

PHENIX

LiDAR SYSTEMS

ACQUISITION TRAINING

1 - INTRODUCTION

Acquisition Training Goals

- Provide an overview in the use of our LiDAR mapping systems.
- Address the basic working principles of the components, system architecture, and software which are necessary to obtain accurate data and produce quality results.

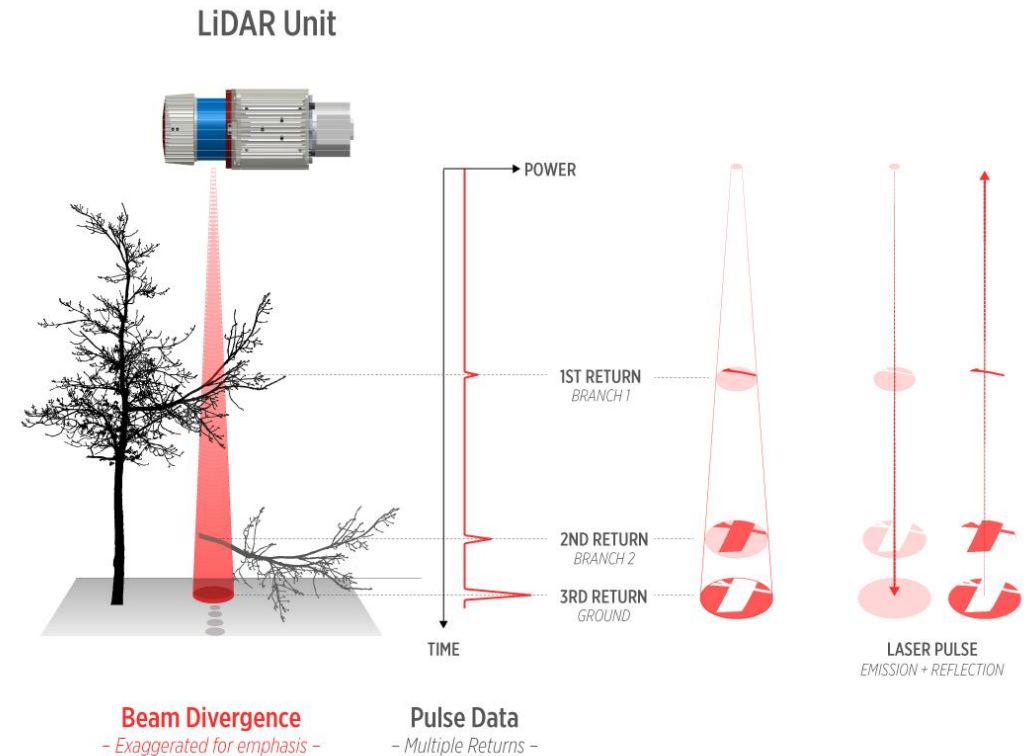
2 – Basics of LIDAR

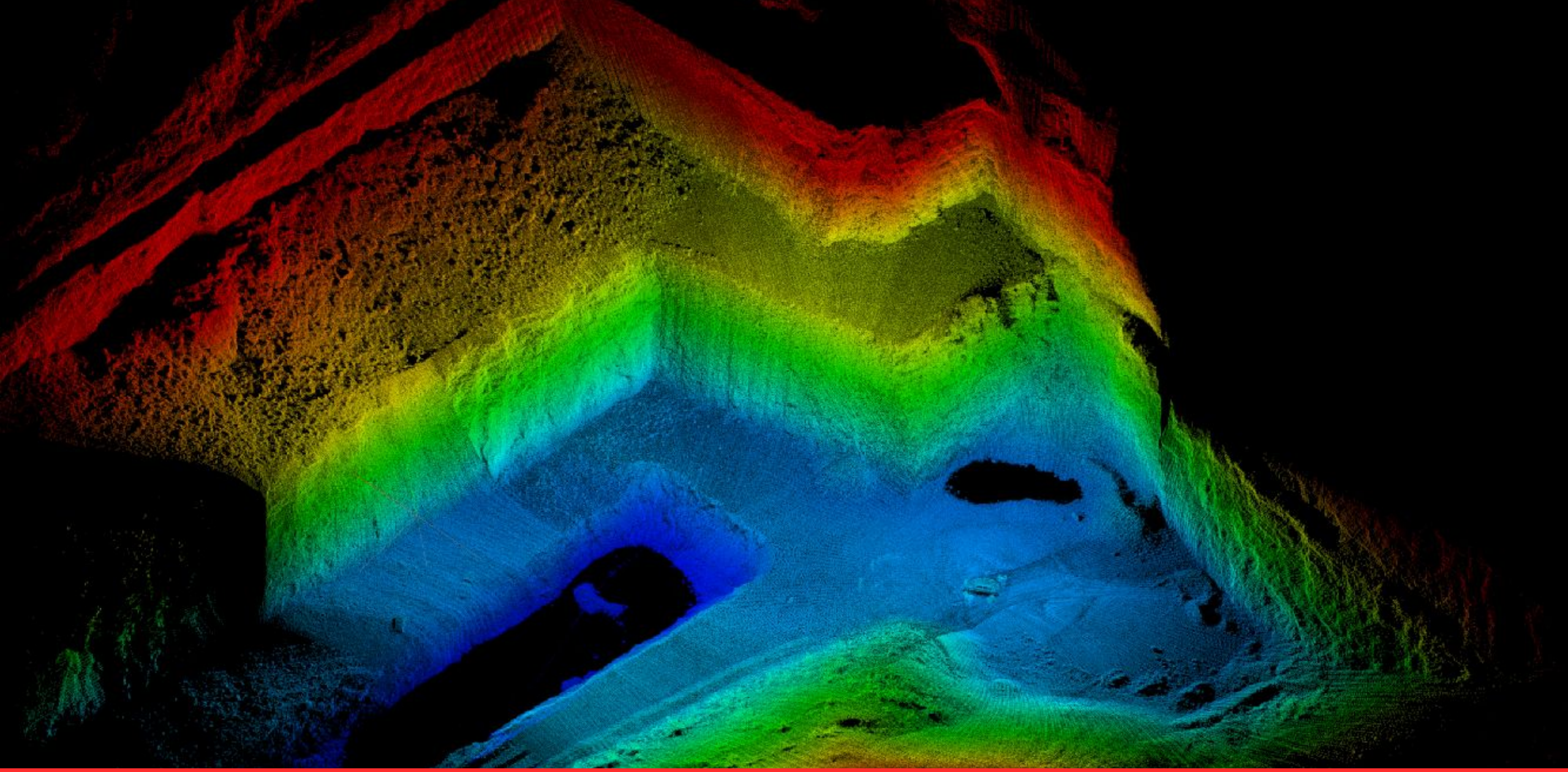
What is LiDAR?

- LiDAR stands for Light Detection and Ranging, and is a remote sensing method.
- Uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.
- These light pulses, combined with other data recorded by a system, are processed to create highly accurate, three-dimensional information about the surface it has scanned.

Active Sensing

- Active sensors provide their own source of energy to illuminate the objects they observe.
- An active sensor emits radiation in the direction of the target to be investigated.
- The sensor then detects and measures the radiation that is reflected or backscattered from the target.





Basics of LiDAR

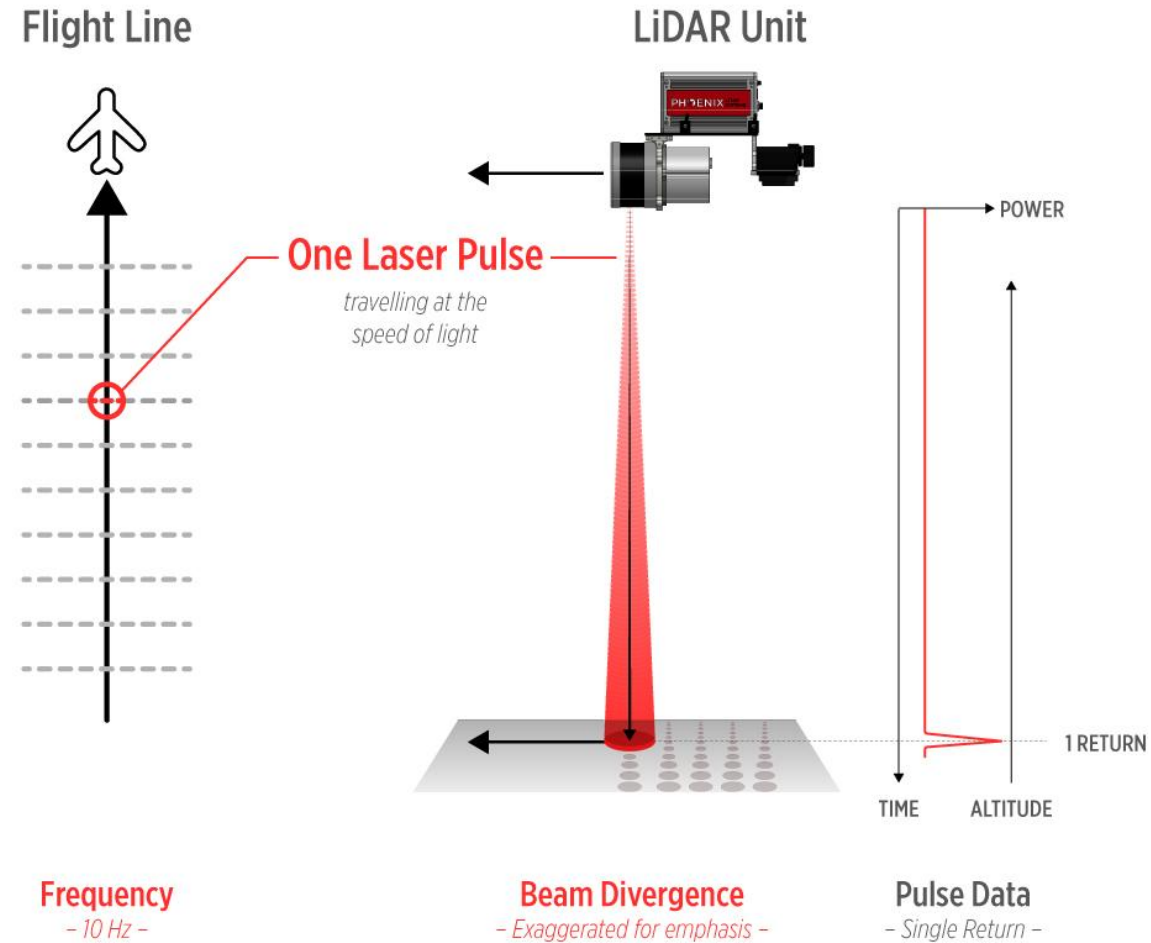
- Field of View (FOV)
- Pulse Repetition Rate
- Scan Rate/Mirror Speed
- Echoes/Returns
- Beam Divergence
- Accuracy
- Precision
- Point Density

Basics of LiDAR

- **Field of View (FOV):** The angle in which LiDAR signals are emitted
- **Pulse Repetition Rate:** The number of emitted laser pulses per second
- **Scan Rate/Mirror Speed:** The rate at which the laser is redirected 360 degrees or how many full revolutions the scanner makes per interval of time.
- **Echoes/Returns:** Returned signal produced from laser reflecting off target
- **Beam Divergence:** Measurement of angle for how a laser beam expands from its emission point

Basics of LiDAR


- Field of View (FOV)
- Pulse Repetition Rate
- Scan Rate/Mirror Speed
- Echoes/Returns
- Beam Divergence



Basics of LiDAR

INPUT/OUTPUT
SETTINGS

Scanner Type



VUX-1LR

Project Requirements

Project Type:

Interactive

Load Results of: Interactive

Stripe Overlap:

0.0

 %

Surface / Target / Atmosphere

Min. Reflectance:

20.0

 %

Target Type:

Topography

Object Diameter:

0.1

 m

Visibility:

23km Standard Clear

Scanner Settings

PRR:

820

 kHz

Laser Power:

100.0

 %

Scan Rate:

72.0

 lps

FOV:

90.00

 °

Flight Parameter

Height AGL:

400

 ft

122

 m

Speed:

12.00

 kn

22.22

 km/h

▶

Result Qualifier

SUCCESS

Scanner Settings

PRR:

820

 kHz

Laser Power:

100

 %

Scan Rate:

72.0

 lps

FOV:

90.0

 °

Angular Step Width:

0.0316

 °

Flight Parameters

Flying Height AGL:

400

 ft

122

 m

Aircraft Speed:

12.0

 kn

22.2

 km/h

6.17

 m/s

Scan Pattern

Line Distance:

0.0858

 m

Point Distance:

0.0672

 m

Point Density:

86.7

 pts/m²

Swath Width:

244

 m

MTA Details

MTA Zone Width:

183

 m

MTA Zones Used:

1

Productivity

Net Area Rate:

1505

 m²/s

Typ. Data Rate:

13.3

 GB/h

Max. Data Rate:

27.3

 GB/h

Laser Safety Information

NOHD:

0

 m

ENOHD:

0

 m

Auxiliary Limits

Max. Meas. Range:

