ZEB-GO
User Guide

Notes

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GeoSLAM Ltd. equipment should not be used as a primary navigation device.

CLASS A COMPUTING DEVICE. 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. The equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the user guide, 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 their own expense.

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1. INTRODUCTION

The ZEB-GO portable laser scanner provides a rapid and simple means of capturing 3D point cloud data. Data is captured as the user walks through the area of interest. The ZEB-GO negates the need for time consuming scanner set-ups and data registration associated with traditional terrestrial laser scanning methods.

Provided the simple guidance set out in this document are adhered to accurate 3D point clouds can be generated in a fraction of the time taken with traditional terrestrial laser scanning methods.

1.1 SPECIFICATION

Maximum range	Up to 30m in optimal conditions Typical max range 15-20m
Points per scan line	1080 (0.25º interval)
Field of view	270º x 360º
Scan rate	40 lines/s 43,000 points/s
Scan range noise	±30mm
Laser safety classification	CLASS I Laser Product (21 CFR 1040.10 and 1040.11)
Laser wavelength	905nm
Operating conditions	Temperature 0º C to +50º C Humidity <85% RH
Power supply	12VDC ±10% approx. 1.5A
Weight	Scanning head 1.0kg Carry case and contents 4.1kg
Dimensions	Scanning head 80x113x140mm (287mm incl handle) Carry case and contents 470x220x180mm
Battery life	Approximately 2 (4Ah) – 4 (8Ah) hours continuous use

Table 1-1: Specification

1.2 PRINCIPAL OF OPERATION

The ZEB-GO consists of a 2D time-of-flight laser range scanner rigidly coupled to an inertial measurement unit (IMU) mounted on a motor drive. The motion of the scanning head on the motor drive provides the third dimension required to generate 3D information. A novel 3D simultaneous localization and mapping (SLAM) algorithm is used to combine the 2D laser scan data with the IMU data to generate accurate 3D point clouds.
The ZEB-GO captures raw laser range measurement and inertial data. This data must be processed using GeoSLAM's SLAM algorithm to convert the raw data into a 3D point cloud. The data is processed using the GeoSLAM Hub processing application.

1.3 LIST OF PARTS

Part no.	Description
1 GS_610227	ZEB-GO handheld laser scanner
2 GS_610048	ZEB-DL2600 data logger
3 GS_610008	ZEB-GO main cable
4 GS_610024	ZEB-DL2600 AUX to USB download cable
5 GS 310025, GS_SW_LICENSE	16 GB USB drive with GeoSLAM Hub licence
6 DEB_TR8136	12V Battery Charger and adapters
7 GS_610068	Backpack with Orange/Black foam insert
8 GS_610118	Reference Base Plate
9 GS_610260	Phone Holder

Table 1-2: List of parts

Figure 1-1

2. SAFETY

2.1 GENERAL SAFETY

The ZEB-GO Portable Mapping System should only be used by trained operators. Always follow basic safety precautions when operating the ZEB-GO Portable Mapping System to reduce the risk of personal injury and to prevent damage to the equipment. Do not operate the equipment with suspected defects or obvious mechanical damage. Please refer all servicing of the equipment to qualified service personnel. Only use the components and accessories supplied with your system or other accessories recommended by GeoSLAM Ltd. Before operating the system for the first time please read this guide in full.

The equipment contains sensitive electrical and mechanical parts and thus requires appropriate handling. Do not bend or pull the cables forcibly. Never push objects of any kind into the connectors or sockets. Keep the equipment out of the reach of children. Under no circumstances should any modifications be made to the ZEB-GO Portable Mapping System without prior written permission from GeoSLAM Ltd.

2.2 LASER SAFETY

The ZEB-GO incorporates a Hokuyo UTM-30LX laser scanner. The UTM-30LX-F is classified as a CLASS 1 Laser Product in accordance with IEC 60825-1: 2007 (2nd Edition) *Safety of laser products. Equipment classification and requirements.* Class 1 Laser Products are safe under reasonably foreseeable conditions of operation, including the use of optical instruments for intra-beam viewing.

