

State of Florida  
Department of Transportation



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**OPERATIONS MANUAL FOR MOBILE  
RETROREFLECTIVITY UNITS**

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State Materials Office  
April 2022



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## **PAVEMENT MATERIALS SYSTEMS SECTION**

The mission of the Pavement Material Systems Section is to monitor and report on the condition, structural integrity, and performance of Florida's roadway system and to provide technical expertise for safe and long-lasting pavement systems.

Our vision is to be acknowledged by our customers and partners as achievers of excellence in the evaluation and performance-prediction of pavement systems.

To learn more about our people, functions, and services, we invite you to visit us at

[FDOT: State Materials Office - Gainesville, FL](#)

## **EXECUTIVE SUMMARY**

One of the functions of the Non-Destructive Testing Unit, a unit of the State Materials Office in Gainesville, Florida, is to evaluate the in-situ performance of pavement striping on Florida's roadways so that District Maintenance Engineers can more effectively plan re-striping strategies. This handbook has been developed as a reference for personnel responsible for or interested in the processes involved in the principles of retroreflectivity and equipment used to measure it. The handbook provides a detailed explanation of the Mobile Retroreflectometer Unit (MRU) along with information vital to its operation and is intended to serve as reference for those using such equipment in the State of Florida. Covered in this manual are the concepts and physics involved with retroreflectivity, setup and calibration of the MRU, and MRU operational procedures. Finally, this manual explains the tasks required to perform proper data analysis and describes methods to archive important information for later use.

# 1 INTRODUCTION

One of the functions of the Non-Destructive Testing (NDT) program is to characterize the in-situ performance of pavement striping along Florida's roadways to effectively plan restriping strategies. The basis for such characterization is the retroreflectivity value ( $R_L$ ). The retroreflectivity value is a measure of the fraction of emitted light reflecting back to its source per unit area and can be directly correlated to how well drivers see pavement striping with their headlights in low lighting conditions or darkness.

Obtaining retroreflectivity values for pavement striping is important for this reason: In situations where there is very little lighting along roadways, the visibility of pavement markings is known to play a major role in the number of nighttime accidents. Nighttime visibility of markings is typically provided by the ability of pavement markings to reflect headlamp light back to the driver (retroreflectance). Since providing street lighting generally requires high installation, operating, and maintenance costs, lighting is typically used only in specific areas. Thus, the nighttime visibility of pavement markings is primarily dependent on their retroreflectivity.

The retroreflectance of pavement markings generally decreases over time for a variety of reasons: abrasion by traffic, sun and heat exposure, application methods, material type and chemicals spilled on the road surface. Thus, in order to ensure safety, a prescriptive specification has typically been employed for marking maintenance. Under this specification, the type of marking material and the method of application are controlled. The marking is then replaced after a predefined interval based on previous wear data. This tends to sacrifice either cost or safety since the markings are either replaced while still providing adequate service for drivers or after the retroreflectance has deteriorated to a point that the markings are no longer visible at night. For a performance specification, continuous assessment over the life of the markings is necessary to ensure visibility and reduce unnecessary costs of remarking.

In 1993, the United States Congress directed the U.S. Department of Transportation to include a minimum level of retroreflectivity for signs and pavement markings in the Manual of Uniform Traffic Control Devices (MUTCD). Subsequently, the Federal Highway Administration (FHWA<sup>[OE1]</sup><sup>[OA2]</sup>) initiated a program to develop instruments to measure the retroreflectance of signs and markings. Due to their speed and ease of operation, the mobile pavement marking van was developed in partnership with the private sector through the Small Business Innovative Research Program (SBIR) and has been successfully commercialized. Because of the millions of dollars that the State of Florida spends each year on pavement markings, it was determined that pavement markings need to be considered as a manageable asset. While there are less expensive handheld retroreflectometers currently on the market, only a mobile based platform is capable of efficiently collecting the vast amounts of data needed to monitor pavement marking performance.

Mobile based retroreflectometers are used for estimating the retroreflectivity value of striping. Retroreflection can be non-destructively induced and measured using various commercially available devices. These devices are designed based on using a light source and optical lenses and filters as measurement sensors. The units can be configured to measure edge lines, skip lines, and centerlines along roadways and can be mounted on either side of the vehicle.



FDOT's Road Vista Mobile Retroreflectometer Units (MRUs) are a light measurement device that consists of a light source capable of illuminating longitudinal pavement markings at a set distance in a manner that imitates actual driver and vehicle headlights in both position and geometry (i.e. angle of entrance and angle of reflection). A retroreflectivity scan is generated by shining a single point light source (usually a laser) at a spinning mirror out at a specified distance from the source. The mirror causes the laser to move in a sweeping motion about 1 meter in length, 6 meters in front of the unit on to the pavement stripe. The reflected light from this sweep is received by the Laserlux unit and converted to digital data. A retroreflectivity value is obtained based on the peak data point values averaged along the generated scanned area after filtering out any signal noise produced by the asphalt or concrete pavement. Over 400 of these scans are performed every second along the stripe width. The retroreflectivity values from all these scans are averaged out over a user defined interval and an average retroreflectivity value is obtained over that interval. The MRU relies on the law of averages as the basis for collecting accurate data. In this methodology, a single reading is unimportant to the overall result as the retroreflectivity value for each interval is typically based on hundreds or thousands of individual scans. ~~Figure 1~~ shows a photographic illustration of one commercially available retroreflectometer, which is in use at the Florida Department of Transportation State Materials Research Park.

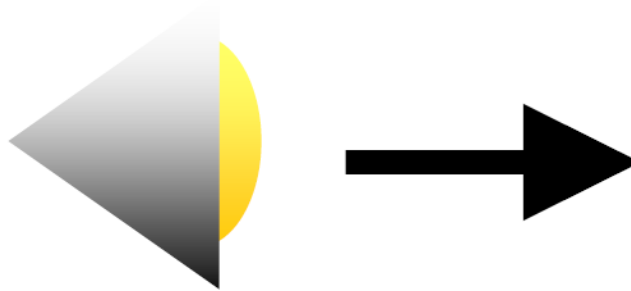


**Figure 1 - Mobile Retroreflectivity Unit**

## 2 DERIVING THE UNITS OF RETROREFLECTIVITY

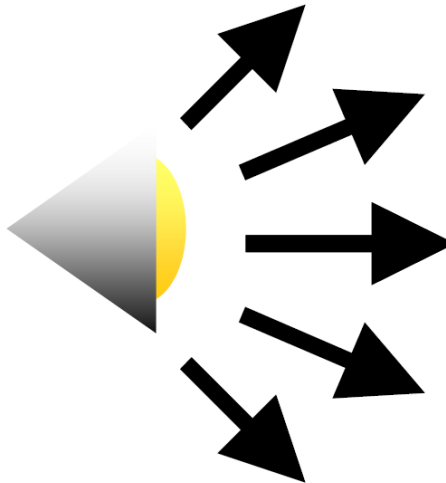
Retroreflectance measurements are typically given in terms of millicandelas per lux per meter squared per lux ( $\text{mcd}/\text{m}^2/\text{lux}$ ). This unit is essentially a fraction of emitted light reflecting back into the direction of the light source. The significance of this unit may be found by studying the definitions of various terms associated with light such as luminous intensity, luminous flux, illuminance and luminance.

Luminous intensity is the intensity of light emanating from a source in a given direction (Figure 2). The magnitude of this vector is measured in terms of candles (cd), where 1 cd is the intensity of 1 candle. As an example, a typical 100W light bulb emits an average of 110 cd.[KO3]



**Figure 2 - Luminous Intensity**

The luminous flux is the sum of the luminous intensity of a source in all directions (Figure 3). Thus, if the intensity is isotropic (emits evenly in all directions) then one can multiply by  $4\pi$  to arrive at the luminous flux[OE4]. Luminous flux is typically given in terms of lumens (or lm). As an example, the same 100W incandescent light bulb emits around 1400 lm.



**Figure 3 - Luminous Flux**

An increased value for the luminous intensity for a light source may not correspond to a bright image. This may be due to the area over which the luminous intensity is spread. Luminance is the luminous intensity of an emitting object divided by the plan area of the emitting object. It is typically expressed in terms of  $\text{cd}/\text{m}^2$ .