190

 m

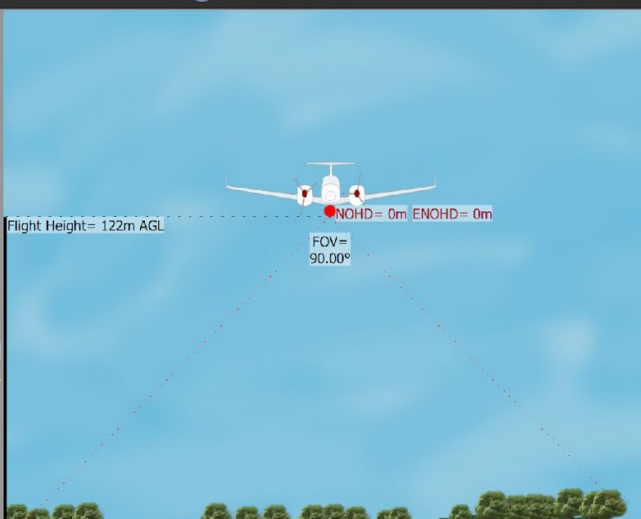
Scan Rate-Range-Prod.:

13652

 m³/lps

🖨️

Visual Simulation



Flight Height= 122m AGL

NOHD= 0m ENOHD= 0m

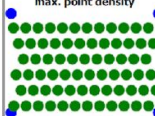
FOV= 90.00°

Min. Flight Height= 0m

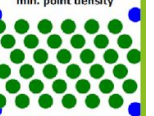
Terrain Altitude= 0m Swath Width= 244m Terrain Variation= 0m

Overview, subsampled by a factor of 142

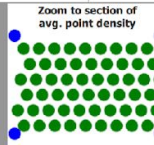
Zoom to section of max. point density



Zoom to section of min. point density



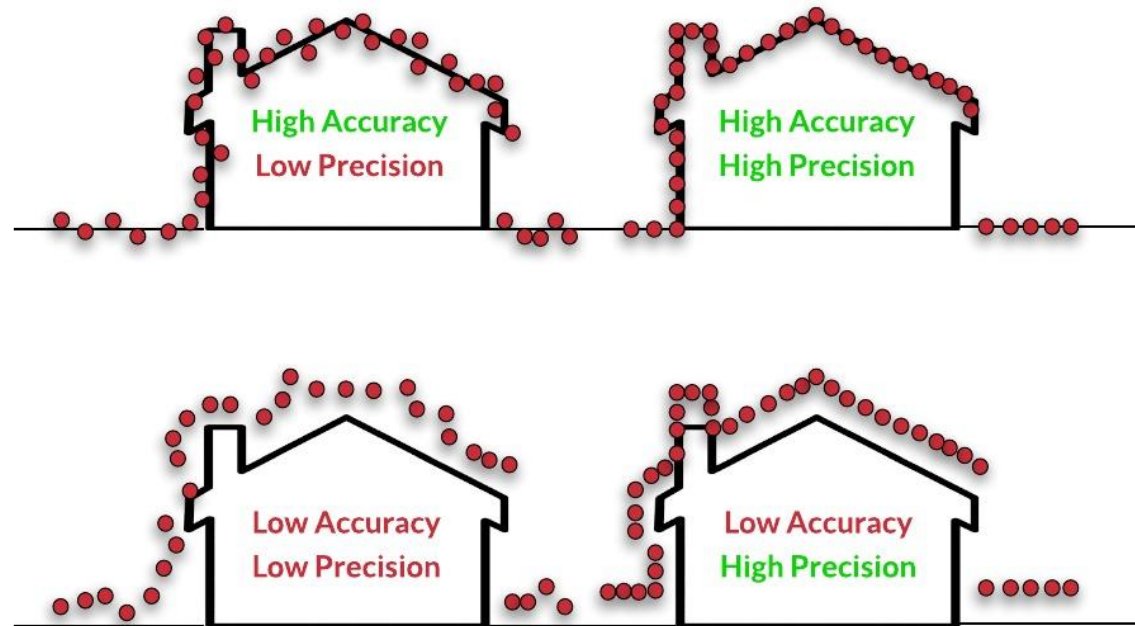
Zoom to section of avg. point density



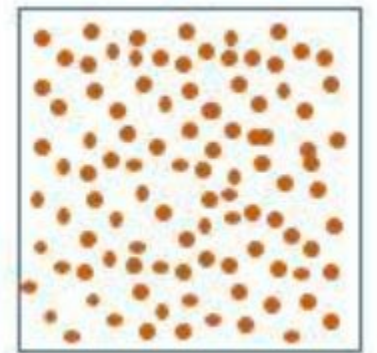
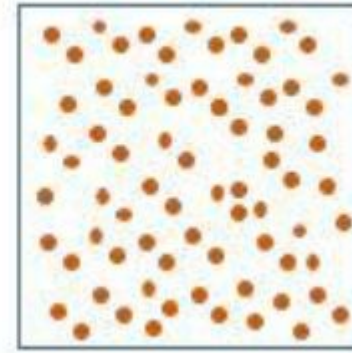
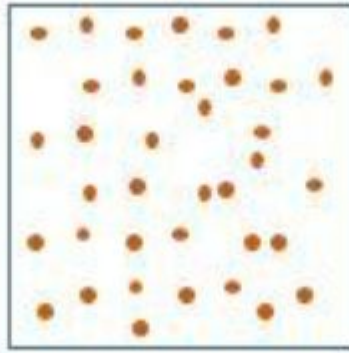
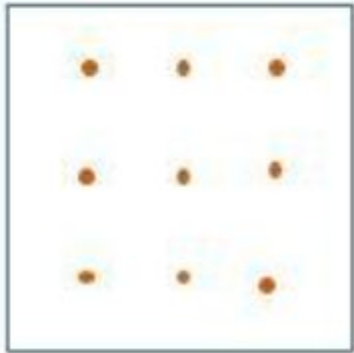
Basics of LiDAR

- **Accuracy:** The difference between the laser system's time of flight ranging measurement vs the true realworld distance measurement
- **Precision:** The variation in repeatable measurements
- **Resolution/Point Density:** Defines the number of returns per area at which the surface of the earth is measured

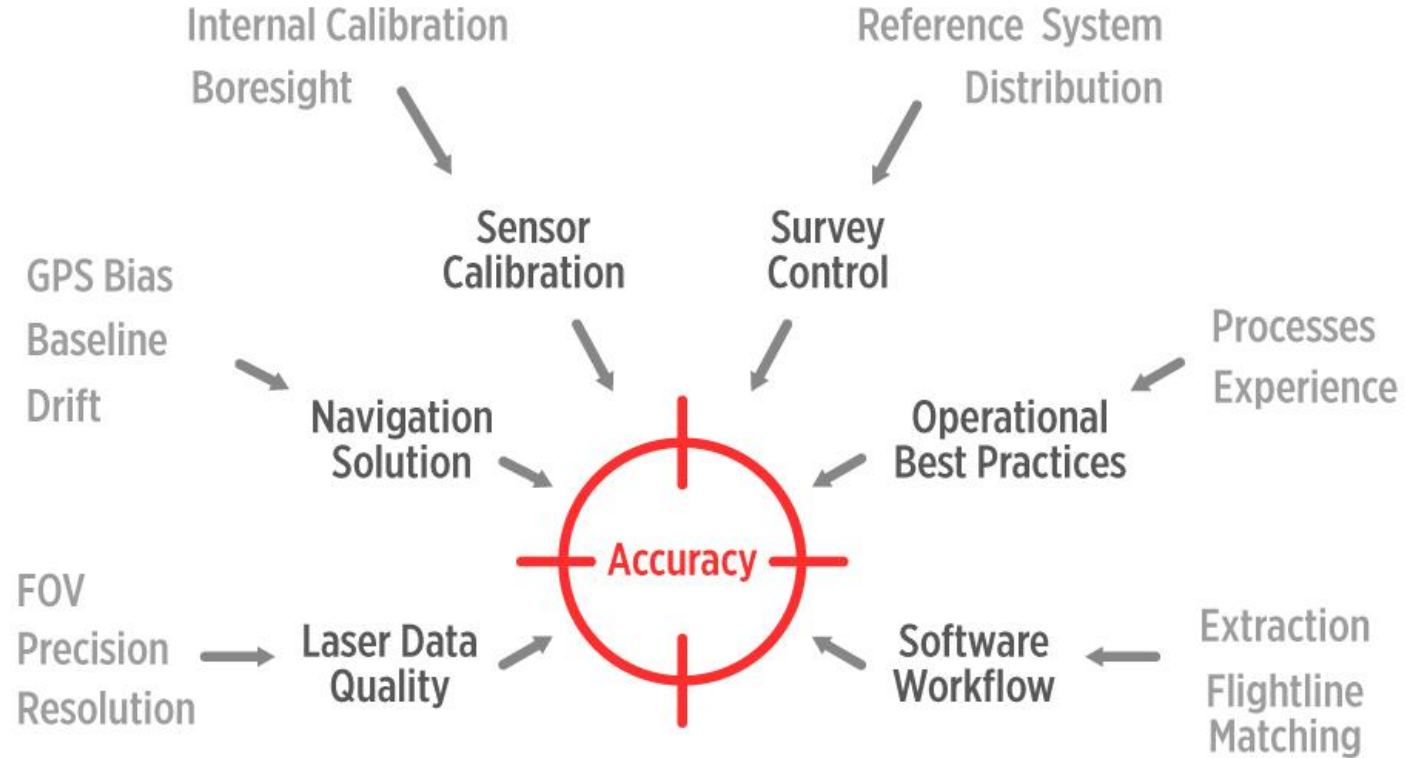
Accuracy vs Precision



Point Density



Factors Affecting Accuracy





3 – SOFTWARE OVERVIEW

SpatialSuite



1. Phoenix LiDAR Systems provides a proprietary software suite for streamlined acquisition, geo-referencing, data fusion, and data export.
2. Comprised of SpatialExplorer and SpatialLightHouse.
3. Software versions 5.0.X and above are only provided directly from Phoenix LiDAR Systems upon purchase/upgrade. Contact support@phoenixlidar.com if you need a specific version.
4. Requirements: Up to date version of NVIDIA graphics driver. Runs on any 64-bit version of Windows 8 and 10.

SpatialSuite



Highlights include:

- Real-time, 3D, RGB colorized, georeferenced point cloud visualization
- Monitor a variety of LiDAR system parameters in real-time
- Real-time photo preview – with specific camera upgrades only
- Connect to a 3G/4G enabled Rover from anywhere and with multiple Spatial Explorer sessions
- Creating accurate, georeferenced, colorized point clouds from real-time or post-processed trajectories
- Exporting point clouds to more than 4000 coordinate systems



SpatialLightHouse

- SpatialLighthouse is a software developed to forward realtime differential corrections from the GNSS base to the rover, otherwise known as RTK (Real Time Kinematic).
- RTK requires an uninterrupted internet connection between the base and rover and is a great tool for certain use cases.
- An alternative to RTK is PPK (Post Processed Kinematic) trajectory processing which is the industry standard.
- PPK produces a more accurate trajectory, and does not require any realtime connection between the base and the rover.
- **We still offer SpatialLightHouse, but recommend PPK trajectory processing (via Novatel's Inertial Explorer or Phoenix LiDAR's NavLab) in lieu of RTK.**



