



LiDAR Mapping Systems

Acquisition Training

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TABLE OF CONTENTS

Legal Notices	4
Disclaimer	4
1. Introduction	5
1.1 Training Goals	5
2. Basics of LiDAR	5
2.1 Factors Affecting Accuracy	6
3. Software Overview	6
3.1 SpatialSuite	6
3.1.1 SpatialLightHouse	6
3.1.2 SpatialExplorer	6
4. System Hardware Overview	7
4.1 Rover	7
4.1.1 Ports and User Elements	7
4.2 IMU (Inertial Measurement Unit)	7
4.3 GNSS (Global Navigation Satellite System) Receiver	7
4.4 Rover Mounting Options	7
5. Network Configuration	8
5.1 Rover Static IP Addresses	8
5.1.1 Ethernet	8
5.1.2 Wireless	8
5.2 Wired Ethernet Network Card	8
6. User Laptop Configuration	8
6.1 Install Latest NVIDIA Drivers	8
6.2 Install SpatialSuite Software	9
6.3 Modify Hosts File	9
6.4 Wired Ethernet Network Card Setup	9
7. Connect to Rover	10
7.1 Connect via Ethernet	10
7.2 Connect via Wi-Fi	10
7.2.1 Bullet Long Range Wi-Fi Module	10
7.3 Connect via Phoenix LiDAR Systems Connection Service	10
8. Reference Station	11
8.1 Hardware Overview	11
8.1.1 Stonex S900	11
8.2 Equipment Setup	11
8.3 Connection Methods	11
8.3.1 Stonex S900	11
8.3.2 Stonex S900 Downloads	12

9. SpatialExplorer	12
9.1 Acquisition - Real Time Connection	12
9.1.1 System Monitor	12
9.1.2 Sensor Controller	12
9.1.3 Commands	12
9.2 Rover Settings	13
9.2.1 General	13
9.2.2 Navigation System	13
9.2.3 LDRX	13
9.2.4 CAMX	13
10. Field Scanning	13
10.1 Reference Station Setup	13
10.1.1 Equipment Setup	13
10.2 Proper Scanning Procedure	14
10.2.1 IMU to GNSS Antenna Offsets	14
10.2.2 Static/Kinematic Alignment	14
10.2.3 Figure Eights	14
10.2.4 Activate/Deactivate Sensors	15
10.2.5 Mirror Beginning and End Procedures	15
11. Download Data	15
11.1 Rover Data	15
11.2 GNSS Reference Station Data	16
11.3 DSLR Images (optional)	16
12. Inspect Data	16
13.1 Load PLP	16
13.2 Playback Data	17

Legal Notices

All the features, functionality, and other product specifications are subject to change without prior notice or obligation. Information contained herein is subject to change without notice.

Please read carefully and visit our website, www.phoenixlidar.com for further information and contact support@phoenixlidar.com for any technical support questions.

NOTE: This document provides an overview of the basics of LiDAR acquisition with the base LiDAR mapping scanning system and relevant components. The product you purchased may not support certain functions dedicated to specific models, upgrades or customizations.

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1. Introduction

Thank you for choosing Phoenix LiDAR Systems! This document provides a brief overview and instruction of our LiDAR acquisition training for our LiDAR mapping systems. It briefly addresses the working principles of the underlying components, explains the system architecture, as well as offers a quick tutorial of the required software. If you would like a complete overview, please refer to the *Phoenix LiDAR Systems Comprehensive User Manual* which can be found on our homepage, www.phoenixlidar.com. This document is not intended to replace customer training; instead it should be used as an outline for LiDAR acquisition training.

Phoenix LiDAR Systems builds compact, multi-vehicle compatible, survey-grade laser mapping & photogrammetry solutions. Phoenix LiDAR products can service a range of applications such as capturing topography in open pit mining areas, power line, and railway track and pipeline inspection. Additionally, our mapping systems are equipped for terrain and canyon mapping, construction site monitoring, corridor mapping, agriculture and forestry, flood zone mapping, landslide survey and mapping, earthquake disaster mapping and much more.