Illuminance is the metric that is usually used to describe a lighting level on a particular surface such as a table or a wall. Illuminance is the luminous flux received on a plane per unit area of that plane. While the units are typically given in lux ( $\text{lm}/\text{m}^2$ ), the plane may be oriented in many different angles, thus orientation of the plane should be given. It is important to note that this may not be based on what is seen by the observer on the plane as some surfaces (such as a table) may have a coating, or color which does not reflect its illumination.

Thus retroreflectance is the luminance (or brightness) of an object as detected by a sensor divided by the illuminance of the object by a light source.  $\text{Retroreflectance} = \text{Luminance}/\text{Illuminance} =$

$$\left(\frac{\text{cd}}{\text{m}^2}\right) \cdot (\text{lux})^{-1} = \left(\frac{\text{cd}}{\text{m}^2}\right) \cdot \left(\frac{\text{m}^2}{\text{lm}}\right) = \frac{\text{cd}}{\text{lm}} \quad [\text{K05}]$$

The areas cancel since the area illuminated is the same as the area used to calculate the brightness. Since lumens in this calculation refer to the total luminous flux of the light source and cd is the luminous intensity of an area of interest, retroreflectivity is a measure of the fraction of the reflected light source intensity as received by the sensor.

### 3 LASERLUX MOUNTING PROCEDURE

Instructions for physically mounting FDOTs Road Vista Laserlux units onto the vehicle are provided in this section. Calibration instructions are provided in the following section. Properly mounting the unit onto the vehicle is critical to calibrating the unit. Also, a unit improperly mounted can result in serious damage to the unit itself, the vehicle, other traffic, and could also result in bodily harm.

**The following are the mounting procedures:**

1. Find level ground to park vehicle for mounting



**Figure 4 - Level ground**

2. Slide box mounting bracket into receiver



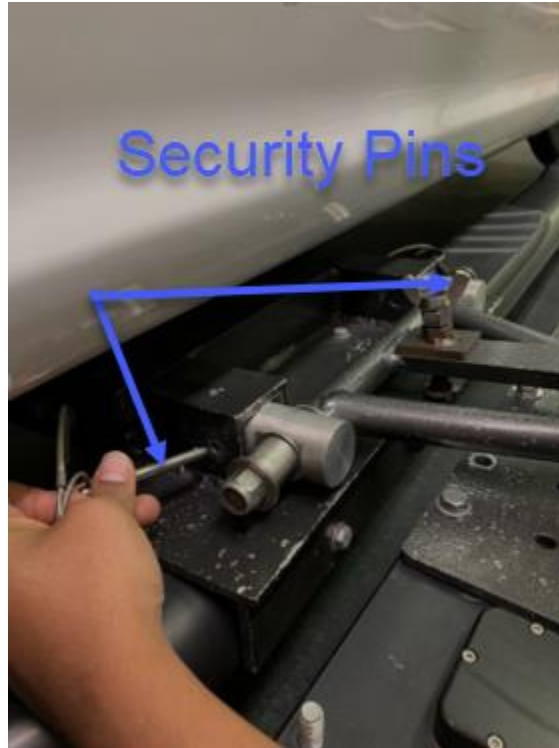
(a) Set the box mounting bracket



(b) Slide box mounting bracket into the receiver

**Figure 5 - Slide box mounting bracket**

3. Insert security pins locking the mounting bracket to the receiver



**Figure 6- Security pins**

4. Use leveling bolt to adjust level of the box relative to the truck. Once leveled tighten the nut on leveling bolt to the top of the bracket. Now tighten the nuts on the side of the bracket to finish securing the bracket to the receiver.