2.3 ELECTROMAGNETIC COMPATABILITY

The ZEB-GO Portable Mapping System meets or exceeds the following standards:

EN61326-1:2013 Electrical equipment for measurement, control and laboratory use - EMC requirements - Industrial Location Immunity - (immunity section only)

EN61326-1:2013 Electrical equipment for measurement, control and laboratory use - EMC requirements - Group 1, Class A equipment - (emissions section only)

CFR 47 Code of Federal Regulations: Pt 15 Subpart B- Radio Frequency Devices - Class A Unintentional Radiators

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 user guide, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause interference.

2.4 BATTERY SAFETY

DO NOT attempt to dismantle the battery.

DO NOT short circuit the battery.

ONLY use the charger supplied with the system.

Excess heat will degrade the battery rapidly. Always store the battery in a cool dry place. DO NOT leave for long periods in the sun or in a hot vehicle.

The battery is splash proof but not waterproof – do not immerse in water.

2.5 SYSTEM DISPOSAL

When the ZEB-GO Portable Mapping System reaches the end of its life-cycle please dispose of the equipment in accordance with Directive 2002/96/EC on Waste Electrical and Electronic equipment (WEEE).

GeoSLAM Ltd is prepared to take back the waste equipment and accessories free of charge at the manufacturing unit in Ruddington, UK for proper treatment with the objectives of the WEEE.

2.6 INSTALLATION

The ZEB-GO can be used as a handheld device using the supplied removable handle or can be mounted to mobile platform using the supplied mounting plate (see Section 7.2).

2.7 FURTHER HELP AND INFORMATION

In the event of a problem that cannot be resolved using the information supplied, please contact GeoSLAM. You can also gain assistance through the support page on our website: https://geoslam.com/support/

For further assistance, contact the GeoSLAM Technical Support by telephone or email. Our Customer Support personnel will discuss your situation, determine the cause of problem and provide the appropriate technical assistance.

Contact GeoSLAM by any of the following methods:

- Phone: +44 (0) 1157 270740 (all countries)
- Phone: +1-833-444-7907 (US & Canada)
- Email: support@geoslam.com

3. DATA CAPTURE

This chapter describes how to connect the ZEB-GO hardware, how to collect raw scan data and how to download the raw scan data from the data logger.

3.1 CONNECTING THE HARDWARE

Attach the reference base plate to the bottom of the handle using the screw and hex key provided.

Connect the ZEB-GO main cable to the socket on the side of ZEB-GO scanner head. Use red dots to align correctly.

Connect the other end of the ZEB-GO cable to the ZEB (white) socket on the DL2600 data logger. Use red dots to align correctly.

DO NOT attempt to connect the ZEB-GO cable (12 pin) to the AUX socket (14 pin- with blue marker)

Connect the DL2600 battery connector to the external battery.

3.2 COLLECTING DATA

The process of collecting data using the ZEB-GO scanning system is highly automated. However, care must be taken to ensure that the collected data can be successfully processed into a 3D point cloud using GeoSLAM's unique SLAM algorithm. It is strongly recommended that the user conducts a survey plan, taking into account the recommendations set out in the Usage Guidelines in chapter 4, before commencing data collection.

When you are ready to start collecting data follow the steps in the table below:

		ZEB LED
Step 1	Position the ZEB-GO scanner on a flat stationary surface. Turn on the ZEB-DL2600 data logger by pressing the on/off button. The LED's on the data logger may flash briefly and then cycle green-orange-red whilst the data logger boots up and connects to the scanner.	
Step 2	Once booted the ZEB LED will switch to pulsing red– **Standby mode.**	
Step 3	To initiate a scan the user must manually rotate scanner head through 90 degrees or more. The ZEB LED will switch to constant red – **Preparing to scan mode**.	
Step 4	After approximately 3 seconds the LED on the scanner will switch to flashing orange – **Initialisation mode**. The scanner must remain stationary during initialisation. If the scanner is disturbed during initialisation the system will revert to Preparing to scan mode (step 3). The ZEB LED will revert to red and wait to start initializing again.	
Step 5	After the ZEB-GO scanner has been in initialisation mode for 15 seconds the LED will switch to green – **Scanning mode**. Press the motor start/stop button on the side of the scanner head to start the scanner rotation and commence the survey.	
Step 4	When the survey is complete position the ZEB-GO scanner in approximately the same position and orientation as used for initialisation (Step 2) and press the motor start/stop button to stop the scanner rotation. After the scanner has been stationary for approximately 5 seconds the LED will switch back to flashing orange - **De-initialisation mode.** If the scanner is disturbed during de-initialisation the ZEB LED will revert to green and wait to start de-initialising again	
Step 5	After the ZEB-GO scanner has been in de-initialisation mode for 15 seconds the LED will switch to pulsing red– **Standby mode.** When the ZEB-GO scanner enters standby mode the AUX LED will flash orange for a short period whilst the recorded data is compressed into a single data file ready for downloading. **! Do not turn the data logger off until the AUX LED is off**	