1.1 Training Goals

The main goal of LiDAR acquisition training is to provide an overview of the use of our LiDAR mapping systems. We will address and explain the working principles of the underlying components, the system architecture, and the required software. Phoenix LiDAR Systems mapping solutions contain multiple hardware sensors that once integrated and controlled by software allow the user to create accurate, high-resolution maps of outdoor environments. Even though the accompanying software suite makes LiDAR scanning a straightforward task, the user must still understand the basic working principles of the system in order to obtain accurate data and produce quality results.

2. Basics of LiDAR

LiDAR stands for Light Detection and Ranging, and is a remote sensing method that 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.

LiDAR sensors are active sensors meaning they provide their own source of energy to illuminate the objects they observe. LiDAR sensors emit radiation in the direction of the target to be investigated and the sensor then detects and measures the radiation that is reflected or backscattered from the target.

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

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

2.1 Factors Affecting Accuracy

The following factors affect the overall accuracy of the final LiDAR data product:

Laser Data Quality - Precision, Resolution, FOV, Acquisition Parameters

Sensor Calibration - Boresight and internal calibration

Navigation solution - GNSS (Baseline length, PDOP, etc) and IMU (Drift)

Survey Control - Reference System and Distribution of control

Operational Best Practices - Acquisition and Processing procedures

Software Workflow - Software, Flightline Matching, Feature extraction

3. Software Overview

3.1 SpatialSuite

Phoenix LiDAR Systems provides a proprietary software suite for streamlined acquisition, geo-referencing, data fusion, and data export. The software suite comprises SpatialLightHouse and SpatialExplorer. 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 SpatialExplorer sessions
- Create accurate, accurate, georeferenced, colorized point clouds from real-time or post processed trajectories
- Exporting point clouds to more than 4000 coordinate systems

Software versions 5.0.X and above are only provided directly from Phoenix LiDAR Systems. Contact support@phoenixlidar.com if you need a specific version.

3.1.1 SpatialLightHouse

SpatialLightHouse allows forwarding differential corrections (satellite errors derived from raw observations) obtained from an NTRIP/CORS networked GNSS reference station to rover. Internet connectivity is required for both the computer running SpatialLightHouse and for the rover. An alternative to RTK (Real Time Kinematic) is PPK (Post Processed Kinematic) trajectory processing which is the industry standard and what we recommend.

3.1.2 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. SpatialExplorer enables in-field quality control and analysis and ensures obtaining a quality solution throughout the acquisition process. It is an exceptional tool for training with how-to-fly visualizations. Furthermore, it allows for the creation of high quality marketing imagery of acquired scans.

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 also cuts down the wait time on extensive photogrammetry applications by creating colorized point clouds in about twice the time of the acquisition. Furthermore, it supports multiple remote sensing equipment configurations.

4. System Hardware Overview

4.1 Rover

The rover's hardware is pre-configured during manufacturing to facilitate the setup procedure for the end user and is comprised of the following major components: Navigation Box (NavBox), IMU (Inertial Measurement Unit), LiDAR sensor, Camera(s) (optional), and Accessories (cables and antennas).

4.1.1 Ports and User Elements

The rover's NavBox has an interface panel that is designed to easily connect system components and external devices. The panel includes Wi-Fi antenna terminal/s, Ethernet port, GPS antenna port/s, CPU power button, Sensor power button (if applicable), LiDAR/IMU port, Status LED indicators, DC power input port, External Input/Output data port. Other panels of the NavBox may include exhaust vents, Mini HDMI port, USB 3.0 ports, micro SD Card Slot.

Depending on the system, you may have a Scout Series NavBox or the AIR NavBox. If you would like a complete overview, please refer to the Hardware section of the *Phoenix LiDAR Systems Comprehensive User Manual* for detailed descriptions and diagrams of the ports and user elements of your specific NavBox.

4.2 IMU (Inertial Measurement Unit)

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). This sensor is used to continuously measure the system's attitude or orientation (roll, pitch, and yaw) of the system.

4.3 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.

4.4 Rover Mounting Options

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

5. Network Configuration

5.1 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.