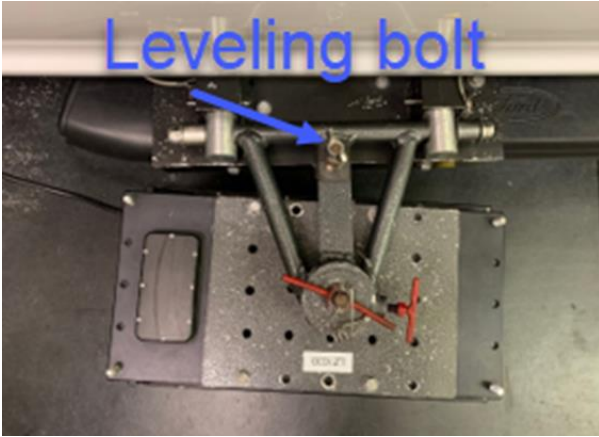
(a) Check the level of the box



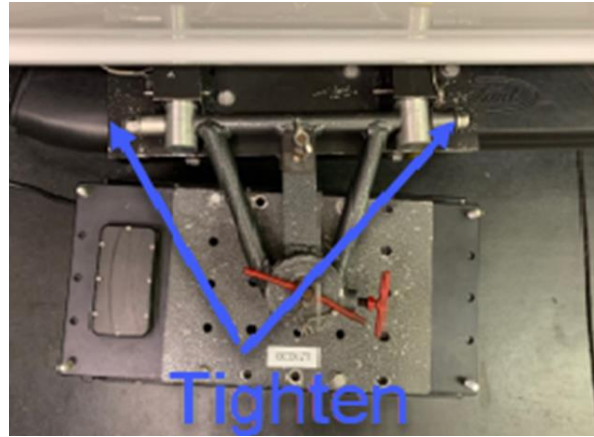
(b) Check the level of the truck

**Figure 7 – Check level of the box relative to the truck**





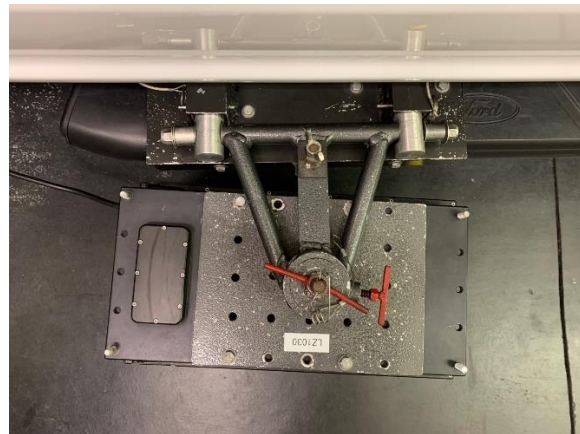
(a) Leveling bolt



(b) Tightening nuts

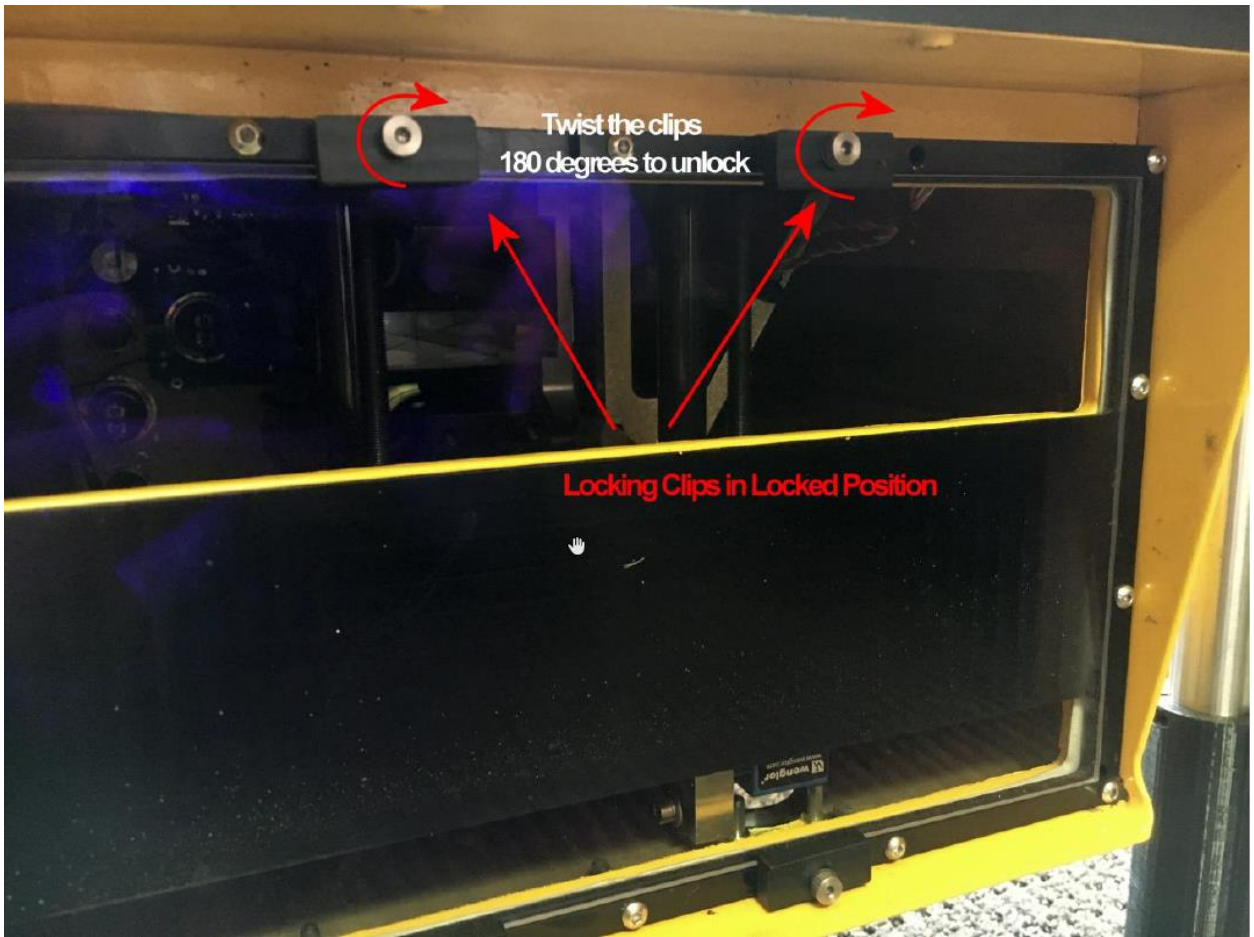
**Figure 8 – Adjust level of the box relative to the truck**

5. Set the box angle out from truck approximately  $3:1_{[HC6][CF7]}$  front to back. (This may vary dependent on the width of the roadway being tested.)



**Figure 9 – Set the box**

6. Clean the main window and the glass using standard window cleaning solution. This is critical as dirt, bugs or fingerprints can block the outgoing laser light and returning light, thus interfering with the measurement. Using your fingers, turn the two retaining tabs located at the top of the glass  $180^\circ$  to release the glass panel. Carefully pull the glass toward you in an upward motion to remove it. Using standard window cleaner and a clean cloth, thoroughly clean both sides of the glass panel removing any contaminants. Visually inspect the main window of the MRU. If this is dirty, carefully clean the window. (Use extreme caution when cleaning the main window as to not scratch or damage the window.) Once clean, reinstall glass panel to original position and secure by turning the retaining tabs  $180^\circ$ .



**Figure 10 – Clean the main window and glass**

## 4 CONNECTING TO THE LASERLUX G7:



**Figure 11 – Rear Panel**

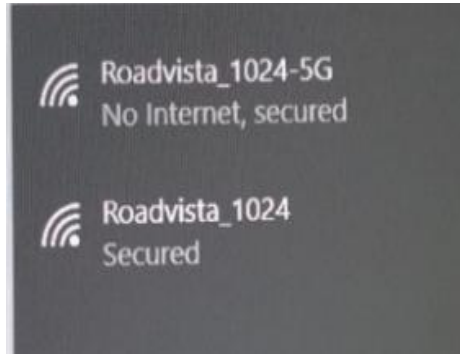
### 4.1 Applying Power:

1. The LLG7 is powered by a standard 12 VDC, cigarette lighter-style plug. Simply plug the provided power cable into the LLG7 and the cigarette plug inside the vehicle.
2. To power on the LLG7, with vehicle running, depress the power button on the rear panel.
3. The power button should illuminate red, and the two red indicators will turn on solid. Once the instrument has fully booted, the indicators will flash rapidly 3 times, then begin a steady 1 Hz flashing pattern, indicating the instrument is ready for operation.
4. To turn off the LLG7, with vehicle running and the data collection user interface closed on the computer, depress the power button on the rear panel. Wait for the indicator lights to stop flashing and the red ring around the power button to go out before turning vehicle ignition into off position.

### 4.2 Connecting to the LLG7:

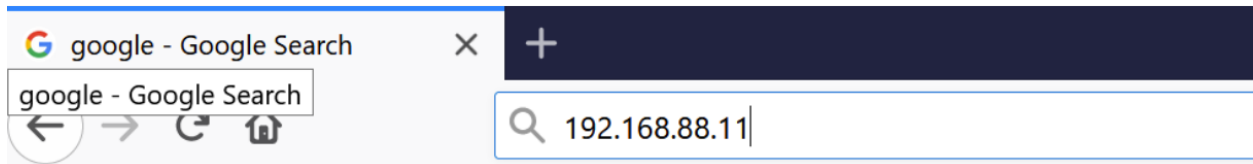


1. From your Wi-Fi enabled device, connect to the SSID named “Roadvista\_XXXX” or “Roadvista\_XXXX – 5G” where XXXX is the last 4 digits of the instrument’s serial number. It is recommended to connect your device to the 5G network as it will be more reliable and less susceptible to radio interference.



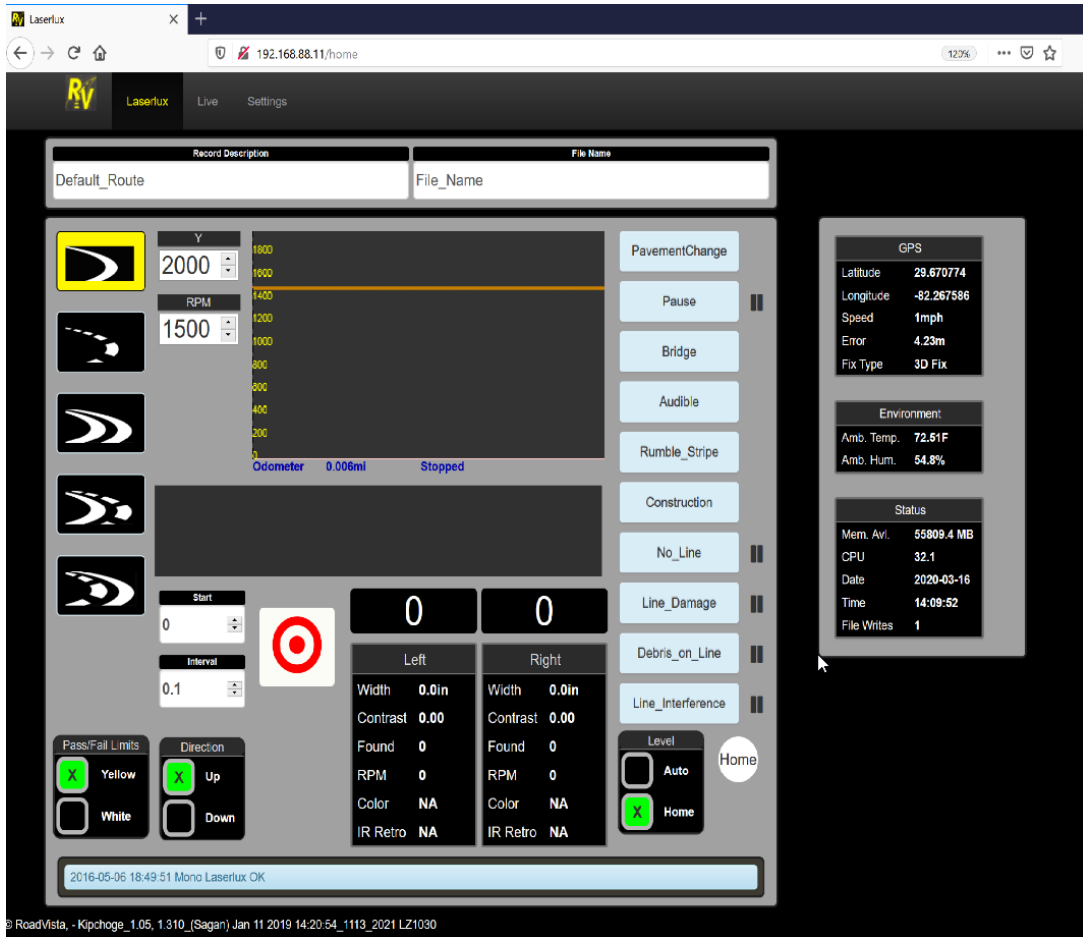
**Figure 12 – Connect to the box**

2. If the device asks you for a password, the password is “Laserlux”
3. Once your Wi-Fi connection is established, open your web browser. In the address bar at the top of the window, in the IP address, type 192.168.88.11 and press enter.