Step 6	To download the raw scan data, see section 0	
	To repeat the scan, or start a new scan, simply rotate the scanner head through 90 degrees. The LED will change to red, **preparing to scan mode** and the sequence will repeat from Step 3	
	To shut down the system, press and hold the data logger power button for 1 second. **! Do not turn the data logger off until the AUX LED is off** Disconnect the battery connector to prevent battery discharging whilst in storage.	

! The scanner must remain static during initialisation and de-initialisation

During data capture the data logger can either be carried in your spare hand or placed in the backpack carry case.

3.3 DOWNLOADING THE RAW SCAN DATA

To download the raw scan data, switch on the ZEB-DL2600 data logger or leave it running after a scan is complete and the data has compressed (Step 5 above). Connect the DL2600 download cable to the AUX socket (with blue socket marker) and connect the supplied USB memory stick to the download cable. The AUX LED light will light green whilst the data is transferring to the memory stick. The USB stick must not be removed when the AUX LED is lit green. After a few seconds (dependent on the size of the data files to be transferred) the AUX LED will turn off. All data that has not previously been transferred will be transferred and the USB memory stick can be removed.

! Do not remove the USB memory stick while the green AUX LED is lit

If there is a problem with the USB memory stick, for example there is insufficient capacity or the format is not recognised the AUX LED will flash red. The raw data will remain on the internal memory of the data logger. The following memory stick file formats are supported, exFAT, FAT16, FAT32 and NTFS.

Downloading data is an automatic process whereby only data that has not previously been downloaded will be transferred.

Please refer to section 7.1 Appendix 2 – USB PREPARE TOOL for info on setup of the USB device for data download.

3.4 FILE NAMING

Files are automatically named in accordance with the start date and time of the dataset recording (with respect to the time/date set on the data logger clock).

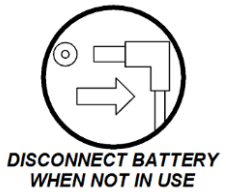
An example file name for a dataset recorded at 13:41 on 31st August 2019 is:

2019-08-31_13-41-26.ZIP

The system date/time can be changed using the Prepare USB tool described in chapter 7.1.

3.5 SHUTTING DOWN

To shut the DL2600 data logger down press and hold the power button for 1 second. After the data logger is shut down the battery cable should be disconnected from the battery to prevent the battery from being drained.



! Disconnect the battery when not in use

ZEB-GO LED		Description
	Red-orange-green	System booting
	Red pulse	Standby mode
	Red	Preparing to scan
	Orange flash	Initialising or de-initialising – data is being logged
	Green	Scanning - data is being logged
	Red flash/ green	Warning – low battery voltage
	Red flash x 1	Error – scanner not detected
	Red flash x 2	Error – IMU not detected
	Red flash x 3	Error – neither scanner nor IMU detected

Table 0-1: ZEB-GO LED status summary

AUX LED		Description
	Green	Copying data to USB memory stick
	Orange flash	Compressing files
	Red flash	USB memory stick error (format error or disk full)

Table 0-2: AUX LED status summary

4. USAGE GUIDELINES

This chapter provides guidelines for how the ZEB-GO Portable Mapping System should be used to achieve the best possible results. Prior to conducting a survey, the user should plan the proposed survey path in order to identify potential problem areas, e.g. feature poor environments, doorway transitions and stairwells. In these areas, the user should plan how to conduct the survey taking into account the recommendations in this chapter. The plan should also make provision for "closing loops" wherever possible. Please adhere to these guidelines in order to achieve the best results. It is recommended that users also watch the accompanying training videos provided on the GeoSLAM YouTube channel.

