses of all FiX1 units which will be acting as spokes.

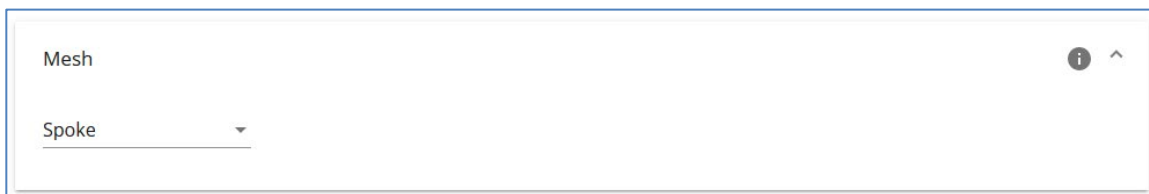
Click **Add Spoke**. Under **Path**, enter the IP address of the first spoke and click **Apply**. When the spoke is found on the network, the status shows as **Active**.

Continue adding all spokes in the installation.



The screenshot shows a web interface titled 'Mesh'. At the top, there is a 'Hub' dropdown menu. Below it is a table with columns: 'Path', 'Name', 'Status', and 'Status'. The first row in the table has the value '192.168.61.62' in the 'Path' column, an empty 'Name' column, and 'active' in the 'Status' column. To the right of the 'active' status is a red trash icon. At the bottom of the interface are two buttons: 'APPLY' and 'ADD SPOKE'.

Open the web application of each spoke and in the Mesh settings, select **Spoke** from the drop-down list.



The screenshot shows the same 'Mesh' web interface, but the dropdown menu at the top now displays 'Spoke' instead of 'Hub'.

When a FiX1 has been designated as a spoke, the web application for that unit offers restricted functionality.

The FiX1 designated as hub retains all functionality. Use the hub to schedule scans, set up surfaces, upload polylines and configure reporting.

The web application of a spoke only need be accessed to:

- Change the scan parameters
- Change the calibration parameters
- Download raw data (LAS files)

During standard operations, the operator communicates just with the hub. The base file and scanning schedule are configured only in the hub.

A scan request is sent to the hub. The hub sends a scan command to the spokes, together with an empty grid. Each spoke runs a scan, fills the grid with elevations and returns the grid to the hub. The hub consolidates data from all FiX1 units in the network, cleans the data and computes a volume.

Note that all units in the hub-and-spoke installation must be geo-referenced on the same coordinate system so that the scans of each unit are correctly registered. If this stage is not completed, the scans from each unit will be mismatched and resulting volumes will be incorrect.

## 11.10 Calibration

Care should be taken not to tamper unnecessarily with settings in the **Calculation** section. Typically, these values are determined and configured on installation of the FiX1. Thereafter there should be no need to adjust the values

as long as the FiX1 is installed in the same location.

The calibration constants are set in the factory during production. These constants account for mechanical misalignment of the laser with respect to the FiX1 housing, eccentricity of the planes of rotation and range inaccuracies.

- Laser range offset
- Pan eccentricity amplitude
- Pan eccentricity phase
- Angle of laser vertical
- Tilt eccentricity amplitude
- Tilt eccentricity phase
- Angle of laser horizontal
- Head tilt angle

Carlson keep all calculated calibration values on record. The calibration values are rechecked whenever the FiX1 is back in the factory for servicing.

If required, the existing calibration can be checked or new calibration values generated, while the FiX1 is installed on-site. Contact Carlson for details of the on-site procedure to follow.

## 12 FiX1 web application – Language

Click Language to select one of the installed languages in the FiX1 web application.

If there is a language you would like to use which is not listed, please contact Carlson to request the additional translation.



## 13 FiX1 web application – Online 3D viewer

The Fix1 automatically generates a volume from collected data without any intervention from the end-user. No manual viewing, analysis of the data is necessary. However, there may be circumstances when it is desirable to view the point cloud: for example, investigating unusual results, troubleshooting the FiX1 or occasional auditing of results.