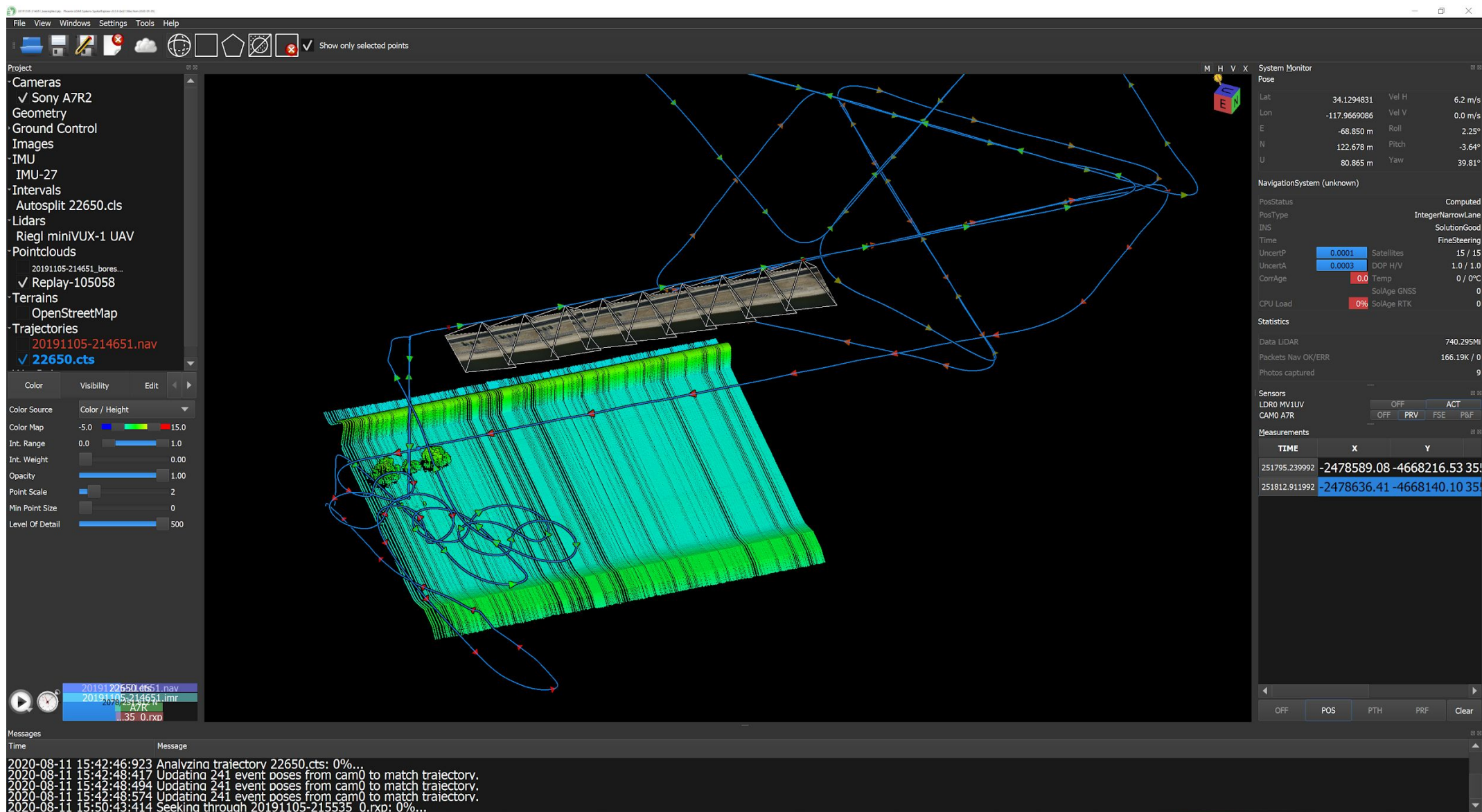
SpatialExplorer

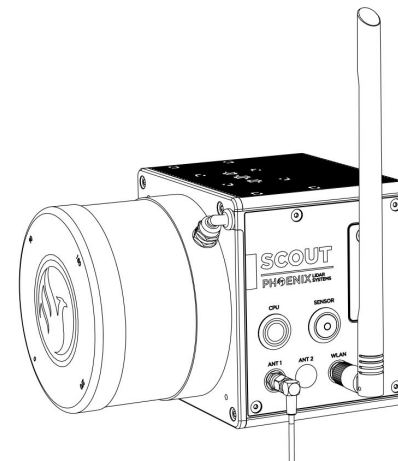
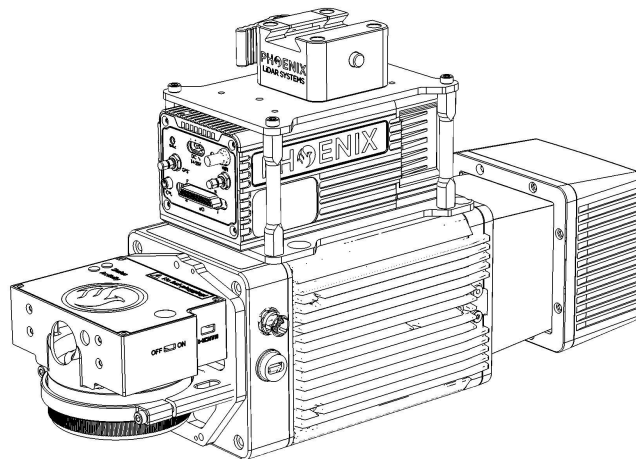
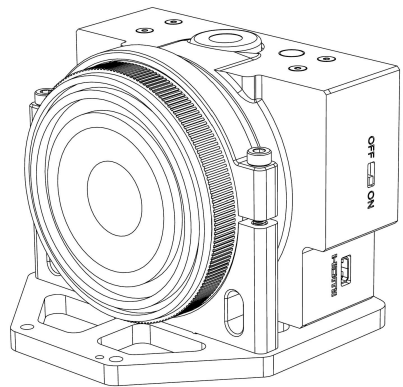
- SpatialExplorer can monitor and control the LiDAR mapping systems offered by Phoenix LiDAR Systems in real-time and replay and visualize LiDAR mapping missions in post
- Enables in-field quality control and analysis and ensures obtaining a quality solution throughout the acquisition process.
- Exceptional tool for training with how-to-fly visualizations.
- Allows for the creation of high quality marketing imagery of acquired scans.



SpatialExplorer

- As a post tool, SpatialExplorer is designed to georeference data acquired by our LiDAR mapping systems into common mapping formats such as LAS/LAZ.
- It cuts down the wait time on extensive photogrammetry applications by creating colored point clouds in about twice the time of the acquisition.
- Furthermore, it supports multiple remote sensing equipment configurations.





4 – HARDWARE OVERVIEW



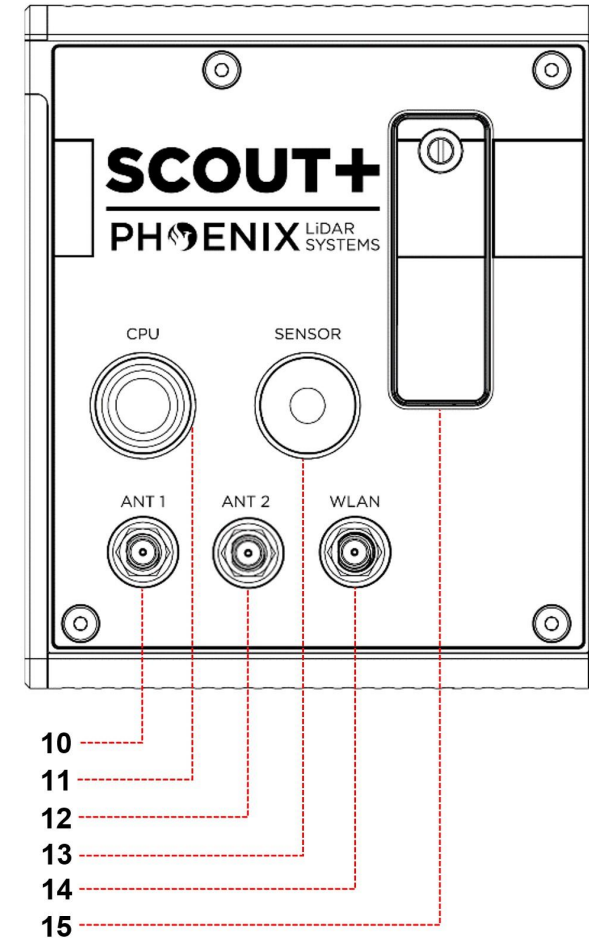
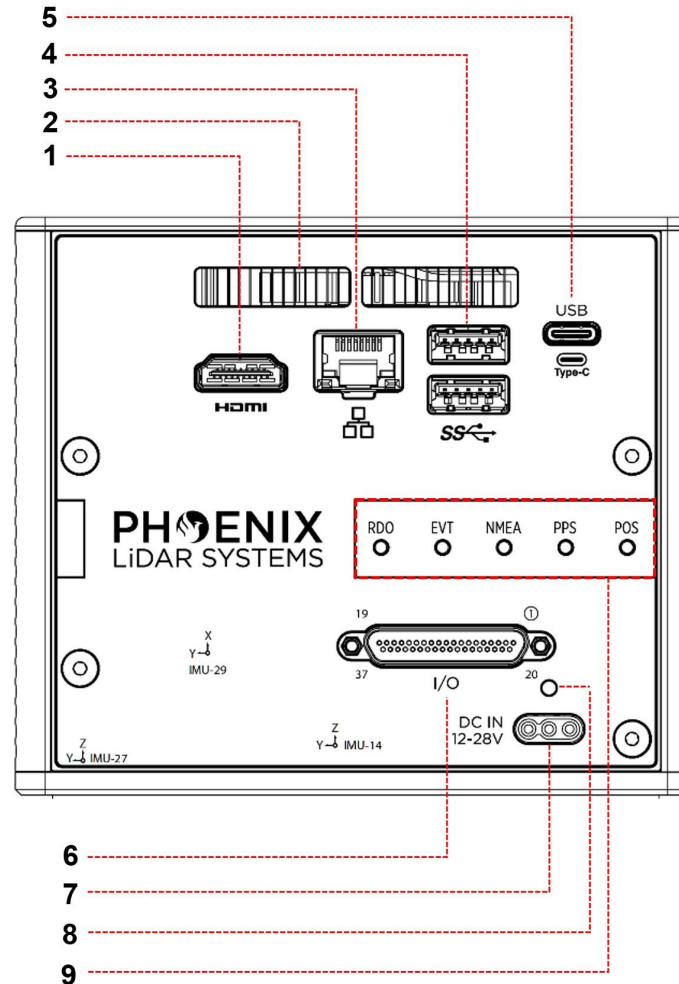
Rover Hardware

Phoenix LiDAR Systems are comprised of the following major components:

1. Navigation Box (NavBox)
2. IMU (Inertial Measurement Unit) / INS(Inertial Navigation Unit)
3. LiDAR Sensor
4. Camera(s) (optional)
5. Accessories (cables & antennas)

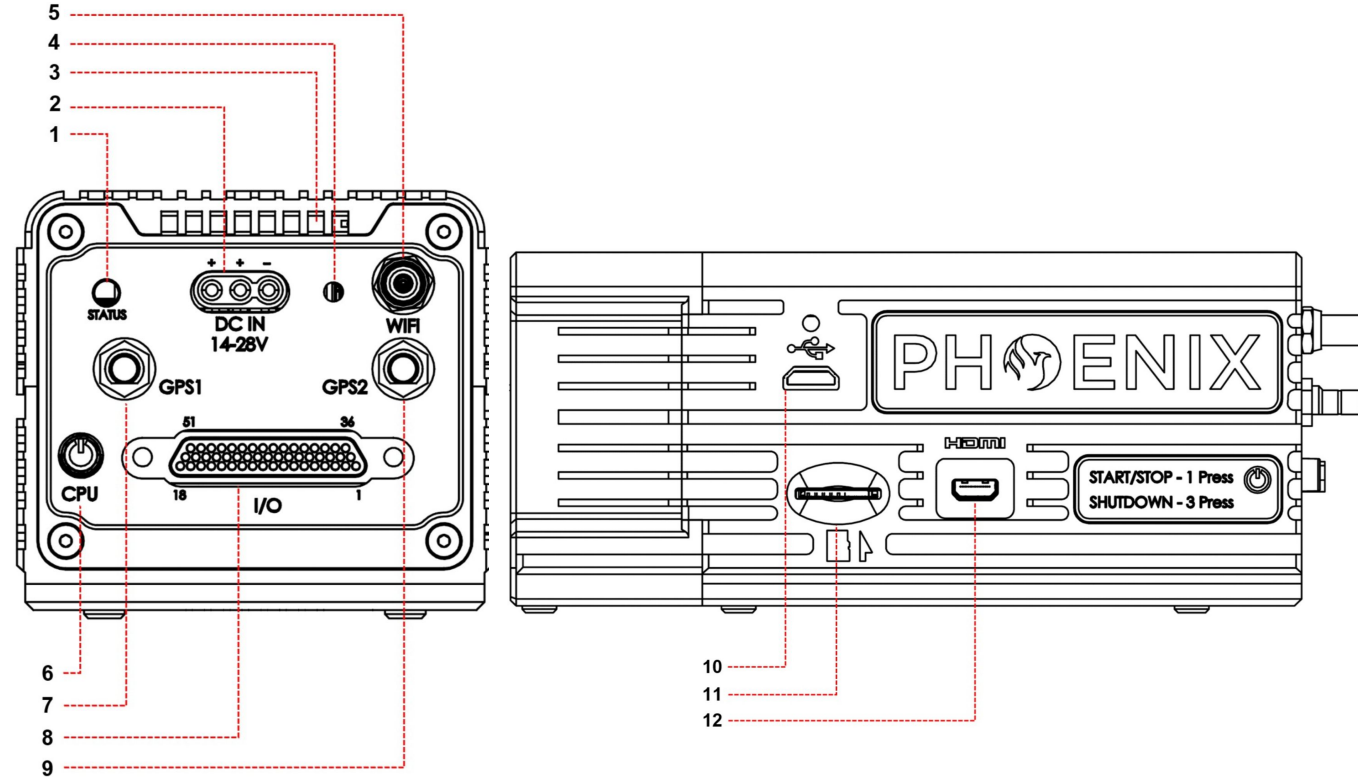
SCOUT NavBox Ports/User Elements

1. HDMI Type A Port
2. Fan Ventilation Openings
3. RJ45 Ethernet Port
4. 2x USB 3.0 Type A Ports
5. USB Type C Port
6. I/O Connector (37-pin)
7. Power Input Connector MR30
8. Power Connector Safety Thread
9. LED Indicators
10. ANT1 Port SMA for external GPS Antenna (primary)
11. CPU Button
12. ANT2 Port SMA for external GPS Antenna (secondary)
13. Sensor ON/OFF Switch
14. WLAN Port SMA for external WiFi Antenna
15. Removable Service Panel with additional USB Ports



AIR NavBox Ports/User Elements

1. RGB Status LED
2. Power Input Connector MR30
3. Fan Ventilation Grills
4. Power Connector Safety Thread
5. External WiFi Antenna Port MCX
6. CPU Power Button
7. External GPS1 Antenna Connector SMB (Primary)
8. I/O Connector (51-pin)
9. External GPS2 Antenna Connector SMB (Secondary)
10. Micro USB Service & Debugging Port
11. Micro SD Card Slot
12. Micro HDMI (Type D) Service & Debugging Port



IMU (Inertial Measurement Unit)

- This sensor is used to continuously measure the system's attitude or orientation (roll, pitch, and yaw) of the system.
- An inertial measurement unit (IMU) is an electronic device that measures and reports a body's specific force, angular rate, and sometimes the magnetic field surrounding the body, using a combination of accelerometers and gyroscopes (sometimes also magnetometers).