**Figure 13 - Address bar**

4. Within a few moments, the main user interface screen should load into your browser.

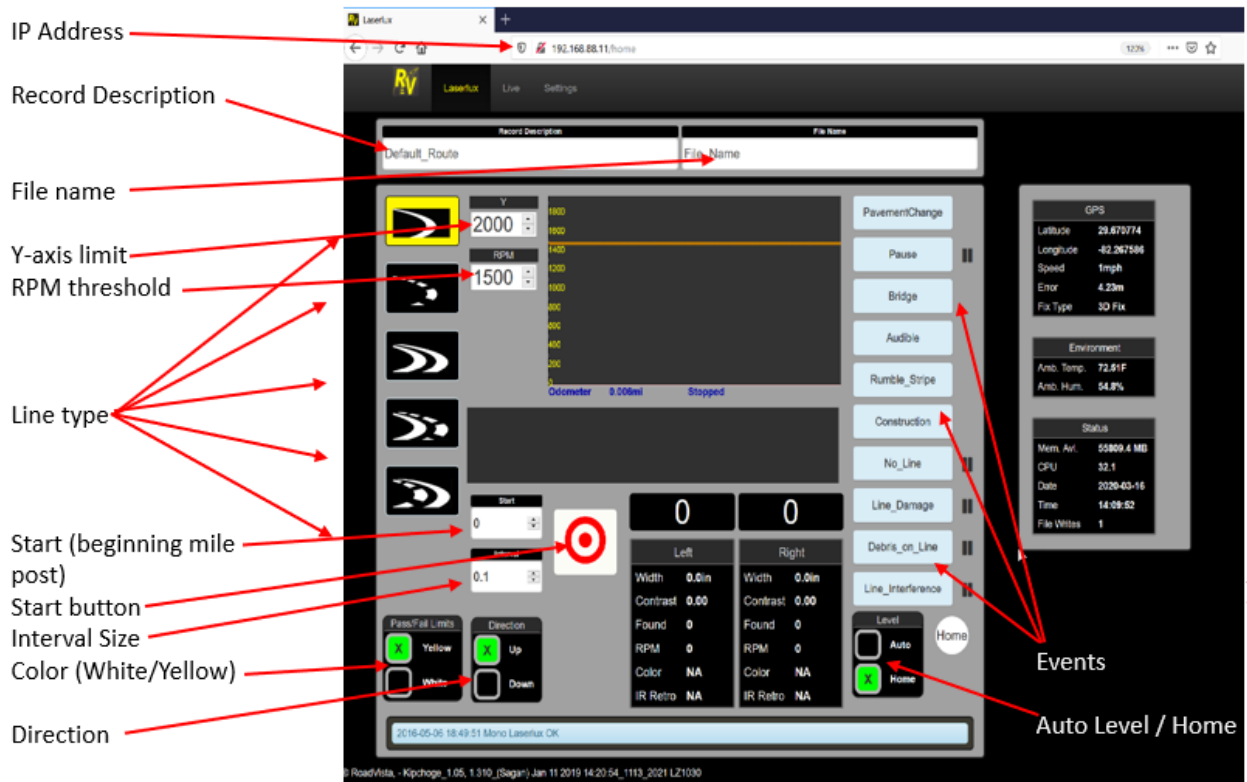


**Figure 14 - Main User Interface**

#### 4.3 Connecting the vehicle mounted camera:

1. Adhere the camera to the inside of the windshield using the supplied suction cup mount and plug it in to any powered USB plug.
2. Once the camera has established communications with the LLG7, all three indicator lights on the back of the camera will turn green, the WLAN indicator light will flash as data is being transferred, and the ring light around the lens on the front will turn green.

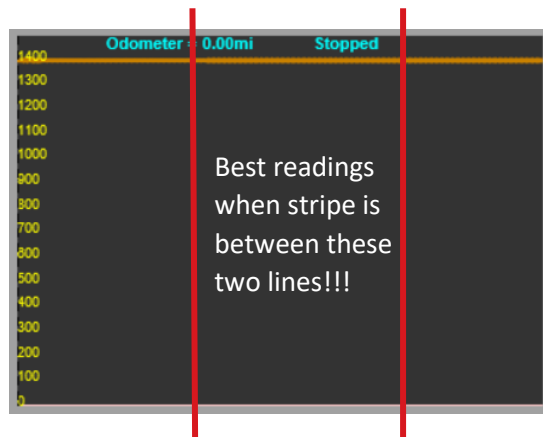
#### 4.4 User Interface Overview:



**Figure 15 - Main User Interface Screen Layout**

1. The IP Address to access the Laserlux should be entered as 192.168.88.11
2. The Record Description should be the State Route. (Example SR\_22)
3. The File Name depends on the road (Example 26050000\_R1SL\_W\_F00). For details information regarding file naming convention, please see the MRU quick guide located at [..\..\..\Training\Operator Training\MRU Quick Guide FINAL.pptx](#)
4. The Start field is used to enter the starting mile post of the project for proper chainage alignment.
5. Interval can be changed. It defaults to 0.1 and should remain this way.
6. Direction can be up or down; this depends on if you are measuring up station or down station. You can click the box to change direction. This makes the odometer count up or down depending on the direction.
7. At the bottom left there is another click box for line color. Click the box to switch between white or yellow.
8. The Level box indicates what position the Laserlux is in. The two positions are Home (Raised) and Auto (Lowered)
9. There are five line types, but for FDOT testing purposes, only the “Single Line” line type should be selected. When selected it will appear highlighted.
10. The “Y” box should remain at the default setting of 1500.

11. The “RPM” or Raised Pavement Marker setting can be altered but should usually be set around 1500 for testing purposes. Speak with the MRU Engineer before changing this setting.
12. The Start button (bullseye) begins data collection on the Laserlux. When clicked to start, it will disappear, and a pause button and a stop button will be present.
13. The pause button will pause recording while continuing the odometer. You will need to pause at various times depending on the road conditions and events (intersections, construction, etc.). You must hit the start button again to continue recording. For details information related to the MRU roadway scenarios and rules, please see the file located at <\\SM.dot.state.fl.us\MappedDrives\Pavement Systems\NDT\MRU\Administration\Business Rule Versions\MRU Roadway Scenarios and Rules>
14. The Stop button stops recording. (End of job, etc.)
15. The GPS box will display Latitude, Longitude, Speed, Errors, and Fix type.
16. The Retroreflectivity Reading area contains graphic information as to the condition of the lines you are reading. Note the odometer at the top of the box in blue, this will indicate how far you have traveled during the project after you have clicked the start button. While recording, there is a “sweet spot”<sup>[HC8][CF9]</sup> for the laser to read the lines on the road. The two red lines indicate the area that is best for proper data recording. (Note: There are no lines on the actual display.)



## 5 OPERATION:

The LLG7, when in operation sweeps a beam of laser light out of a horizontal path along the pavement approximately 1 meter (369 inches) wide, 6 meters (19.685 feet) from the front of the instrument. The reflected light from the sweep is received by the LLG7, converted to digital data, and is processed and stored.