4.1 THE ENVIRONMENT

The SLAM algorithm used to process the raw laser scan data into a 3D point cloud relies on there being features in the scanned environment that are repeatedly scanned as the operator passes through the scanned environment. For a feature to be significant the ratio of its size to its range must be approximately 1:10, e.g. at 5m range for a feature to be significant it must be >0.5m in size. 'Feature poor' environments include open spaces and smooth walled passageways. In smooth walled passageways there may not be sufficient features in the direction of travel for the SLAM algorithm to determine forward motion. In feature poor environments we recommend the following steps are taken:

- If possible augment the environment with additional features. e.g. boxes in a corridor or a parked vehicle in an open field.
- Ensure that whatever limited features are available are scanned repeatedly as you move through the environment by pointing the ZEB-GO in the direction of the feature. By doing so more measurement points are made of the feature increasing the likelihood that it will be used by the SLAM algorithm. This is particularly important when the feature is at long range (>10m). e.g. when scanning a smooth walled passageway where the only feature in the direction of travel is the end wall or door.
- Avoid scanning moving objects (e.g. passing pedestrians or vehicles) as the SLAM algorithm may lock on to these objects as static features.

4.2 LOOP CLOSURE

The SLAM algorithm used to process the raw scan data into a point cloud uses a method analogous to the traverse technique used in survey practice, in that a previously known position is used to determine its current position. Not "closing the loop" can result in the compounding of any error introduced causing measure position to "drift". It is good survey practise to "close the loop" by re-surveying a known position so that the compounded error can be spread around the loop.

As a minimum, it is required that the operator must start and end the survey in the same position to ensure at least one loop closure. However, it is recommended where possible that the operator closes the loop as often as possible in order to minimise error and improve the accuracy of the resulting point cloud.

In general, it is better to do circular loops rather than "there and back" loops where the survey path simply doubles back on itself. This applies to horizontal and vertical loops, i.e. if possible enter and exit through different doors, move between floors via different stair wells.

It is important to scan the closed loop regions carefully to ensure the key features are scanned from a similar perspective. It may be necessary to turn around if you return to a region from a different direction. This is particularly important in feature poor environments.

4.3 TRANSITIONING BETWEEN ENVIRONMENTS

Extra care must be taken when transitioning between environments, for example passing through a doorway or turning through a tight bend to avoid introducing errors. When transitioning between environments the local view may change abruptly and the SLAM algorithm may have difficulty placing the new environment relative to the previous environment. This may result in rooms either side of a doorway being slightly misaligned.

Transition through doorways slowly and ensure that there is a period when the scanner can view features on both sides of the doorway (i.e. into both rooms).

Try to open all doors before starting the survey. Avoid scanning doors as they are being opened. If necessary, face away from the door and open from behind then pass through the doorway backwards.

Transition around tight bends slowly and ensure that there is a period when the scanner can view features on both sides of the bend.

Take care when transitioning from an enclosed feature rich environment to an open feature poor environment, for example exiting a building. It may be necessary to turn and face the exit and the exterior of the building if no other features are within range.

Avoid scanning any other moving objects (e.g. walking pedestrians) as you pass through a transition.

4.4 WALKING SPEED

It is recommended that data is captured at a slow walking pace to ensure good coverage and high-resolution data. If the forward movement is too fast there may not be enough repeat scans of features for the SLAM algorithm to be able to process the raw laser data into a point cloud.

4.5 MINIMUM AND MAXIMUM RANGE

Data within a small range value is not processed (by default) to eliminate data from the scanner operator being included in the final point cloud. Avoid close proximity to walls and ceilings.

The maximum range of the scanner is 30m. This range will only be achieved in optimal conditions (indoors with good target reflectivity). The typical maximum range will be 15-20m in most conditions. It is recommended that the range is kept to less than 10m where possible to ensure good point density and to assist the SLAM algorithm.

4.6 DURATION OF SCANNING

For very large surveys the project should be broken down into more than one scan mission. This is to avoid very large file sizes as well as reduce any drift that might be created in the data. It is recommended that each survey is limited to 25 minutes. At walking pace, it is possible to cover approx. 2000m of survey distance.

4.7 SURVEY AREAS WITH RESTRICTED OR DIFFICULT ACCESS

The scanning head can remain stationary for short periods of time whilst the operator negotiates difficult access points (e.g. tight squeezes in cave systems). The scanning head can also be held in the hand and moved up and down to mimic the normal oscillating motion for short periods of time to assist transition through survey areas with restricted or difficult access.