GNSS (Global Navigation Satellite System) Receiver

- Global Navigation Satellite System (GNSS) refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers.
- The receivers then use this data to determine location.
- By definition, GNSS provides global coverage.
- Examples of GNSS include Europe's **Galileo**, the USA's NAVSTAR Global Positioning System (**GPS**), Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (**GLONASS**) and China's **BeiDou** Navigation Satellite System.

Rover Mounting Options

- Phoenix LiDAR Systems designs and develops compact and lightweight 3D laser mapping solutions for use with ground, manned and unmanned aerial vehicles.
- Systems are vehicle agnostic, that is they can be designed for multi-rotors, cars, bicycles, backpacks, helicopters, trains, etc.

5 – NETWORK CONFIGURATION

Rover Static IP Addresses

- Phoenix LiDAR Systems rovers are pre-configured with static IP addresses that can be reached via an ethernet (**192.168.200.10**) or a Wi-Fi connection (**192.168.20.10**).
- To avoid typing in the IP addresses, computers configured by Phoenix LiDAR Systems contain individual entries in the Windows hosts file that map the ethernet and Wi-Fi IP addresses to specific names, **rover-wire** and **rover-wifi** respectively.

Wired Ethernet Network Card

- Any computer with a properly configured ethernet adapter can be used to establish a direct connection to the rover using an ethernet cable.
- Field computers configured by Phoenix LiDAR Systems will default to an alternative IP configuration of **192.168.200.20** when no IP address is obtained through DHCP on the primary ethernet port within 3 minutes.
- This will allow a computer to establish a connection to the rover via ethernet after 3 minutes of connection.
- Refer to the *Phoenix LiDAR Systems Comprehensive User Manual* for instructions on configuring the ethernet adapter on a new computer if needed.

6 – USER LAPTOP CONFIGURATION

User Laptop Configuration

- If you **DID NOT** purchase a laptop preconfigured by Phoenix LiDAR Systems, you will need to configure your own computer to ensure it properly works with our LiDAR mapping systems.
- If you **DID** purchase a laptop preconfigured by Phoenix LiDAR Systems, you can move onto “7 - *Connect to Rover*”!

Install Latest NVIDIA Drivers

- SpatialExplorer requires the latest NVIDIA graphics card drivers be installed on your computer.
- Determine the model of your graphics card and download the most recent driver from the [NVIDIA Driver Downloads page](#).

Install SpatialSuite Software

- Phoenix LiDAR Systems provides a proprietary software suite for streamlined acquisition, geo-referencing, data fusion & export.
- If you are using your own computer as a base station, you must install the Phoenix LiDAR Systems Spatial Software Suite.
- SpatialExplorer 5.0.X and above are provided only directly by Phoenix LiDAR Systems upon system purchase or upgrade. Please contact our support team at support@phoenixlidar.com to request a specific version to install.

Modify Hosts File

- The *hosts* computer file is an operating system file that maps hostnames to IP addresses. It is a plain text file.
- It serves the function of translating human-friendly hostnames into numeric protocol addresses, called IP addresses that identify and locate a host in an IP network.
- The contents of the hosts file is used preferentially with various name resolution methods, one such being the Domain Name System (DNS).
- To modify the *hosts* file in Windows 8/10, open Notepad as an administrator (right-click on Notepad, hover over the *More* option, and click on *Run as administrator*).
- If you have User Account Control (UAC) enabled, click Yes to allow Notepad to open with administrative permissions.

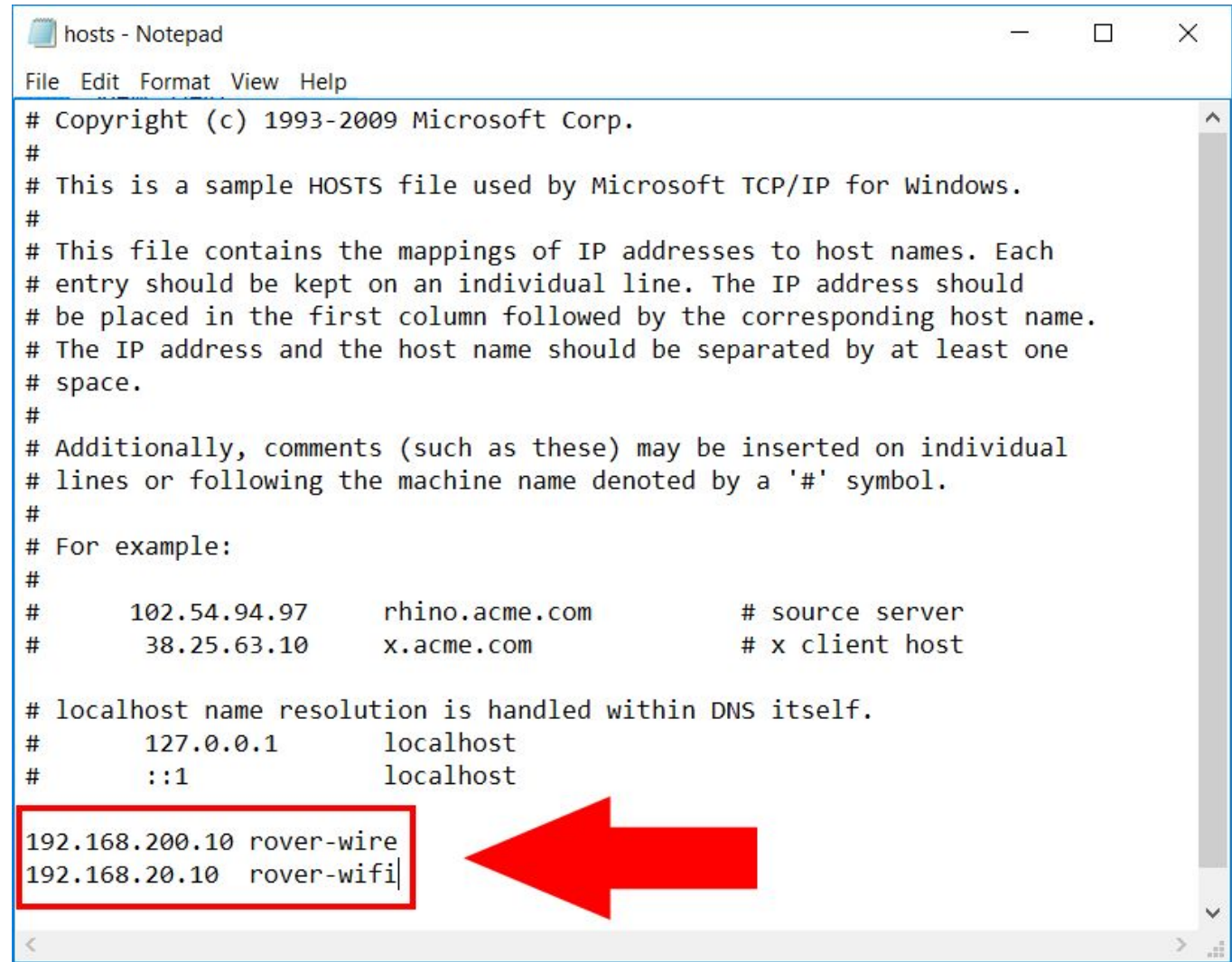
Modify Hosts File

- Navigate to the folder `C:\Windows\System32\drivers\etc` and locate the *hosts* file. If necessary, select the option to view “All Files (*.*)” to display the *hosts* file.
- Click on the *hosts* file and click the *Open* button.
- With the *hosts* file open, enter the following two entries at the end of the file, each on their own separate line:

```
192.168.200.10 rover-wire  
192.168.20.10 rover-wifi
```

- Save the *hosts* file and close Notepad.

Rover Static IP Addresses



```
hosts - Notepad
File Edit Format View Help
# Copyright (c) 1993-2009 Microsoft Corp.
#
# This is a sample HOSTS file used by Microsoft TCP/IP for Windows.
#
# This file contains the mappings of IP addresses to host names. Each
# entry should be kept on an individual line. The IP address should
# be placed in the first column followed by the corresponding host name.
# The IP address and the host name should be separated by at least one
# space.
#
# Additionally, comments (such as these) may be inserted on individual
# lines or following the machine name denoted by a '#' symbol.
#
# For example:
#
#       102.54.94.97       rhino.acme.com           # source server
#       38.25.63.10       x.acme.com               # x client host
#
# localhost name resolution is handled within DNS itself.
#       127.0.0.1        localhost
#       ::1              localhost
192.168.200.10 rover-wire
192.168.20.10  rover-wifi
```

Wired Ethernet Network Card Setup

- You must configure a Windows 8/10 computer with an alternative IP address.
- This will enable your computer to connect to the rover via ethernet when no IP address is obtained through DHCP on the primary ethernet port within 3 minutes.

Wired Ethernet Network Card Setup

- In Windows, open up the Control Panel and navigate to Network and Sharing center.
- Click on “Change adapter settings” located near the top, left-hand side of the window and identify the primary ethernet adapter in your computer.
- Right-click on the primary ethernet adapter and select “Properties” Click and select “Internet Protocol Version 4 (TCP/IPv4)” and click on “Properties.”

Wired Ethernet Network Card Setup

- Click on the alternate configuration tab and select the “User configured” option.
- Enter the IP address *192.168.200.20* in the IP address field box and subnet mask address *255.255.255.0* in the Subnet mask field box.
- Click “OK” and then “Close” the ethernet adapter properties.
- Your computer should now have an alternate IP address configured.

Wired Ethernet Network Card Setup

Internet Protocol Version 4 (TCP/IPv4) Properties

General **Alternate Configuration**

If this computer is used on more than one network, enter the alternate IP settings below.

☒ Automatic private IP address

☐ User configured

IP address: . . .

Subnet mask: . . .

Default gateway: . . .

Preferred DNS server: . . .

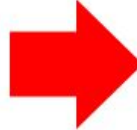
Alternate DNS server: . . .

Preferred WINS server: . . .

Alternate WINS server: . . .

☐ Validate settings, if changed, upon exit

OK Cancel



Internet Protocol Version 4 (TCP/IPv4) Properties

General **Alternate Configuration**

If this computer is used on more than one network, enter the alternate IP settings below.

☐ Automatic private IP address

☒ **User configured**

IP address: 192 . 168 . 200 . 20

Subnet mask: 255 . 255 . 255 . 0

Default gateway: . . .

Preferred DNS server: . . .

Alternate DNS server: . . .

Preferred WINS server: . . .

Alternate WINS server: . . .

☒ Validate settings, if changed, upon exit

OK Cancel

7 – CONNECT TO ROVER



Methods to Connect to Rover

SpatialExplorer can be launched to connect to a Phoenix LiDAR Systems rover via 3 main methods:

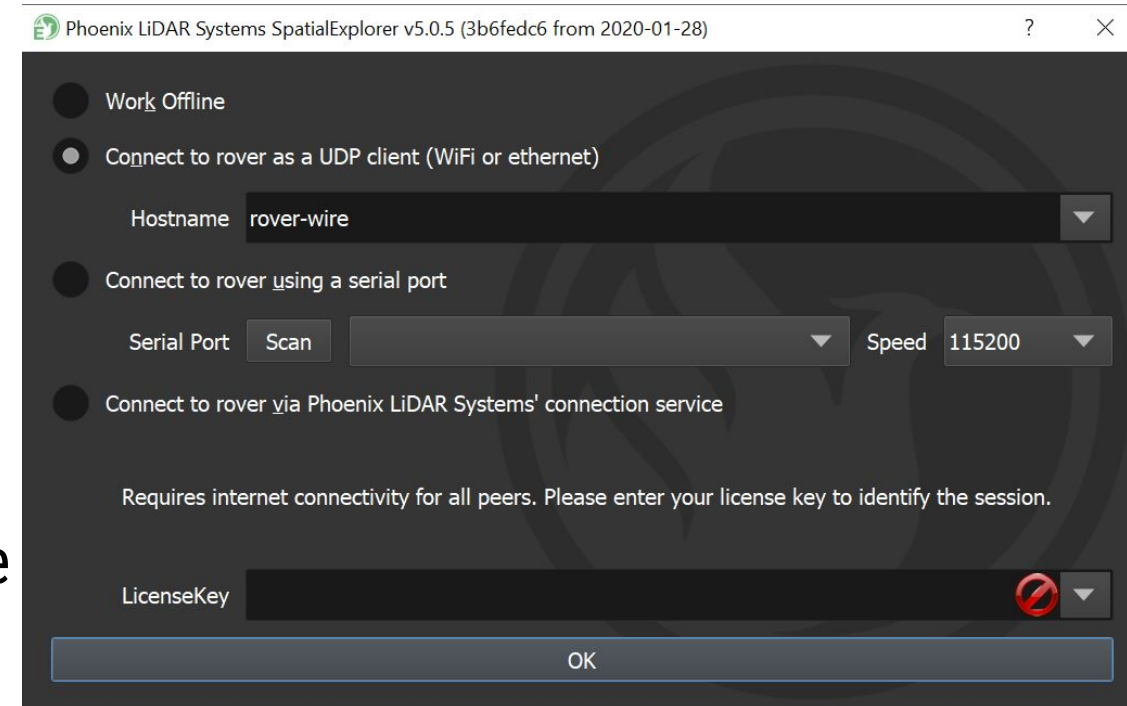
- UDP client (Wi-Fi or Ethernet)
- Serial Port (900 MHz radio)
- Phoenix LiDAR Systems Connection Service (3G/4G).