### 5.1 General Calibration Procedure

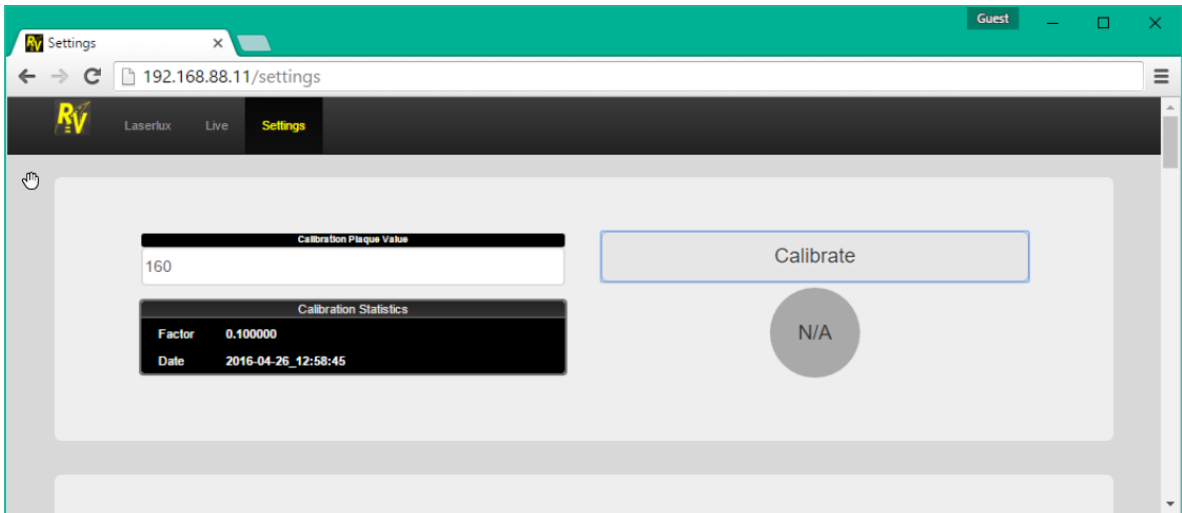
Procedures for calibrating FDOTs Gamma Scientific Laserlux units are defined in this section. The Mobile Retroreflectometer Unit (MRU) is a very sensitive optical measuring device and therefore, proper calibration is critical. Unlike other roadway testing equipment which may only require calibration verification or recalibration of their respective unit every month or even less frequently, the MRU requires calibration every time it is used. Also, anytime the unit is transferred from one side of the vehicle to the other or even moved to its resting position inside the vehicle, it must be recalibrated prior to the next use. The steps and figures outlined below explain the process for calibrating the MRU:

1. Allow calibration block to warm up to ambient temp before attaching to box. [HC10]
2. Insert the alignment pins of the calibration panel into the front locator holes on top of the front plate of the LLG7 until the alignment pins are completely inserted.



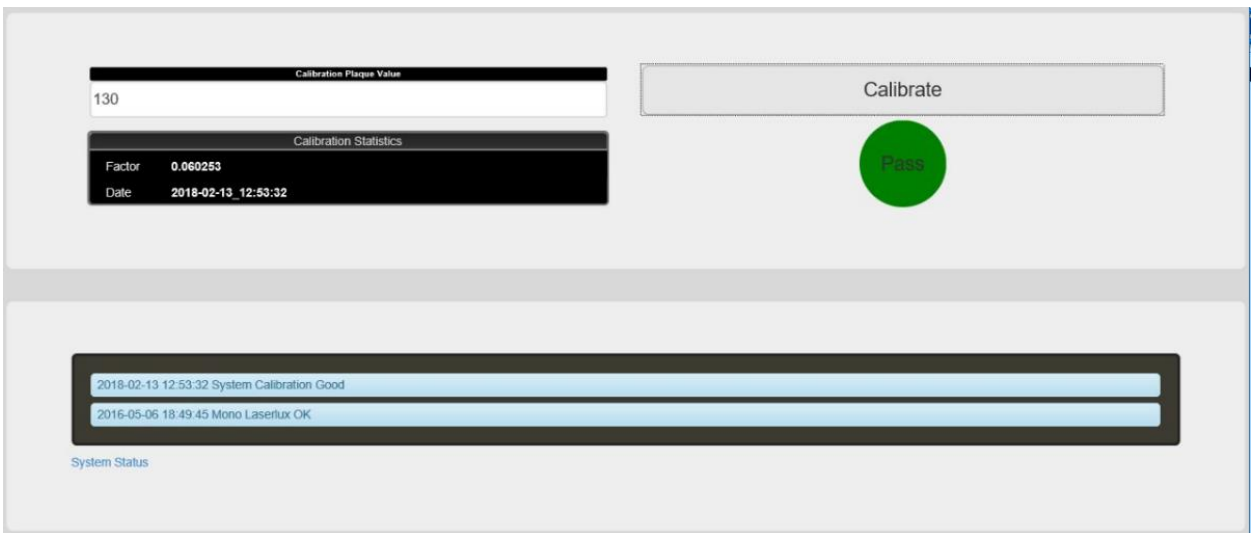
Figure 16 - Insert calibration panel

3. Go to the Settings page of the User Interface.
4. Verify that the calibration value on the settings page and the calibration panel match.
5. Click the calibrate button. The Calibration Status circle will be grey and say “N/A”.



**Figure 17 - Start Calibration**

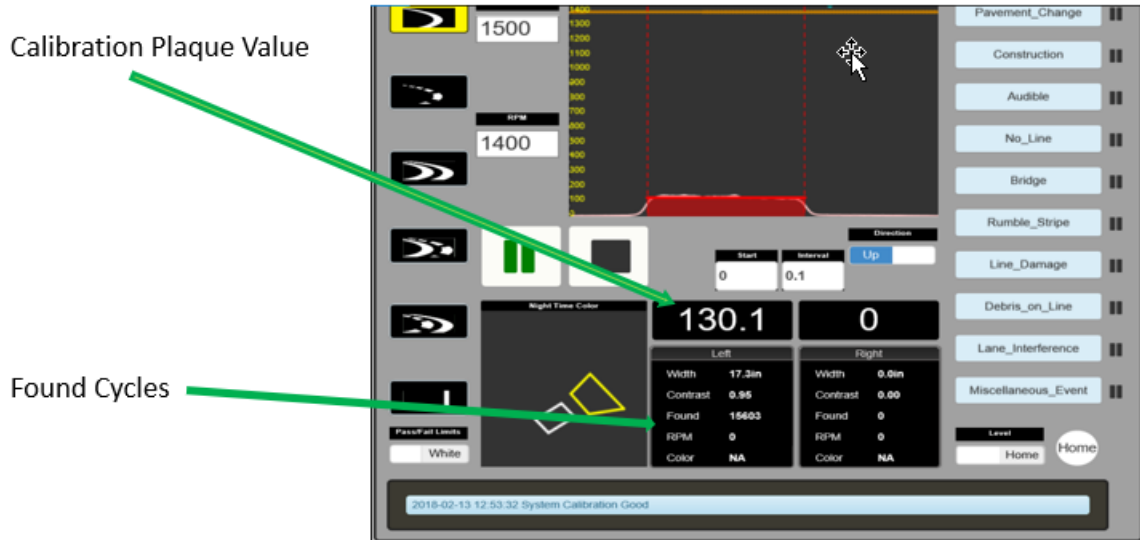
6. The calibration process will take approximately 20-30 seconds. After it is complete, the circle will turn green and say “Pass” upon successful completion of the calibration.



**Figure 18 - Successful Calibration**

7. If the circle turns red and says “Fail,” please check the setup, make sure the instrument is powered on and that there are no warning or error messages in the system status section of the User Interface and repeat the process starting with Step 2.
8. Now that your system has passed calibration, switch back to the Laserlux main page and input description and file name according to the naming convention and click the start button. Let the system run until it reaches 15,000 “Found” data points to make sure the

system has warmed up and is reading properly. The value for your calibration plaque should be displayed below. Click stop after you have measured for 15,000 found cycles. If the value scanned is more than 5% off the calibration plate value, you must re-calibrate.



**Figure 19 - Read the calibration panel**

## 5.2 Setting up the data collection:

This section deals primarily with setting up the software to run a test on a stripe. At this point, it is assumed that the unit has been successfully mounted and calibrated. Also, provided in the Appendix is an operator checklist for both pre and post testing procedures.