5.1.1 Ethernet

The rover's IP address on the primary ethernet interface is **192.168.200.10** or **rover-wire** (requires properly configured Windows .hosts file). Be aware that the rover will NOT act as a DHCP server and assign IP addresses to connected computers. Instead, the connected computer must have a valid IP address in the 192.168.200.* range configured.

5.1.2 Wireless

Rover has an integrated wireless networking card that allows it to serve as a wireless access point. The rover's IP address on the primary wireless interface is **192.168.20.10** or **rover-wifi** (requires properly configured Windows .hosts file). In contrast to the ethernet interface, rover will act as a DHCP server and it will assign an IP address to connected computers.

5.2 Wired Ethernet Network Card

All Phoenix LiDAR Systems rovers are pre-configured with static IP addresses that can be reached via an ethernet or a Wi-Fi connection. To avoid typing in the IP addresses, field 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.

Additionally, 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 a connection timeout period.

6. User Laptop Configuration

If you did not purchase a base station preconfigured by Phoenix LiDAR Systems, you will need to configure your own computer to ensure it properly works with our LiDAR mapping systems. You may skip to section 7 if you purchased a preconfigured laptop from Phoenix LiDAR Systems.

6.1 Install Latest NVIDIA Drivers

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

6.2 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. Prior to installation, make sure you have the latest NVIDIA graphics card drivers installed. 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.

6.3 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.

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.

6.4 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.

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."

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.

7. Connect to Rover

SpatialExplorer can be launched to connect to a Phoenix LiDAR Systems rover as a UDP client, via a 900 MHz radio, or using our Connection Service. All three of these configurations will allow you to view your georeferenced point-cloud data and configure sensors in real-time while scanning.

7.1 Connect via Ethernet

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.

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**.

7.2 Connect via 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**.

7.2.1 Bullet Long Range Wi-Fi Module

To establish a strong wireless connection between your laptop and rover, you must use the Bullet Long Range Wi-Fi module. The Bullet 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.

To 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. When powering the Bullet Long Range Wi-Fi module, we recommend using a **4 cell Li-Po** battery.

7.3 Connect via Phoenix LiDAR Systems Connection Service

The Phoenix LiDAR Systems Connection service allows for communication between SpatialLightHouse/SpatialExplorer and rover via a remote online server. An internet connection is required on both the computer running SpatialLightHouse/SpatialExplorer and rover for this to function. Communication is established through an alphanumeric License Key that is uniquely assigned to each rover.

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

8.1 Hardware Overview

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. Post-Processed Kinematic (PPK) is an alternative technique to Real-Time Kinematic (RTK). 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.

8.1.1 Stonex S900

The Stonex S900 features a new, high accuracy multi constellation antenna, a powerful UHF transmitter and the GSM 4G modem, for a fully integrated communications choice, combined with a light and modern design. The integrated GNSS receiver tracks all the present constellations and satellite signals GPS, GLONASS, BEIDOU, GALILEO and QZSS and through the upgradable firmware offers the opportunity to be day by day updated with the latest available features.

- 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 12 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

8.2 Equipment Setup

We recommend mounting the GNSS reference station antenna with a clear view of the sky, away from buildings and powerlines.

★ When applying ground power to the S900 GNSS reference station, make sure to ONLY use a 4 cell Li-Po battery.

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.

8.3 Connection Methods

8.3.1 Stonex S900

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.

8.3.2 Stonex S900 Downloads

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. SpatialExplorer

9.1 Acquisition - Real Time Connection

9.1.1 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).

9.1.2 Sensor Controller

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	
<i>OFF</i>	Deactivates the LiDAR sensor.
<i>SLT</i>	Activates the LiDAR sensor, but does not display the point cloud in the main viewing window.
<i>ACT</i>	Activates the LiDAR sensor and displays the point cloud in the main viewing window.

SpatialExplorer Real time Camera Sensor Options	
<i>OFF</i>	Deactivates the camera sensor.
<i>SLT</i>	Activates the camera sensor, but does not display the photo preview frustum in the main viewing window.
<i>ACT</i>	Activates the camera sensor and displays the photo preview frustum in the main viewing window.