All three of these configurations will allow you to view your georeferenced point-cloud data and configure sensors in real-time while scanning.



Connect to Rover as UDP Client- Ethernet

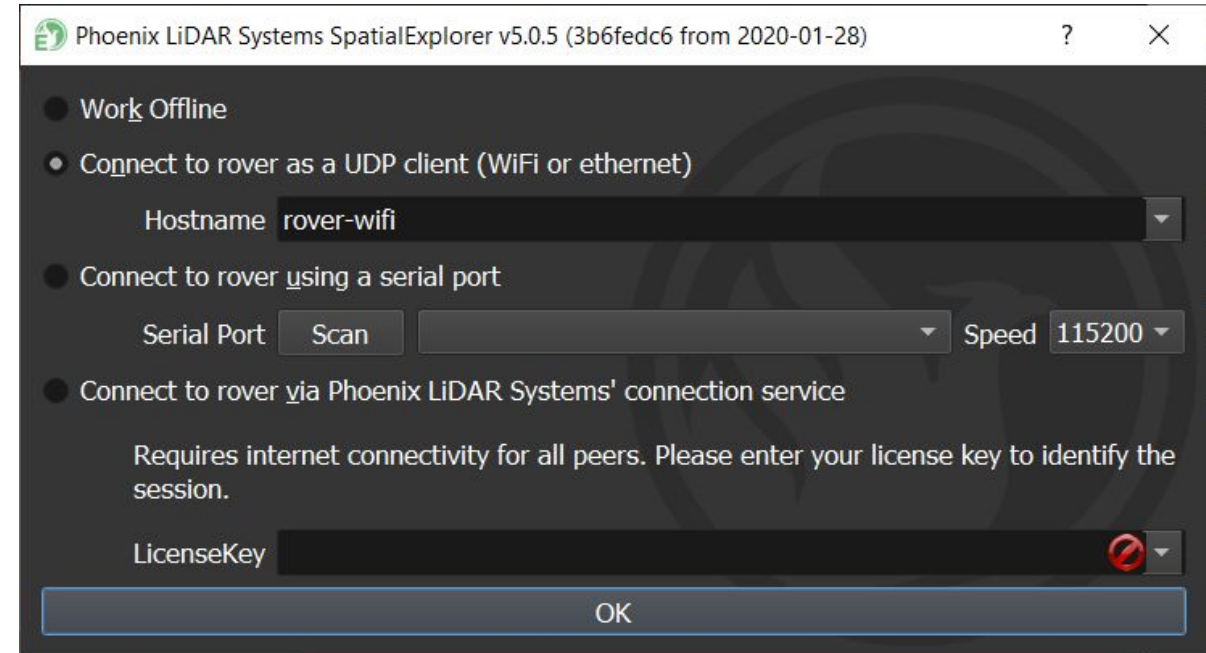
- Any computer with a properly configured ethernet adapter can be used to establish a direct connection to the rover using an ethernet cable (after 3 min.).
- Once connected via ethernet, **connect to Rover as a UDP Client** through SpatialExplorer using the IP address **192.168.200.10** or the hostname **rover-wire**.





Connect to Rover as UDP Client – Wi-Fi

- The proper method of connecting to rover via Wi-Fi is using the Bullet Wi-Fi antenna.
- Once the Bullet Wi-Fi antenna is powered on and connected, **connect to Rover as a UDP Client** through SpatialExplorer using the IP address **192.168.20.10** or the hostname **rover-wifi**.





Bullet Long Range Wi-Fi Module

- To establish a strong wireless connection between your laptop and rover, you must use the Long Range Wi-Fi module.
- The Long Range Wi-Fi module is configured to automatically connect to the rover's wireless access point.
- Remember to attach the included 5.8 GHz Wi-Fi antennas to the rover's WLAN terminals.

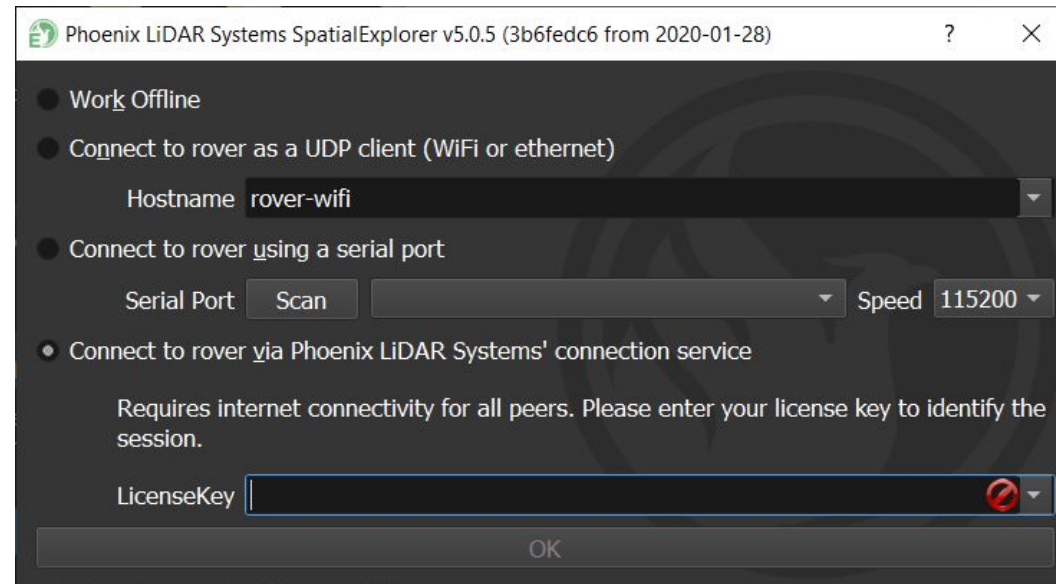


Long Range Wi-Fi Module Setup

- Connect the ethernet end of the ethernet data+power cable to the ethernet port on the laptop.
- If your laptop does not have an ethernet port, use a USB to ethernet adapter.
- Connect a Li-Po battery to the XT60 end of the power adapter.
- When powering the Long Range Wi-Fi module, we recommend using a **4 cell Li-Po** battery.



Connect to Rover via Connection Service



LicenseKey

Every system is configured and associated with a unique alphanumeric key that must be entered to associate the base station with the rover on the server.



Connect to Rover via Connection Service

- The Phoenix LiDAR Systems Connection service allows for communication between SpatialExplorer and rover via a remote online server.
- An internet connection is required on both the computer running SpatialExplorer and rover for this to function.
- While in the field, we recommend connecting your laptop to a dedicated mobile hotspot; rover requires an external USB cellular modem, preferably a compatible 4G USB modem.
- Rover will automatically connect to the remote server upon establishing a connection to the internet.

8 – REFERENCE STATION

Reference Station Setup

- The primary purpose of a GNSS reference station is to collect GNSS data in the form of raw positioning observations, to be utilized later on during PPK Trajectory Processing.
- With PPK workflow, accurate positioning doesn't happen in real time, all algorithms are applied afterwards.
- Both base on the ground and rover (LiDAR System) record raw GNSS logs, which are then processed to receive an accurate positioning track.
- If you want to post-process the rover's trajectory, raw observations from the reference station are needed.

Stonex S900



L1 Phase Center

ARP (Antenna Reference Point)

Stonex S900

- 555 channels provides an excellent on board real time navigation solution with high accuracy
- All GNSS signals (GPS, GLONASS, BEIDOU and GALILEO) are included, no additional cost
- Web UI Control to initialize, manage, monitor the settings of the receiver and to download data using a laptop or PC, smartphone or tablet with Wi-Fi capability
- Dual slot for two Smart hot swappable batteries gives you up to 10 operating hours
- IP67 certification combined with a high shock resistance guarantee the maximum strength and the best water and dust tight even in harsh environments

Reference Station Setup

- We recommend mounting the GNSS reference station antenna with a clear view of the sky, away from buildings and powerlines.
- You must mount the GNSS reference station onto a survey-grade tripod, composed of either wood, aluminum, or fiberglass.
- To prevent any discrepancies when measuring the Antenna Reference Point (ARP) height, we recommend a fixed height survey grade tripod
- This will ensure a uniform measurement throughout all scanning missions.

S900 Configuration and Downloads

- The Stonex S900 can be set to manually log upon establishing a connection through the Web UI Config.
- Alternatively, it can be set to log automatically based on a minimum number of satellites.
- Make sure to download the Stonex Rinex Converter from our website under the “downloads” section under “client links”.
- It is also a good idea to download and print a copy of “Static Base Configuration via Web Interface” document under the “User Manuals” section under “Client Links”

9 – SPATIAL EXPLORER



System Monitor

The **System Monitor** window displays various system parameters relating to the rover and sensors. The types of parameters monitored are **Pose** (latitude/longitude, roll/pitch/yaw, etc.), **GNSS/INS** (PosStatus, UncertaintyP, CorrAge, etc.), and **Statistics** (Packets, Points, Photos).

System Monitor			
Pose			
Lat	34.1288415	Vel H	6.8 m/s
Lon	-117.9661640	Vel V	0.0 m/s
E	-0.862 m	Roll	3.05°
N	50.886 m	Pitch	-3.84°
U	80.772 m	Yaw	39.68°
NavigationSystem (unknown)			
PosStatus		Computed	
PosType		IntegerNarrowLane	
INS		SolutionGood	
Time		FineSteering	
UncertP	0.0001	Satellites	14 / 14
UncertA	0.0004	DOP H/V	1.0 / 1.0
CorrAge	0.0	Temp	0 / 0°C
		SolAge GNSS	0
CPU Load	0%	SolAge RTK	0
Statistics			
Data LiDAR			926.941Mi
Packets Nav OK/ERR			175.59K / 0
Photos captured			11



Sensor Controller - Real Time

The **Sensor Controller** window allows you to configure the available cameras and sensors. When connected in real-time to the rover, this window will allow you to trigger the sensors ON/OFF during your scan.



SpatialExplorer Real-time LiDAR Sensor Options

- OFF** Deactivates the LiDAR sensor.
- SLT** Activates the LiDAR sensor, but does not display the point cloud in the main viewing window.
- ACT** Activates the LiDAR sensor and displays the point cloud in the main viewing window.

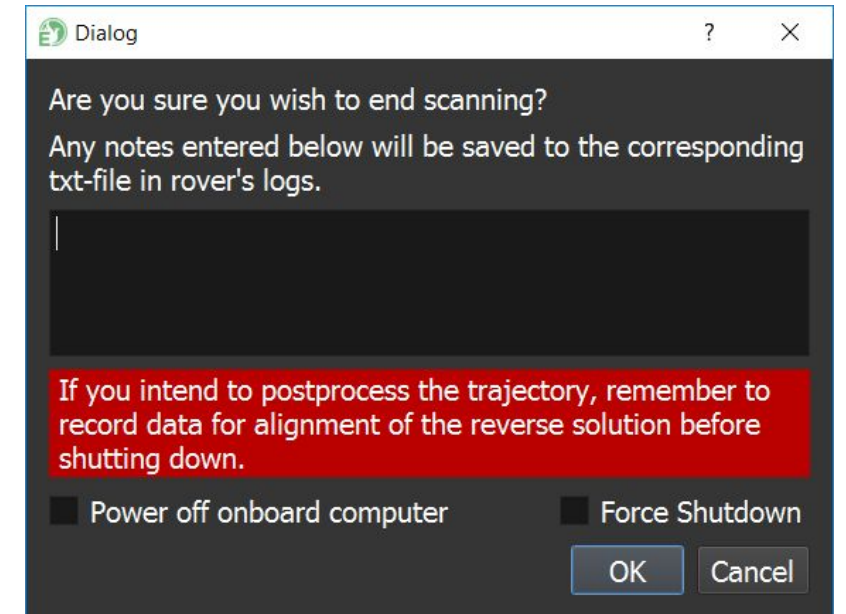
SpatialExplorer Real-time Camera Sensor Options

- OFF** Deactivates the camera sensor.
- SLT** Activates the camera sensor, but does not display the photo preview frustum in the main viewing window.
- ACT** Activates the camera sensor and displays the photo preview frustum in the main viewing window.