1. Select the Record Description and File Name for your data set. The Record Description should be the State Route. (Example SR\_22). The File Name depends on the road (Example 26050000\_R1SL\_W\_F00). See Production and QA Naming Conventions (further in this document)

Record Description	File Name
SR_24	26050000_R1SL_S_00

2. Select the Stripe type from the left-hand column of icons. There are five line types, but for FDOT testing purposes, only the “Single Line” line type should be selected. When selected it will appear highlighted.



3. Make sure your Pass/Fail Limits selector is set to the color of the stripes you are measuring, and make sure your Minimum Valid, Minimum Marginal, and Minimum Good values have the correct values entered for your job. This pass/fail limit has no effect on measurement.



4. Enter the starting mile post of the project in the “Start” field. Set your data averaging interval in the “Interval” box. This is typically 0.1 miles or 0.1 km but can vary depending on the specifics of your job.



5. Direction can be up or down; this depends on if you are measuring up station or down station. You can click the box to change direction. This makes the odometer count, up or down, depending on the direction.





- When you are ready to start recording, set the level position to 'Auto' to send the LLG7 to the measurement position.



### 5.3 Pavement Stripe Nomenclature

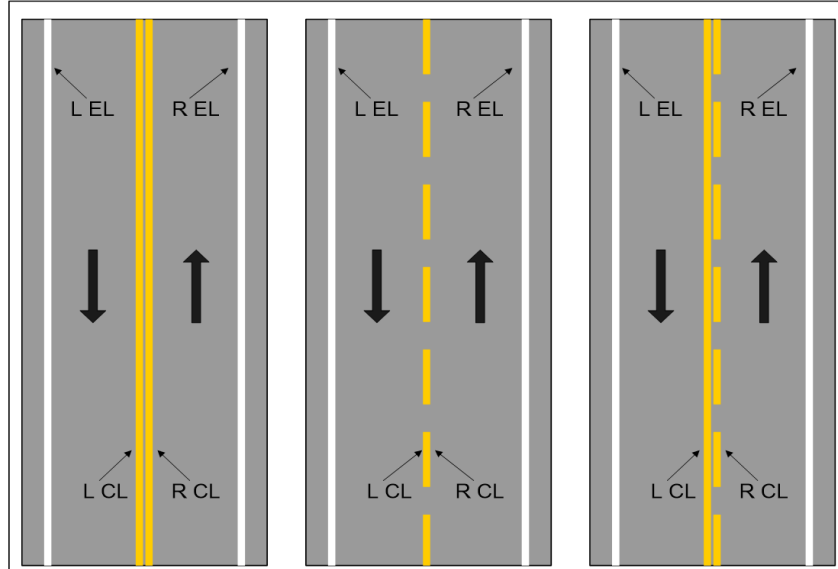
A standard naming convention was devised to identify each pavement stripe regardless of the number of lanes. Table 1 shows an explanation of the nomenclature used.

**Table 1 - Pavement Stripe Nomenclature**

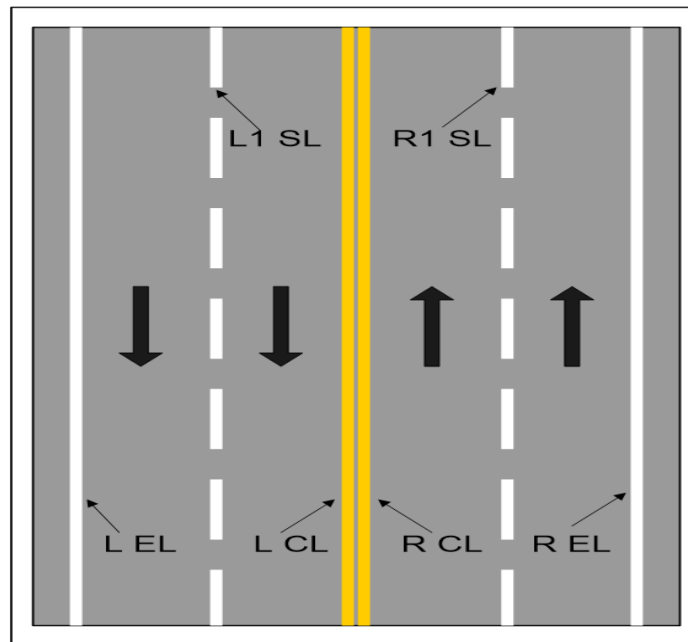
Purpose	Code	Description
*Direction	L	Descending (downstation) mileposts [HC11][OE12]
	R	Ascending (upstation) mileposts [HC13][OE14]
Stripe Type	EL	White edge line
	CL	Yellow center line. <u>All</u> yellow stripes including yellow skip lines are considered as center lines.
	SL	White skip line. A number is placed between the Direction and the Stripe Type to indicate the order of the skip lines starting with the one closest to the center line

\*Note: These directional codes only indicate the travel direction of the MRU, not the individual stripe (left or right stripe) nor the direction of stripe application.

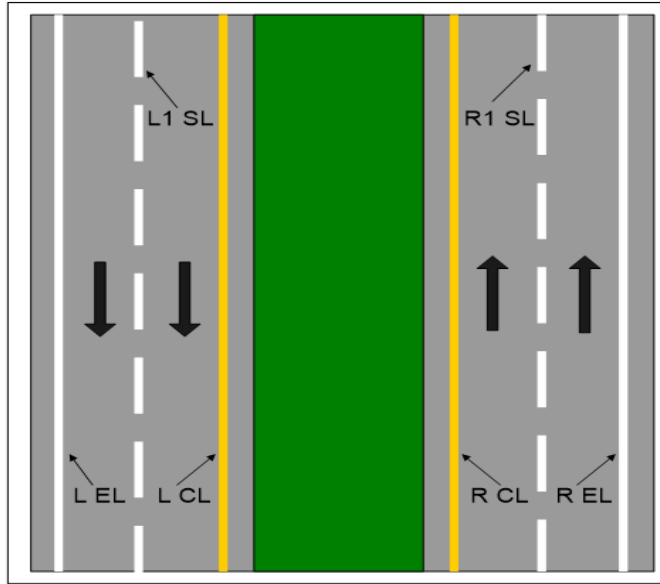
The pavement stripe nomenclature includes the direction (L or R) followed by the stripe type (EL, CL, SL) as indicated in table 1. For skip lines, a number is inserted between the direction and stripe type. As an example, the ascending skip line closest to the center line would be named R1SL, while the edge line in the same direction would be named REL. The following four figures show examples of the naming convention for several different scenarios. Consider the right lanes to be running north or east for all examples. [HC15][OE16]



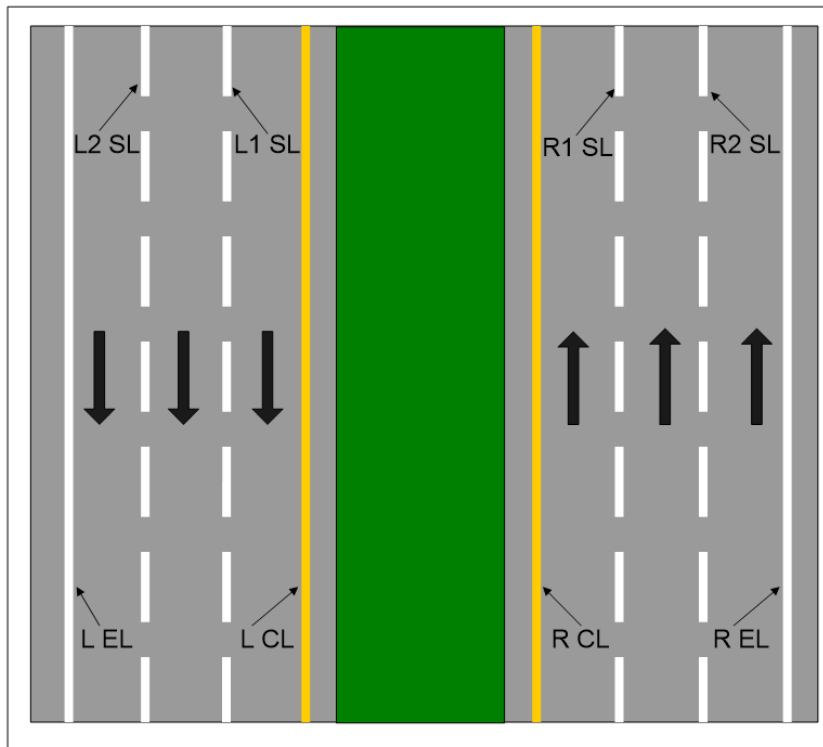
**Figure 20 - Nomenclature For 2-Lane Undivided Road**