4.8 MOVING OBJECTS IN THE ENVIRONMENT

In most case the SLAM algorithm is able to handle moving objects in the environment. In order to estimate the scanner motion the algorithm must assume a large proportion of the environment is static. However, in some feature poor environments where 3D structure is lacking in some dimensions, moving objects can have a greater impact on the solution. In particular, moving objects should be avoided in long tunnel-like environments (e.g. corridors), relatively open spaces and when transitioning through doorways.

It is best practice not to have other people closely accompany the operator during the scan acquisition as they will be scanned throughout the map leaving streaks of data and potentially corrupting the solution in feature poor environments. If people are required to follow the operator they should ideally maintain a distance of 20m or more from the operator.

5. DATA PROCESSING

It is necessary to process the raw data collected by the ZEB-GO portable mapping system using GeoSLAM's novel 3D SLAM algorithm to generate a 3D point cloud of the environment that has been mapped. This is done using the GeoSLAM Hub processing software.

5.1 GEOSLAM HUB SOFTWARE

Installation and processing of GeoSLAM Hub software is described in detail a separate User Guide.

To convert proprietary .zip files into a variety of widely used pointcloud formats, Open Windows Explorer and navigate to the location of the .zip file to be processed. Drag and drop the .zip file in the "Drop datasets here…" field on the user interface (see Figure 5-1). The application will copy the dataset into a processing folder.

A processing progress bar is displayed as the data set being processed. The data will take approximately as long to process as it did to capture (using default processing options). Data processing may take considerably longer if none default settings are selected.

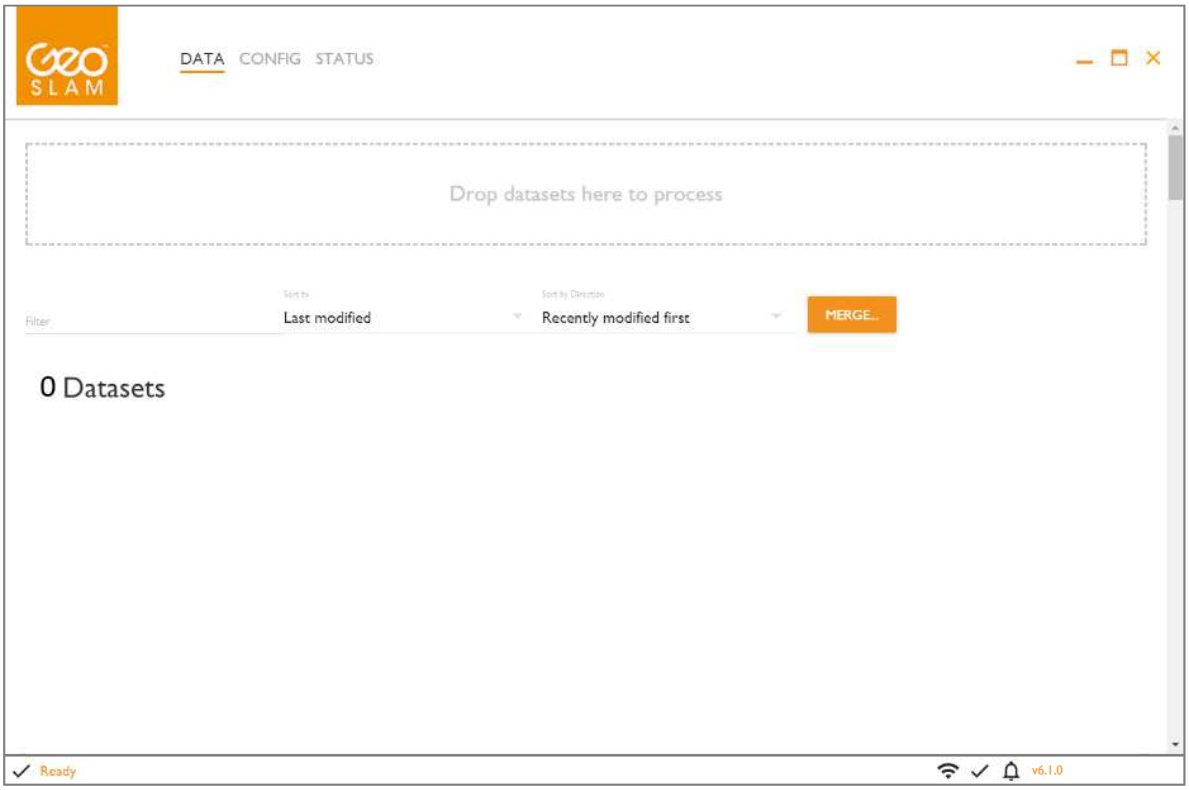


Figure 5-1

To view the processed dataset, click the VIEW button next to the file name in the dataset list. A 3D view of the dataset opens in a new GS View window.