The point clouds can be downloaded from the FiX1, but the data can also be viewed online without downloading any data. The point cloud viewer is hosted on the FiX1 and viewed in your web browser. No external software is required.

From the **Scan** list, select the appropriate scan and click **View**. The point cloud opens in a new tab in your browser.

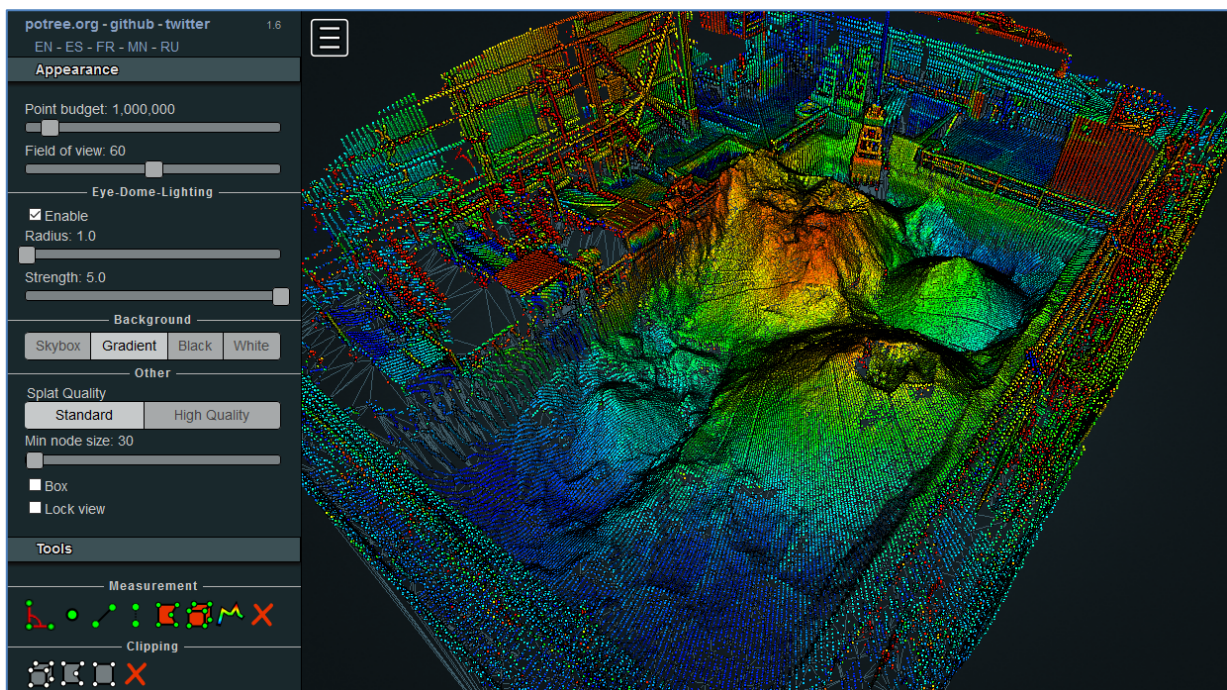


Figure 86 3D Viewer

# PRODUCT INFORMATION

## 14 System specifications

Laser module	
Laser classification	Class 1 (BS EN 60825-1: 2007 and US standards 21CFR 1040.10 and 1040.11, except for deviations pursuant to Laser Notice no. 50, dated June 24, 2007)
Type	InGaAs Laser Diode
Wavelength (typical)	905nm
Accuracy*	±10mm
Maximum energy per pulse	0.461uJ
Range resolution	10mm
Maximum range to passive target**	250m
Minimum range	0.5m
Beam footprint at 50m	141mm x 103mm
Maximum measurement rate	15,000 Hz (15,000 points per second)
Angular measurement	
Type	Opto-electronic encoder
Angular accuracy	0.0055°
Pan angle resolution	0.0055°
Tilt angle resolution	0.0055°
Scanning field of view (horizontal)	360°
Scanning field of view (vertical)	200°
Motion	Servo controlled brushless DC motor
Physical Data	
Dimensions	(H x W) 495 mm x 314 mm - rotational clearance 368 mm
Weight	12.5 kg
Power input	90 - 264 Vac, 80 W
Power consumption	80 W (max); 10 W (idle)
Environmental	
Water and dust resistance	IP67
Operating temperature	-40°C to + 50°C
Storage temperature	-40°C to +85°C