Commands

- **Shutdown Rover:** this command will end the connection between the rover and SpatialExplorer.
- There is a designated text box that will allow the user to enter any notes; the notes will be saved as a text file in the rover's log directory.
- To *shutdown* rover, you must check the box labeled **"Power off onboard computer."** Otherwise, if left unchecked, it will *reboot* rover.





Satellites

The Satellites window provides a list of the visible global navigational satellite systems connected to the rover's GNSS receiver. It displays several parameters such as space vehicle name, name of signal, signal strength, and locktime.

SV	Name of GNSS satellite. Acronym stands for Space Vehicle.
Signal	Name of the GNSS carrier band.
RSSI	Measurement of the power present in a received radio signal. Measured in dBHz.
LockTime	The amount of time since the satellite last obtained signal and navigation data. Max amount of time is 131s. Lower value indicates the satellite is constantly losing signal.

Satellites			
SV	Signal	RSSI	LockTime
▼ Gps-32			
	GpsL1CA	49 dBHz	131 s
	GpsL2Y	40 dBHz	131 s
▼ Gps-27			
	GpsL1CA	40 dBHz	131 s
	GpsL2Y	34 dBHz	131 s
▼ Gps-24			
	GpsL1CA	45 dBHz	131 s
	GpsL2Y	36 dBHz	131 s
▼ Gps-21			
	GpsL1CA	49 dBHz	131 s
	GpsL2Y	39 dBHz	131 s
▼ Gps-20			
	GpsL1CA	42 dBHz	110 s
	GpsL2Y	27 dBHz	109 s
▼ Gps-18			
	GpsL1CA	48 dBHz	131 s
9 GPS 7 GLO 0 GAL			



Rover Settings: General

- There are multiple rover parameters that can be configured via SpatialExplorer. These settings are only visible when connected to the rover in real-time. They are accessible by navigating to Settings -> Rover in SpatialExplorer.
- In most cases, users should not alter any of the parameters in the General section unless instructed to do so by Phoenix LiDAR Systems.



Rover Settings: General

Rover Settings

General
Navigation System
Network
LDR 0: Riegl miniVUX-1
CAM 0: MicroController

License
License Key: [Redacted]

AutoStart /AutoScan
System startup: Off (Rover starts once SpatialExplorer connects.)
Recording Camera / LiDAR data: Manual (Recording sensor data is controlled manually through SpatialExplorer.)
Minimum velocity to be "moving": 4.0 m/s horizontal or 1.0 m/s vertical

Devices
Temp Sensor / MicroController: /sys/class/hwmon/hwmon1/temp1_input /dev/serial/by-id/usb-FTDI_Quad_RS232-HS-if02-port0:9600

I/O Port 0
Port: /dev/serial/by-id/usb-FTDI_Quad_RS232-HS-if01-port0:115200
Mode Receive / Transmit: DifferentialCorrections Inactive
Received Differential Corrections: RTCM 3.0 [Configure Satel modem on this port...]

I/O Port 1
Port: [Redacted]
Mode Receive / Transmit: DifferentialCorrections Inactive
Received Differential Corrections: NovAtelXObs [Configure Satel modem on this port...]

Sensors
Add Sensor...
Remove Sensor...

Profiles
Profile Management...

Data Streaming
Minimum LiDAR Point Distance: 0.14 m

Show Help Load Settings Save Settings Save Settings & Close



Rover Settings: Navigation System

- There are various navigation system parameters located within this tab.
- Most important is the "IMU" and "Orientations & Offsets" section which includes the Vehicle/Body rotation and IMU to GNSS antenna offsets.
- Do not change these parameters unless instructed. They will be preset based on your system configuration and saved to a corresponding rover profile.



Rover Settings: Navigation System

Rover Settings

Navigation System

General

Network

LDR 0: Riegl VUX-240

CAM 0: PhaseOne IXM-100

Sensors

Profiles

vux240drive

Configuration

System Type

NovAtel OEM7

Antenna-Type

NOV702GG

Dynamics Profile

Default

Initialization on startup

☒ Initialize Configuration

50 Hz position and orientation

☒ Dual Antenna Setup

☐ Restrict Alignment to Dual Antenna

Connections

Port Main 0

Leave empty for autodetection, or specify serial/network ports to be used, e.g. /dev/ttyUSB0:9600 or 192.168...

Port Main 1

Leave empty for autodetection, or specify serial/network ports to be used, e.g. /dev/ttyUSB0:9600 or 192.168...

Port Attitude 0

Specify serial/network ports to be used, e.g. /dev/ttyUSB0:9600 or 192.168.1.2:3001

IMU

IMU Orientation (ZXY order)

-180.000 ° X

0.000 ° Y

90.000 ° Z

Configure...

Type

IMU-52

Orientation & Offsets

Offset IMU to Antenna 1

-0.265 m X

-0.001 m Y

-0.331 m Z

Uncertainty

0.02 m X

0.02 m Y

0.02 m Z

Offset IMU to Antenna 2

0.000 m X

0.000 m Y

0.000 m Z

Uncertainty

0.02 m X

0.02 m Y

0.02 m Z

Show Help

Load Settings

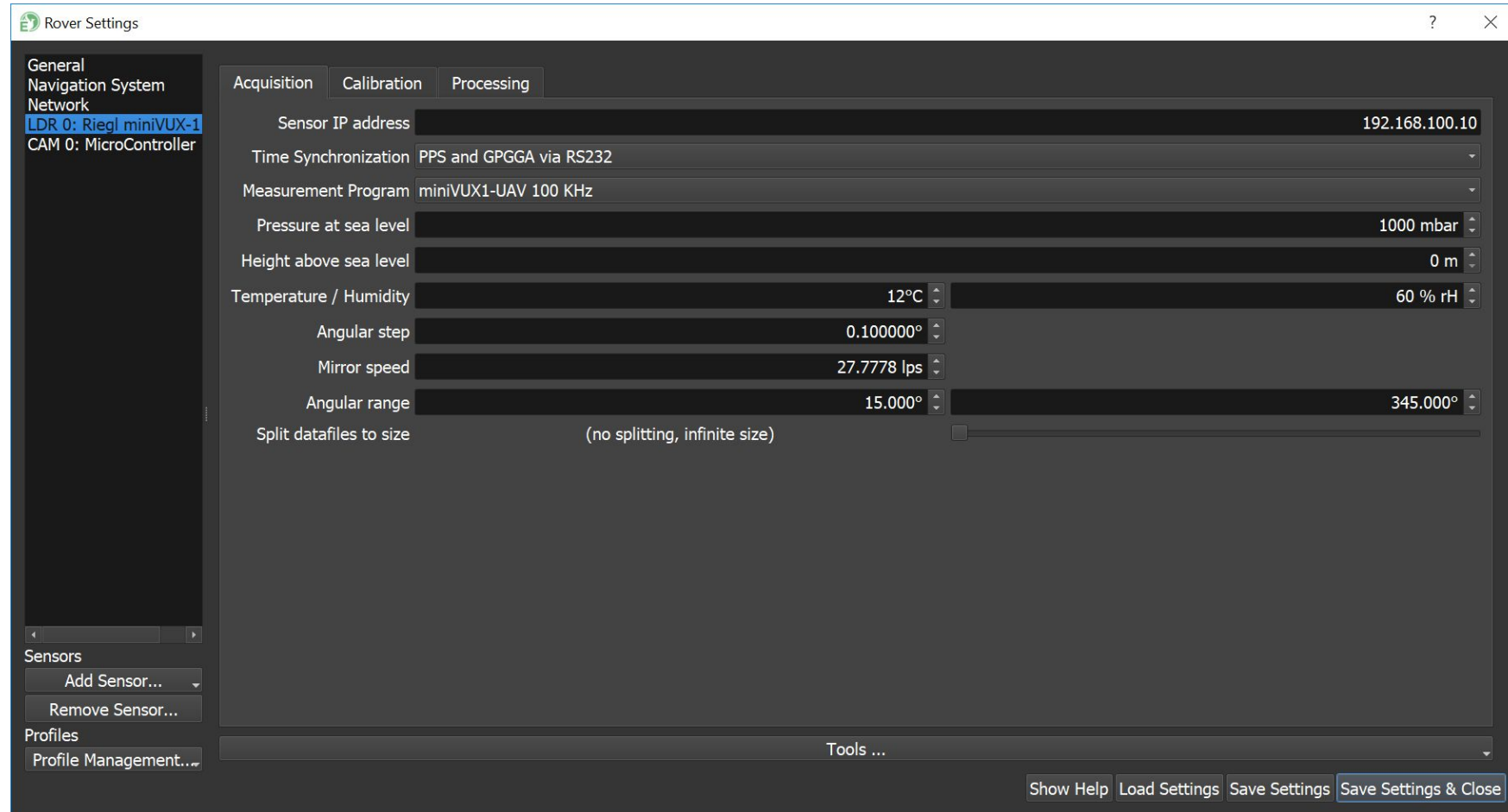
Save Settings

Save Settings & Close



Rover Settings: LDRX - Acquisition

- Ability to select Measurement Program PRR, Mirror Speed, Angular Range (RIEGL)
- Ability to set RPM (VELODYNE)





Rover Settings: LDRX - Calibration

- Calibration values for the LiDAR sensor are entered here along with the IMU to Sensor rotation and translation values

Rover Settings

General
Navigation System
Network
LDR 0: Riegl miniVUX-1
CAM 0: MicroController

Sensors
Add Sensor...
Remove Sensor...

Profiles
Profile Management...

Acquisition Calibration Processing

Transform IMU to Sensor

Translation -0.046m X vehicle-right -0.051m Y vehicle-up 0.083m Z vehicle-backwards

Rotation (extrinsic ZXY order) 180.0000° X vehicle-right 0.0000° Y vehicle-up -180.0000° Z vehicle-backwards

Adjust Sensor P/Y/R

Corrections (in sensor-frame)

	Translation X/right	Translation Y/up	Translation Z/rear	Rotation X/pitch	Rotation Y/yaw	Rotation Z/roll	Rotation	RangeScale	RangeOffset
1	0.000 m	0.000 m	0.000 m	0.0000 °	0.0000 °	0.0000 °	0.00°	1.00000	0.000 m

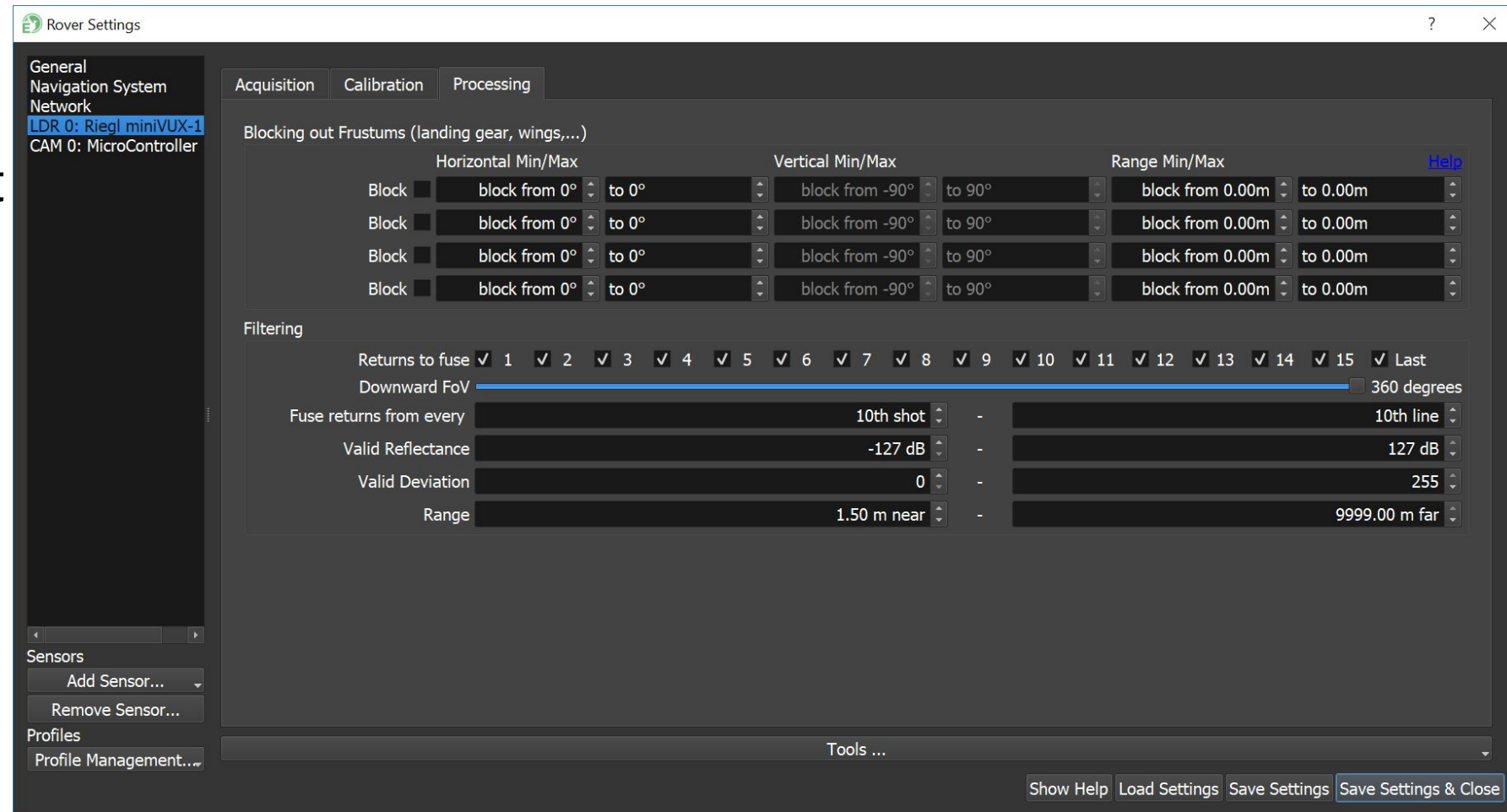
Tools ...