**Figure 21 - Nomenclature For 4-Lane Undivided Road**



**Figure 22 - Nomenclature For 4-Lane Divided Road**



**Figure 23 - Nomenclature For 6-Lane Divided Road**

## 5.4 Collecting data

By now, it is assumed that you know how to mount the unit, perform a calibration, and set up a test. The next step is to go out in the field and successfully collect data with the unit. The MRU is a sensitive unit and there are many important factors to be aware of which can cause errors in the data acquisition. Following the established protocol will help minimize these issues. Most of the procedures that the Florida Department of Transportation has in place to ensure accurate data are supported by other state and highway agencies, as well as private contractors owning the same type of equipment. These procedures have been developed based upon thousands of hours of laboratory and field studies of the equipment sensitivities to various effects.



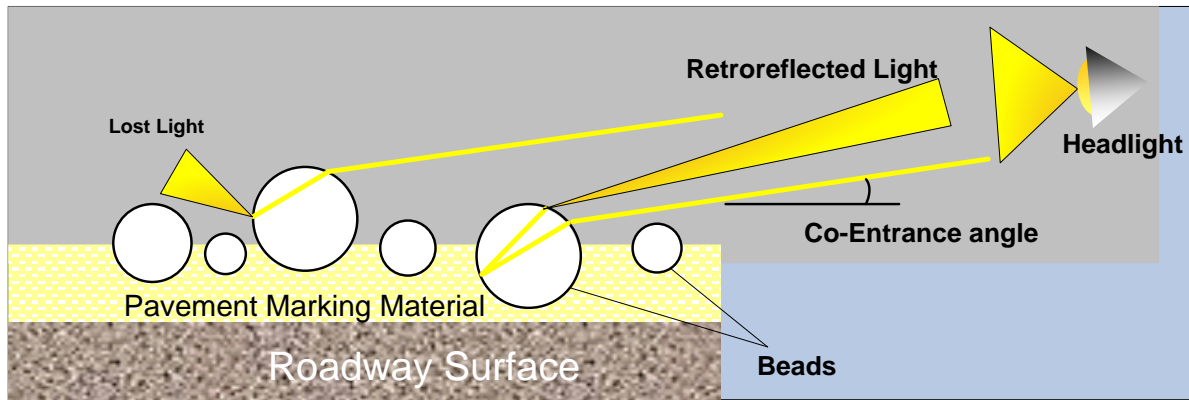
**Figure 24 - Installed G7 LaserLux**

Things to consider while collecting data:

1. Keep the vehicle in the center of the lane so that the pavement stripe is centered in the laser sweep. Periodically check the position of the stripe on the host computer screen. Keep up with the traffic flow but do not exceed the posted speed limit.
2. Try to avoid unnecessary heavy braking or accelerating. Though the instrument can compensate for changes in the vehicle pitch, it is reactive and will take a few moments to adjust its position.
3. Be aware that the LLG7 extends out 15 to 20 inches (38 to 51 cm) from the side of the vehicle and is 4.75 inches (12 cm) above ground.
4. The instrument's operator can select different road condition codes/events on the screen to flag the data for reference.

## 5.5 When not to operate MRU

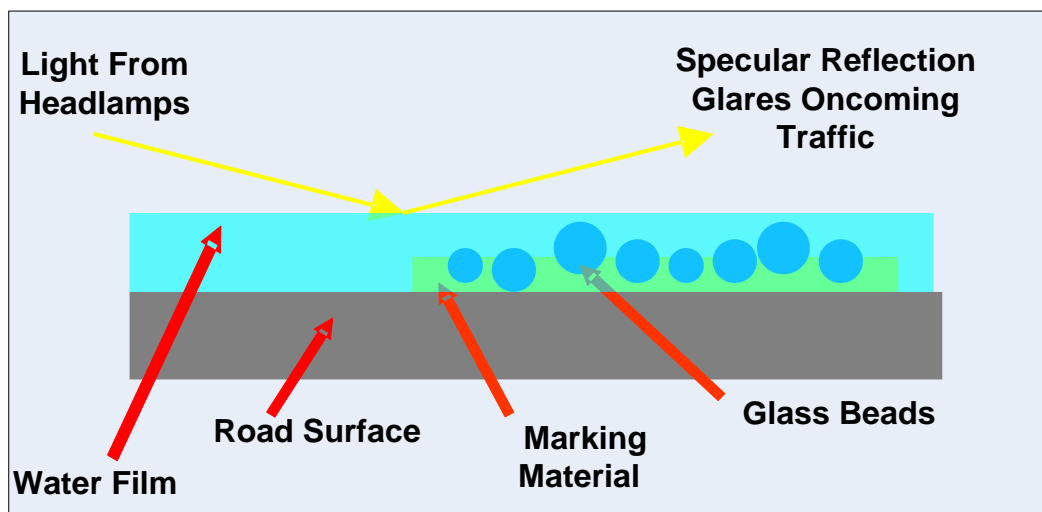
Before discussing how best to collect data, it's important to understand when not to test with the unit. Because pavement markings use spherical beads embedded in the striping material to reflect light back to its source, retroreflection will not occur when there is significant moisture or standing water covering the striping. The physics behind this phenomenon are explained with the aid of the two figures below.



**Figure 25 - Physics of Retroreflection**

**Error! Reference source not found.**<sup>5[HC17]</sup> shows the concept of retroreflectivity on pavement striping. Light from a vehicle's headlamps projects outward and arrives at the glass beads. The light then travels into the bead and refracts inward toward the marking material. Then the light is reflected off the material and sent back into the direction of origin. Beads that are embedded too deep or not deep enough will cause light diffusion, reducing the pavement marking's visibility.

The illustration in Figure 26 demonstrates what happens when water covers a stripe. Incoming light from the headlamp now hits the water and not the beads. Since standing water does not form the same spherical shape as the glass beads, the source light now bounces off the surface of the water (specular reflection) away from the headlamps, thus causing an effect opposite to the one desired. Because light reflects away from the source, the markings are not seen as well.



**Figure 26 - Effect of Water on Measurements**

A laser line is used as the light source in the MRU instead of headlamps, but this makes no difference on the outcome. Laser source light will still hit the water and reflect away if there is standing water or significant moisture on the stripe. Because no light is reflecting back, the Laserlux will not detect any.

Moisture that is in the air, whether it be rain, sleet, snow, or fog (also smoke) will also result in low or no readings. These environmental effects will cause the source light to diffuse before hitting the stripe. In other words, as the light reflects off suspended particles in the air, the amount of light that hits the stripe would be only a fraction of what it would be if there were no particles in the air. If less light is making it to the stripe, less light will be reflecting back. The Laserlux will not “know” if less light is reaching the stripe though, and  $R_L$  readings will be much lower and not accurately represent the  $R_L$  of the stripe.

## 5.6 Road Conditions and Event Codes

Pavement markings can have a lot of different variables that need to be handled appropriately to represent an accurate reading of the stripe. Not only does operator need to understand the influence of acceleration, braking, and stopping on the  $R_L$  but there are pavement changes, intersections, turn lanes, etc. which need to be marked by event codes in order to get an accurate representation. The operator should understand the importance of event codes and how important it is to have them accurately marked.