Further instructions for data export and the other post processing options in GeoSLAM Hub are described in the separate GeoSLAM Hub User Guide.

Once the data has processed, select the Export button to save the data in its preferred format, as described in the GeoSLAM Hub User Guide.

6. BATTERY

6.1 SPECIFICATION

Output voltage	12V nominal
Capacity	4Ah or 8Ah (+/-5%) 96Wh
Charge voltage	12.6V
Weight	0.6kg
Charging temperature	0^0C to 45^0C
Life cycle	>300 cycles
Protection	Over charge, over discharge and short circuit protected
Transportation	UN 38.3 transportation test certified

Table 6-1 Battery Specification

6.2 RECHARGING

Plug the charger into the AC mains – the LED light will glow green.

Plug the charger lead firmly into the battery the LED light will change to red to indicate charging.

When the LED light changes back to green, the battery is fully charged.

Disconnect the charger from the battery and from the AC mains.

! Do not leave the charger connected to the battery for long periods after the battery is charged.

6.3 CHARGE INDICATOR

Press and hold the charge indicator push button:

3 green & 2 red LEDs	75-100% capacity
2 green & 2 red LEDs	50-75% capacity
1 green & 2 red LEDs	20-50% capacity
2 red LEDs	10-20% capacity
1 red LED	<10% capacity
No LED	0%

6.4 BATTERY CARE

DO NOT dispose of in normal household waste.

DO NOT attempt to dismantle the battery.

DO NOT short circuit the battery.

ONLY use the charger supplied with the battery.

The battery should be charged fully before use.

If storing the battery, store in a charged state. Recharge after every 6 months.

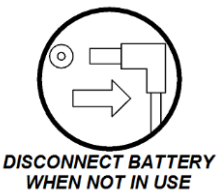
Excess heat will degrade the battery rapidly. Always store the battery in a cool dry place. DO NOT leave for long periods in the sun or in a hot vehicle.

It is recommended to recharge the battery within 12 hours if fully discharged.

The battery is splash proof but not waterproof – do not immerse in water.

6.5 TRANSPORTATION

The battery has been tested and passed section 38.3 of the UN Manual of Tests and Criteria (UN Transportation Testing) and is approved for air shipment. The battery is below the 100Wh limit for transportation on passenger planes. For the purposes of air transportation, the battery is classed as “Packed with equipment” (ICAO/IATA Packing Instruction 966, Section II) – Cells or batteries contained in a package with associated electronic equipment. Special rules may apply to the transportation of spare batteries. It is recommended that you check with your local air transportation safety authority and/or the proposed air carrier for specific requirements on lithium battery transportation.



! Disconnect the battery during transportation

7. APPENDICES

7.1 APPENDIX 1 - USB PREPARE TOOL

The USB Prepare application in the Tools folder in the GeoSLAM Windows Program Group enables users to perform some basic interaction with the ZEB DL-2600 data logger. The Program Group is accessed via the Windows Start button.

Figure 7-1

The following tasks can be performed:

- Download Log File
- Delete All Files
- Download All Files
- Download specific Files
- Set Time and Date

To perform any of the above tasks, insert a USB memory stick into a USB port on your computer and start the USB Prepare Tool. Select the Drive with the USB memory stick (see Figure 7-2) and check the tick box against the task you want to perform.

In order to **Download Specific Files,** enter the date of the required files (YYYY-MM-DD). The example in Figure 7-2 will download all data collected during May 2014.

In order to **Set Time and Date**, enter the required time and date.

Click **Prepare** and a small command file will be written to the USB memory stick. Eject the USB memory from the computer and attached to it to the ZEB DL-2600 data logger. Start the data logger and the requested task(s) will be performed after the data logger has booted. For the download tasks, the data will be written to the USB memory stick. If you have selected **Download All Files** a USB memory stick of at least 64GB is recommended.