External connectors	
Serial	Rugged 9-pin D-type
Ethernet	Rugged RJ45
USB	STD USB A Female
Antenna	2 x 50Ω SMA
Power	4-pin rugged binder connector
SD card	Access via IP67 threaded plug
Connectivity	
Serial	115200 baud, with 12V, 1A power. Isolated data and power.
USB	Full Speed USB2.0 with 5V, 500mA isolated power.
Ethernet	10/100 Base T
Wi-Fi	<ul style="list-style-type: none"> <li>• 802.11 b/g/n 1x1 (1-14, max channel width 20MHz)</li> <li>• Up to 72.2Mbps OTA throughput, 50Mbps actual throughput</li> <li>• High performance 2.4 / 5 GHz IEEE 802.11 a/b/g/n</li> <li>• Up to 100Mbps (UDP), and 80Mbps (TCP).</li> </ul>
Cellular	<ul style="list-style-type: none"> <li>• USA: LTE Cat 4; 3G fallback; LTE bands 2, 4, 5, 13, 17</li> <li>• Europe, Asia: LTE Cat 4; 2G/3G fallback; LTE Bands 1, 3, 5, 7, 8, 20</li> <li>• APAC, S.America: LTE Cat 4; 2G/3G fallback; LTE Bands 1, 3, 5, 7, 8, 28</li> <li>• Japan (DoCoMo); LTE Cat 4 ;3G fall-back; LTE Bands 1,3,5,8,19</li> </ul>

\* Max measuring accuracy recorded at 50 m against Kodak white card (90% reflectivity) to  $1\sigma$ . Accuracy is defined as the degree of conformity of the measured sample mean range to its actual (true) value, measured with reference to a total station under Carlson test conditions.

\*\* Max measuring ranges are recorded against Kodak white card (90% reflectivity).

## 15 Product information

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### Warranty

Equipment requiring attention under warranty must be returned to your equipment supplier.

Unless otherwise specifically agreed in writing between you and Carlson, if you purchased the equipment from a Carlson company, the warranty provisions contained in Carlson's CONDITIONS OF SALE apply. You should consult these conditions to find out the details of your warranty but, in summary, the main exclusions from the warranty are if the equipment has been:

- neglected, mishandled or inappropriately used, or
- modified or altered in any way except with the prior written agreement of Carlson.

If you purchased the equipment from any other supplier, you should contact them to find out what repairs are covered by their warranty.

### Safety

It is essential that the FiX1 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 equipment 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*.

### 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 FiX1 system, including those mentioned in Carlson product literature.



### **EC declaration of conformity**

Carlson declares that the FiX1 complies with the applicable standards and regulations.

Contact Carlson or visit [www.carlsonsw.com](http://www.carlsonsw.com) for the full EC declaration of conformity.

### **Radio-frequency disturbance characteristics**

As defined by *BS EN 55011:2016 Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*, the Carlson FiX1 is defined as Group 1, Class A equipment.

The Carlson FiX1 probe is suitable for use in all locations other than those allocated in residential environments and those directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes. The Carlson FiX1 does not use radio-frequency energy for the treatment of material, for inspection/analysis purposes, or for transfer of electromagnetic energy.



**CAUTION:** This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

### **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 upon 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.

## POTREE

Potree 3D renderer - <http://potree.org>

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