9.1.3 Commands

The Shutdown Rover 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 only reboot rover.

9.1.3 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.

9.2 Rover Settings

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.

9.2.1 General

The General settings window allows for configuring settings such as the device file of the temperature sensor as well as the modes for the I/O ports. In most cases, users should not alter any of the parameters in the General section unless instructed to do so by Phoenix LiDAR Systems.

9.2.2 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.

9.2.3 LDRX

In the Acquisition tab, the user has the ability to select the Measurement Program PRR, Mirror Speed, and Angular Range for RIEGL scanners, and the ability to set RPM for Velodyne scanners. In the Calibration tab, calibration values for the LiDAR sensor are entered here along with the IMU to Sensor rotation and translation values. In the Processing Tab, there are filtering settings which are only cosmetic adjustments to the real time point cloud viewed during acquisition.

9.2.3 CAMX

In the Acquisition tab, the user has the ability to adjust how the camera is triggered (by distance/time). In the Calibration tab, calibration values for the Camera sensor are entered here along with the IMU to Sensor rotation and translation values. In the Processing tab, the user has the ability to select the colorization method for real-time RGB colorization.

10. Field Scanning

10.1 Reference Station Setup

10.1.1 Equipment 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.

10.2 Proper Scanning Procedure

10.2.1 IMU to GNSS Antenna Offsets

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.

1. 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.
2. 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.

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.

10.2.2 Static/Kinematic Alignment

Launch SpatialExplorer and connect to the rover to monitor the system. 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.

Leave the system powered on and idle at its departure site for a period of about 5-10 minutes. 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. 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.

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.

10.2.3 Figure Eights

In order to achieve an INS status of **SolutionGood**, you must conduct two to three 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.

10.2.4 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. Data acquired during turns will be much less accurate. Furthermore, avoid sharp turns and extreme elevation changes, and turn only at 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.

10.2.5 Mirror Beginning and End Procedures

Before landing, if you intend to post-process the trajectory for increased accuracy, you must conduct another two to three sets of figure eights then 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.

If possible, end the mission from the same place it was initiated. 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. During this period, the IMU must be completely stationary. Next, proceed to shut down the rover using the "Shutdown Rover" radio button in SpatialExplorer. Alternatively, you can use the CPU button on the system. However, be aware that shutting down rover this way will result in a forced shutdown.

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

11.1 Rover Data

After you've finished scanning, you must download the data from rover to your computer/server.

Option 1:

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. Do **not** remove the microSD card when the system is on. The process described in detail below using an ethernet connection can also be used to pull data from the rover.

Option 2:

The rover's IP address on the primary ethernet interface is **192.168.200.10**. Be aware that the rover will NOT act as a DHCP server and assign IP addresses to connected computers. Instead, the connected computer must have a valid IP address in the 192.168.200.* range configured.

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. If you want to retrieve data from the rover, we recommend **NOT** using the rover's Wi-Fi connection due to the slow transfer rate.

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. Everytime 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.

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.

11.2 GNSS 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.

11.3 DSLR Images (optional)

When using RAW images taken with a DSLR, you must manually download them from the DSLR's SD card onto your computer 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

With rover, GNSS reference station, and image data downloaded onto your computer, we recommend you inspect the acquired data in SpatialExplorer. Launch SpatialExplorer in "Work Offline" mode. While in offline mode, you will be able to load and analyze your post-mission georeferenced point-cloud data.

12.1 Load PLP

SpatialExplorer requires that you load an initial Phoenix LiDAR Project (.plp) file in order to process data. After opening the .plp, SpatialExplorer will search the plp's root directory for other data files from LiDAR sensors and cameras and automatically add those files to the project.

12.2 Analyze Data

Once you've loaded your .plp file, you can then open any post-processed trajectories and create flightline intervals. Next, you can create a pointcloud or playback your data. Once you've finished processing your data, you can then export it as an LAS/LAZ.

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If you have any questions about this document, please contact Phoenix LiDAR Systems by sending a message to support@phoenixlidar.com.

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