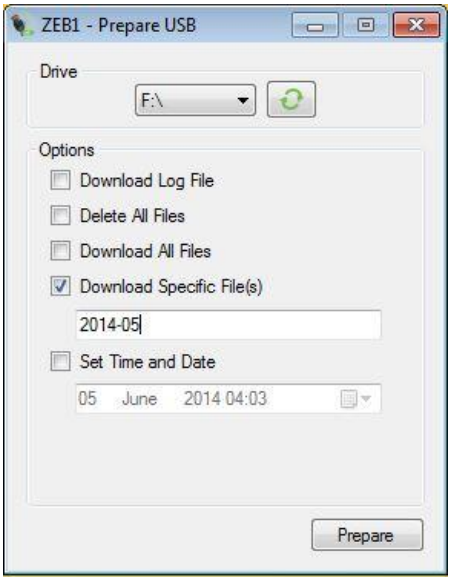
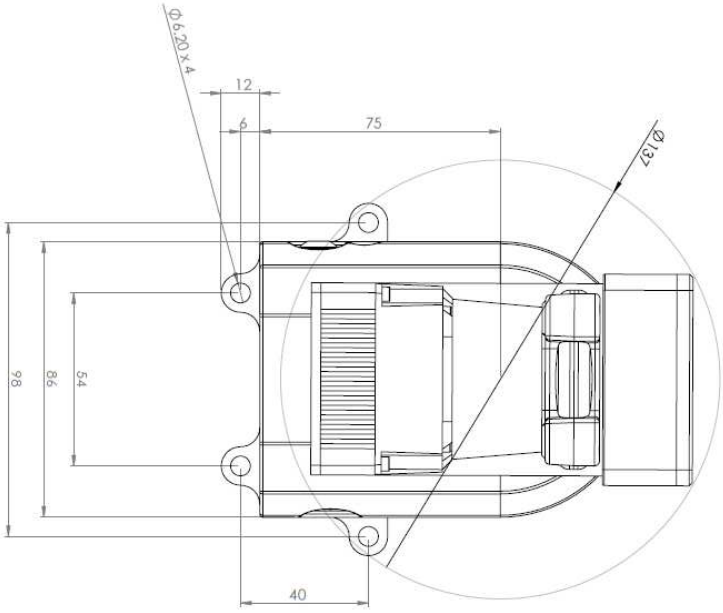
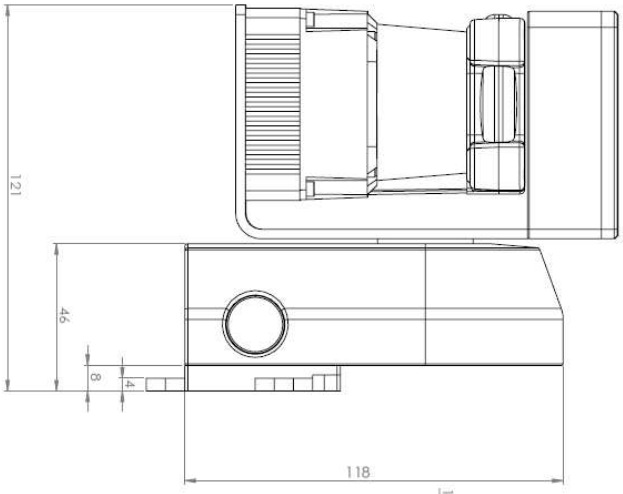


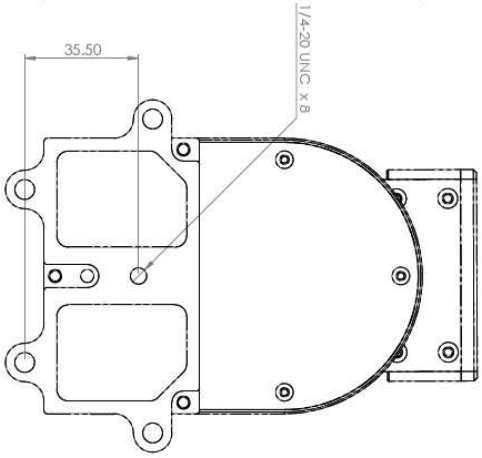
Figure 7-2

7.2 APPENDIX 2 – DIMENSIONAL DRAWINGS

Dimensional drawings with optional mounting plate on rear face







Dimensional drawings with optional mounting plate on bottom face