Show Help Load Settings Save Settings Save Settings & Close



Rover Settings: LDRX - Processing

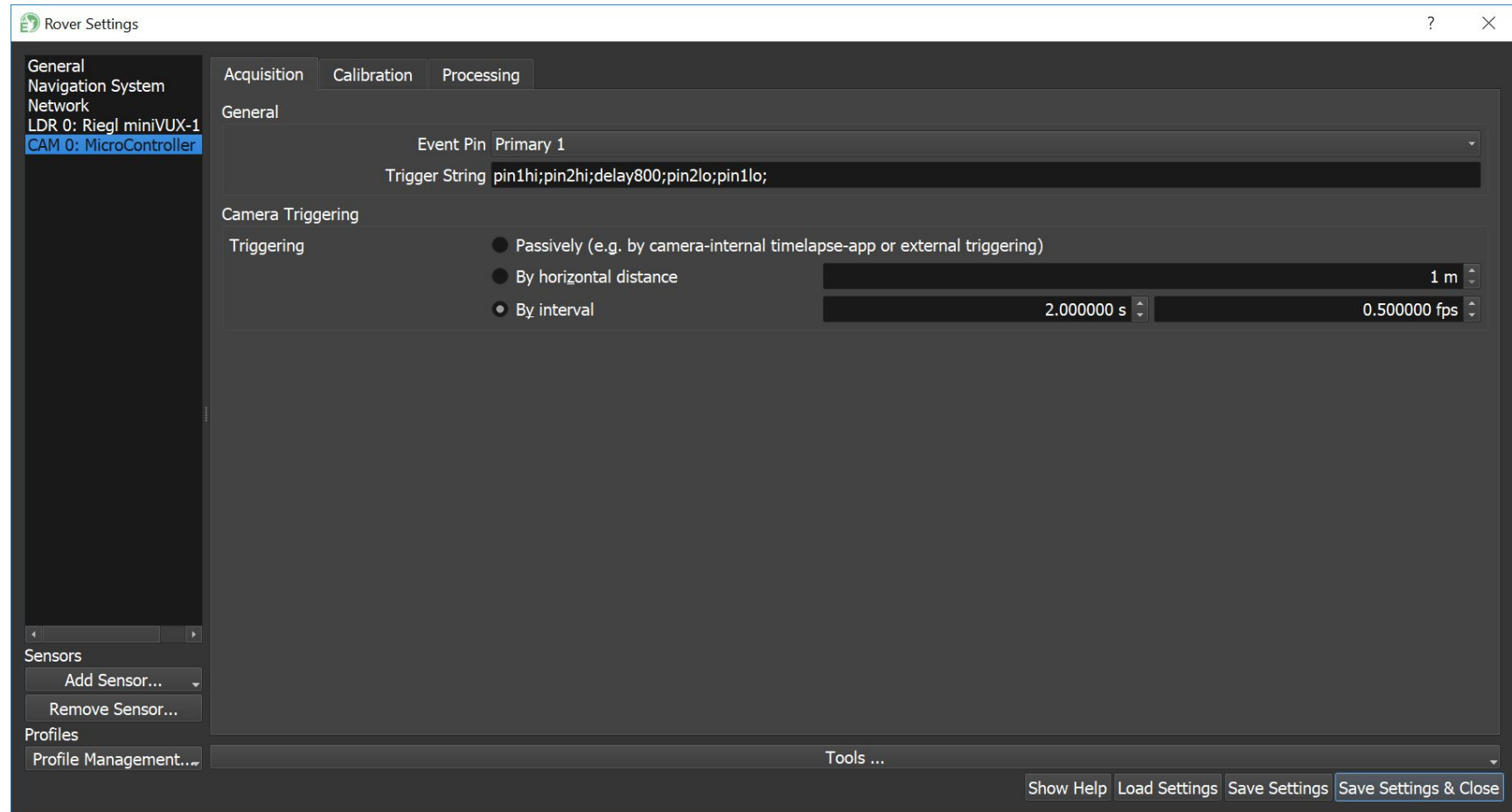
- These filtering settings are only cosmetic adjustments to the point cloud that you view in real-time during acquisition
- Does not affect the points records for post processing





Rover Settings: CAMX - Acquisition

- Ability to adjust how the camera is triggered (by distance, by time)





Rover Settings: CAMX - Calibration

- Calibration values for the Camera sensor are entered here along with the IMU to Sensor rotation and translation values

The screenshot shows the 'Rover Settings' application window with the 'Calibration' tab selected. The left sidebar lists various settings categories: General, Navigation System, Network, LDR 0: Riegl miniVUX-1, and CAM 0: MicroController (which is currently selected). Below these are sections for Sensors (Add/Remove Sensor...), Profiles (Profile Management...), and Tools ...

The main content area is divided into three sections:

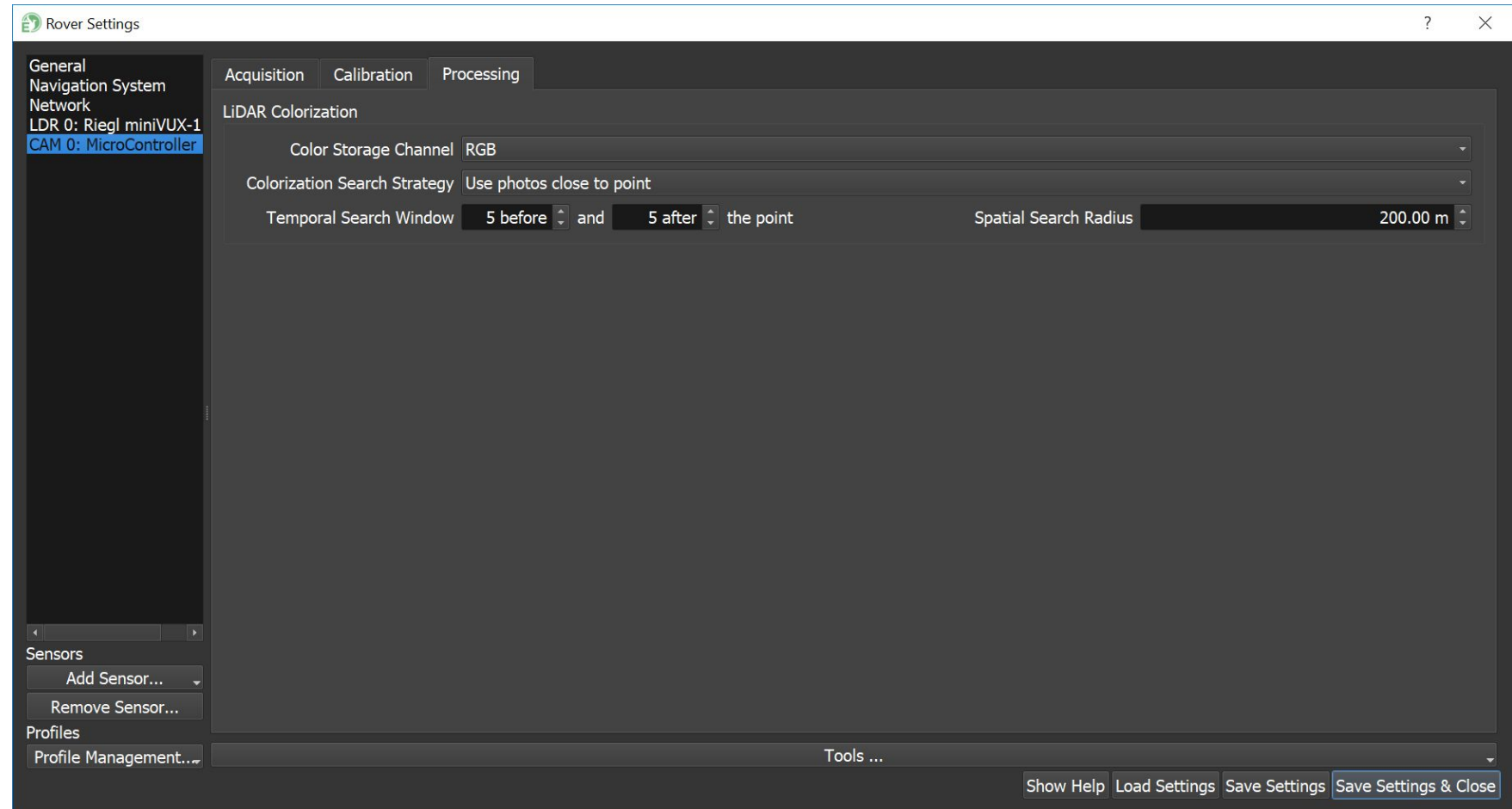
- Transform from IMU to Sensor:** This section contains three input fields for Translation (X, Y, Z) and three for Rotation (X, Y, Z). The values are: Translation X: -0.040m, Y: -0.058m, Z: -0.141m; Rotation X: -90.00°, Y: 0.00°, Z: 0.00°. Below these are three sliders for Adjust Sensor P/Y/R.
- Transform from Sensor to each Receptor (in sensor-frame):** This section contains a table with columns for Translation X/right, Translation Y/up, Translation Z/rear, Rotation X/pitch, Rotation Y/yaw, and Rotation Z/roll. The values for receptor 1 are all 0.000.
- Intrinsics of each Receptor:** This section contains a table with columns for Width, Height, PixelCount (w/h), Principal Point (x/y), and Focal Length. The values for receptor 1 are: Width: 35.900mm, Height: 24.000mm, PixelCount: 7952 w / 5304 h, Principal Point: 3976.00 x / 2652.00 y, Focal Length: 21.00 mm.
- Lens Distortion for each Receptor:** This section contains a table with columns for k1, k2, k3, p1, and p2. The values for receptor 1 are all 0.00000.

At the bottom right, there are buttons for Show Help, Load Settings, Save Settings, and Save Settings & Close.



Rover Settings: CAMX - Processing

- Ability to select the colorization method for real-time RGB colorization



10 – FIELD SCANNING

Field Scanning – Reference Station Setup

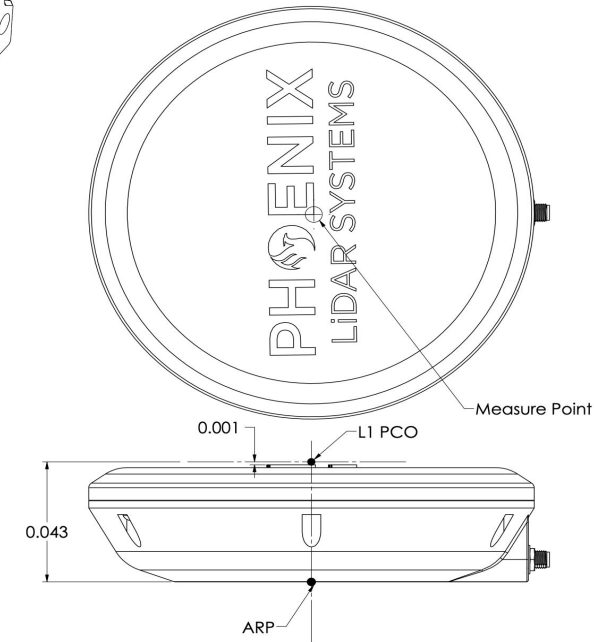
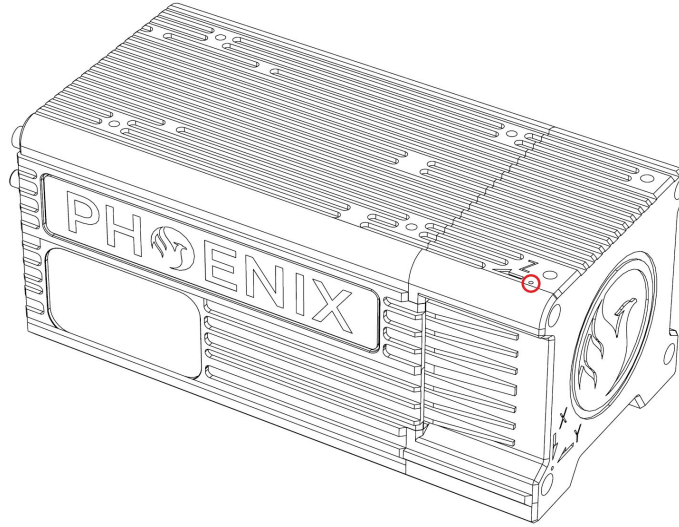
- The first thing you want to set up in the field is your GNSS reference station. Make sure it is setup in a location with a clear view of the sky, away from buildings and powerlines.
- Provide power to your GNSS reference station.
- Set the GNSS reference station to log raw observations at interval of 1 Hz (once per second).
- Make sure to document the Antenna Reference Point (ARP) height above the ground.

Field Scanning – IMU to GNSS Antenna Offset

- It's important to ensure that your IMU to GNSS antenna offset measurements are within an appropriate range before initiating a mapping mission.
- If these measurements are not within an acceptable range, it will cause a mismatch between uncertainty values (position and attitude), which will make it difficult to obtain a proper IMU alignment solution.
- Before powering on rover, we recommend verifying the IMU to GNSS antenna offset measurements.

Field Scanning – IMU to GNSS Antenna Offset

- Locate the GNSS antenna L1 Phase center and the IMU center of navigation. The location of the antenna L1 phase center can be found in the antenna's datasheet, while the IMU center of navigation is displayed on the IMU/enclosure label.
- Measure the distance from the IMU center of navigation to the GNSS antenna L1 phase center along each axis of the IMU and record the measurements.



Field Scanning – IMU to GNSS Antenna Offset

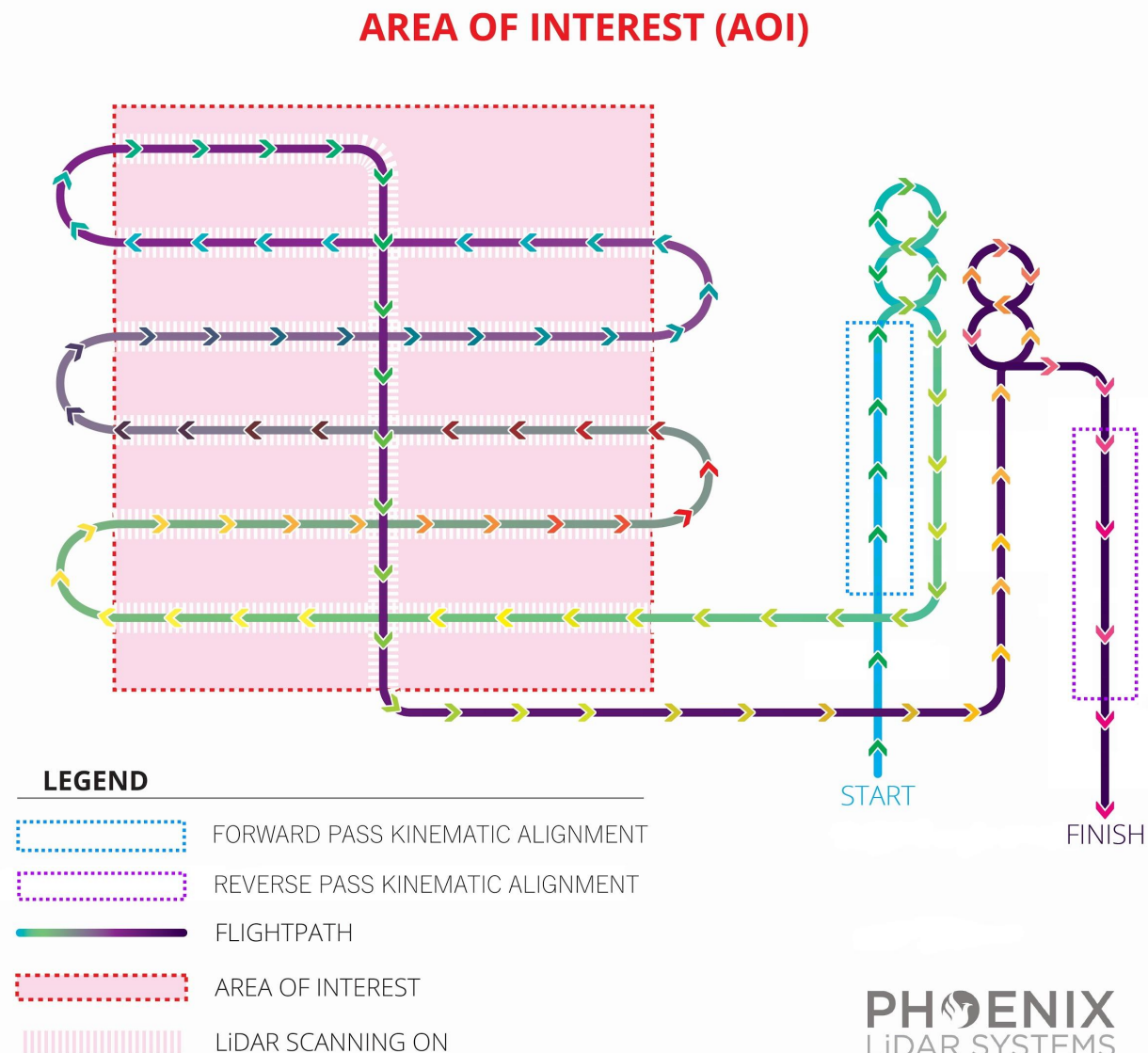
- To compare your measurements with the entered values in rover you need to power on rover and connect through SpatialExplorer; open the *Orientation & Offsets* settings in SpatialExplorer located in *Settings* → *Rover* → *Navigation System*.
- There is an uncertainty value that determines the standard deviation of each measurement.
- Therefore, your measurements are considered estimates but should be as accurate as possible.
- Always verify your measurements before updating them in SpatialExplorer. Make sure to restart rover if you update the IMU to GNSS antenna offset values.

Field Scanning

- Place UAV at the takeoff site and remove cap from the sensor
- Provide power to the system
- Power on the system. The CPU will turn on automatically when power is supplied to the MR30 input connector. In a rare case where the CPU button does not light up after power has been supplied, the CPU can manually be turned on using the CPU button.
- Launch SpatialExplorer and connect to rover through the desired method (Section 7)

Field Scanning – Outline

1. Static Alignment (if applicable)
2. Forward Pass Kinematic Alignment
3. Figure-8's
4. Scan AOI
5. Figure-8's
6. Reverse Pass Kinematic Alignment
7. Static Alignment (if applicable)



Field Scanning – Static/Kinematic Alignment

- First, ensure that your rover is mounted correctly and set to the correct profile if you have multiple (aerial, ground 30 deg mount, etc.) before the mission begins.
- Before initiating a LiDAR mapping mission, you must align your IMU (Inertial Measurement Unit).
- This is an EXTREMELY important procedure and CANNOT be skipped.
- The type of alignment technique you must perform will depend on the type of IMU included with your system.

Field Scanning – Static/Kinematic Alignment

- Leave the system powered on and idle/stationary at its departure site for a period of about 5-10 minutes.
- If your system is capable of static alignment, the system will determine its heading and the navigation system status (INS) in SpatialExplorer will switch from ***Aligning*** to ***AlignmentComplete*** during this time.
- If you have a **Scout Series NavBox**: LONG press the SENSOR button on the system to power on the LiDAR sensor. If the system includes a Velodyne LiDAR sensor, it must warm up for a period of 5-10 mins.

Field Scanning – Static/Kinematic Alignment

- To perform a kinematic alignment maneuver, you must travel forward for a period of at least 10 seconds, at a minimum velocity of 5 m/s (18 km/h), moving as straight and as level as possible with an unobstructed clear line of sight.
- During kinematic alignment, the navigation system status (INS) will read ***Aligning*** until movement is detected.
- You will notice the navigation system status (INS) in Spatial Explorer switch to ***AlignmentComplete*** indicating that the heading has been determined with sufficient certainty.

Field Scanning – Figure Eights

- In order to achieve an INS status of ***SolutionGood***, you must conduct one to two sets of figure-eights, either manually or using waypoint mode to stabilize the navigation system.
- This allows the software to process the current IMU drift and noise.
- We recommend flying a figure eight pattern because it helps lower the covariances (Uncertainty Position and Uncertainty Attitude), which are estimated errors of position and attitude.

Field Scanning – Activate/Deactivate Sensors

- After achieving an INS status of ***SolutionGood*** and lower covariance values, you can activate the sensors (camera, LiDAR, etc.) within SpatialExplorer and begin scanning your flight.
- We highly recommend flying straight to obtain smooth scan lines throughout the scan area.
- Furthermore, avoid sharp turns and extreme elevation changes, and turn outside the perimeter of your scan area.
- Using autopilot will result in the best scan results.
- Always make sure to maintain forward motion, minimizing hovering or crabbing of the vehicle during flight and before landing.
- Once you've finished scanning your flight, deactivate the sensors from within SpatialExplorer.

Field Scanning – Mirror Beginning and End Procedures

- Before landing, if you intend to post-process the trajectory for increased accuracy, you must conduct another one to two sets of **figure eights** then travel forward for a period of around 10 seconds, at a minimum velocity of 5 m/s (18 km/h), moving as straight and as level as possible with an unobstructed clear line of sight (**kinematic alignment**)

Field Scanning – Mirror Beginning and End Procedures

- Land the UAV
- Before shutting down a multilaser sensor (Velodyne), you must turn the LiDAR sensor OFF (LONG press the sensor button on NavBox).
- Leave the rover static for a period of about **5-10 minutes** to allow the IMU to obtain a reliable static alignment.
- Proceed to shut down the rover using the “Shutdown Rover” radio button in SpatialExplorer.
- Alternatively, you can use the CPU button on the system.

Field Scanning – Mirror Beginning and End Procedures

- We recommend mirroring the same procedures during the beginning and end of a scan to help increase the accuracy of your processed trajectory in NovAtel Inertial Explorer.
- During trajectory post-processing, NovAtel Inertial Explorer calculates the best trajectory solution by processing the data in various directions: forward, reverse, or both.
- When the software's algorithm processes both directions, it helps to have similar procedures at beginning and end of scan to obtain the best solution.

11 – DOWNLOAD DATA

Download Rover Data - Micro SD Card (AIR NavBox)

- For systems with the AIR NavBox, all data is stored on the removable on-board micro SD card, which can be removed from the NavBox to access the data
- It is also possible to pull data from the rover using an ethernet connection, which is described next

Download Rover Data - Ethernet (Scout Series NavBox)

- To download data you must access the rover's **\logs** directory.
- Connect an ethernet cable from rover's ethernet port to your computer.
- Wait approximately 3 minutes, and connect to **\\192.168.200.10\logs** with the username "**phoenix**" (no quotes) and password "**aeriallidar**" (no quotes).
- Alternatively, if you have configured the *hosts* file as instructed, you can connect to **\\rover-wire\logs**.
- Same username and password.

Download Rover Data - Ethernet (Scout Series NavBox)

- Once you've accessed the **\logs** directory, locate the folder containing your desired data.
- Folders are named with the following naming scheme: YEARMONTHDAY-UTCTIME (e.g. 20170802-210846).
- You may find numerous folders inside the **\logs** directory. Every time rover is powered on it creates a folder named with a corresponding timestamp.
- To locate the correct folder/s, we recommend sorting the **\logs** directory by descending *date modified* and searching for the most recent folders containing LiDAR files (.ldr or .rxp).
- Once you've located the folders with the desired data, copy (DO NOT move) the data to a location of your choice on your computer.
- We recommend creating a folder on your desktop to temporarily store the data.

Download Rover Data

- Once the data has been copied, you can close the **\logs** directory window.
- Access the copied data on your desktop and create a new folder named **rover** inside the folder containing the data.
- Move the contents of the folder inside the newly created **rover** folder. This will allow you to organize all your original rover data in one place.
- Repeat this procedure for any remaining data sets you copied from the **\logs** directory.

Download Reference Station Data

- To download data from the Stonex S900, power on the S900 and connect the USB cable located on the end of the LEMO power/data cable to your computer.
- The S900 will act as an external hard drive and should pop up in Windows. Locate the folder containing your desired data.
- Access the folder and copy the corresponding file containing the raw observations in .DAT format.
- You will need to convert the DAT file to RINEX in order to post process your static data.

Download DSLR Images (if applicable)

- When using RAW images taken with a DSLR, you must manually download them from the DSLR's SD card onto your computer and convert them to JPG, TIF, or PNG before SpatialExplorer can use them.
- Raw images from Basler cameras are automatically decoded.
- You must place the converted DSLR JPG images in the **camX/** folder (usually CAM0 if you only have one camera) found within the **rover** folder that you created when downloading rover data.
- This will ensure that SpatialExplorer is able to properly load the images.

12 – INSPECT DATA



SpatialExplorer - Work Offline

- SpatialExplorer can be launched in **Work Offline** mode to process data. While in offline mode, you will be able to:
 - Load your .plp which references the trajectory, LiDAR, and Camera data
 - Open a post processed trajectory and create intervals
 - Create a pointcloud and playback data
 - Export a LAS/LAZ