### Event Codes:

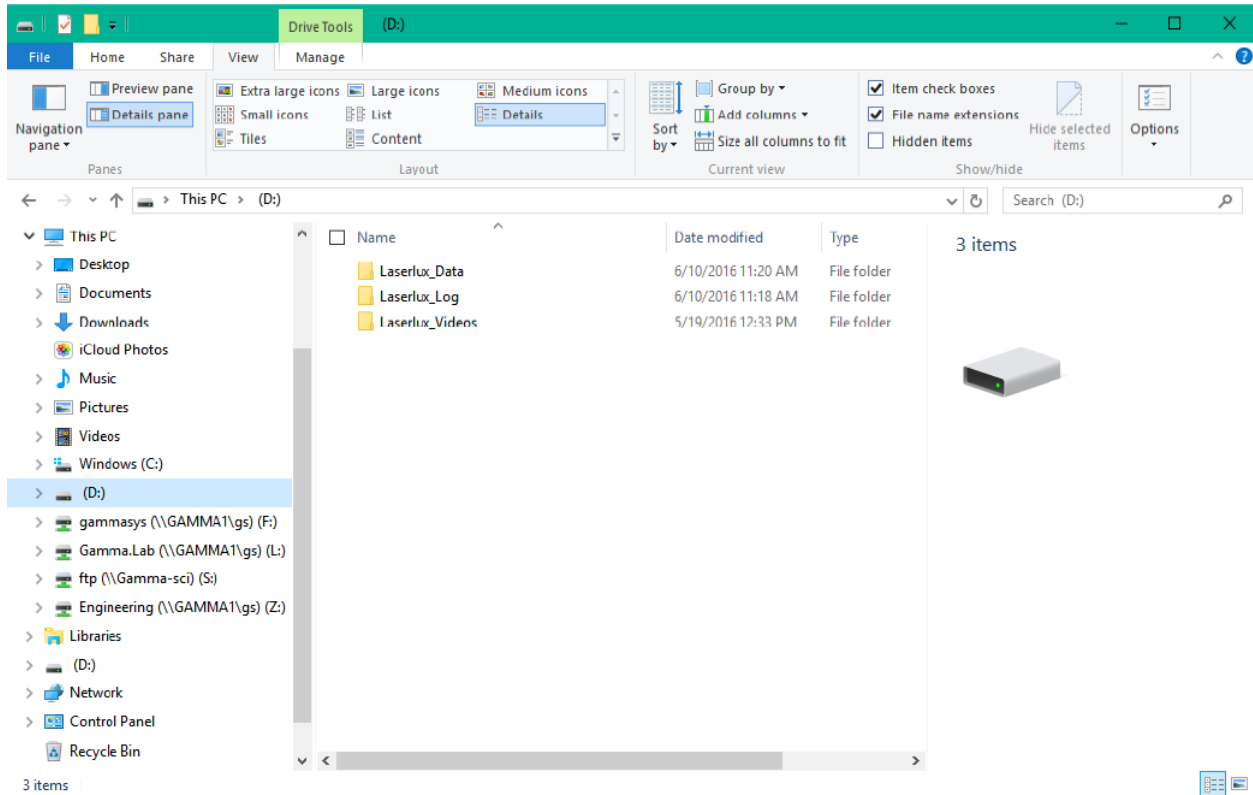
1. **Pavement Change** – Should be marked when a pavement change occurs. This allows the separation of data at the point a new pavement and pavement marking has been applied.
2. **No Line** – Should be marked when no line is available to test on yellow and white lines.
3. **Bridge** - Should be marked at the beginning and end of the bridge. Similar to pavement change, this allows the separation of data in case a different pavement marking applies.
4. **Damage/Debris on Line** (significant, < 0.05mi) – [HC18] Should be marked when a section of the line is damaged or has significant debris on it for more than 0.05 miles. This could be due to something scrapping the pavement marking away while it is drug down the road or heavy grass, dirt, other paint, etc., are covered over the pavement marking.
5. **Construction** – Should be marked if construction is taking place on the pavement marking you are testing. This should be marked at the beginning and end of the construction zone and if the software does not cut out the data, the *Stop Collection (F12)* function should be used or it should be taken out manually.
6. **Lane Interference** - Should be marked if the vehicle has to maneuver around traffic to continue testing at highway speeds.
7. **Audible** - Use this to indicate the presence of rumble strips on the edge line of the roadway.

## 5.7 Accessing Data

The LLG7 automatically saves three types of files to the USB flash drive which can be accessed by removing the USB thumb drive from the LLG7 and plugging it into the computer, or accessed wirelessly through the supplied WinSCP program on the Surface Pro.

### 5.7.1 Access data directly from USB thumb drive:

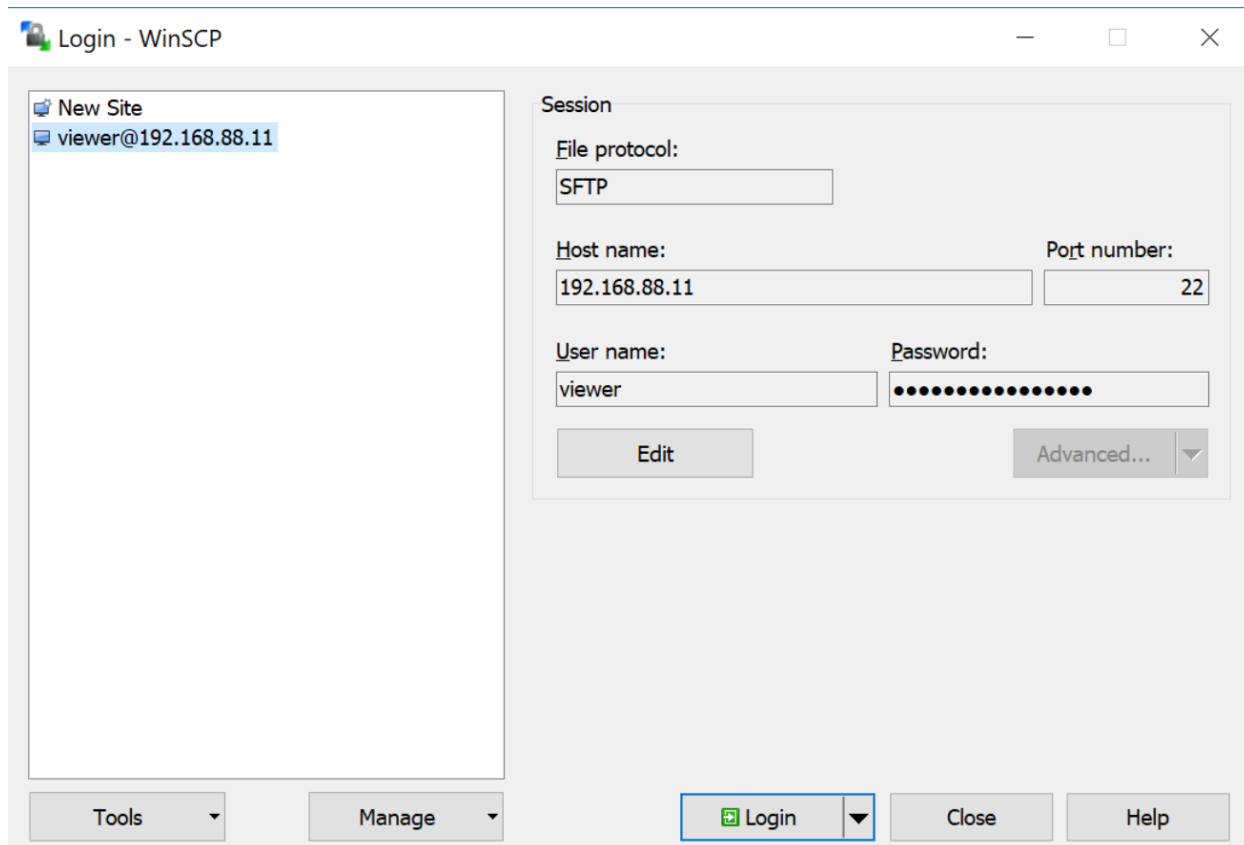
Remove the USB thumb drive from the LLG7 and plug it into your computer. Using Windows Explorer, navigate to the thumb drive. The right-side panel should show three folders as shown in Figure 27.



**Figure 27 - USB Thumb drive folders in Windows Explorer**

### 5.7.2 Access data using the WINSCP program:

Start WinSCP program by double-clicking or tapping the icon on the desktop. You will be taken to the login screen shown below in Figure 28.



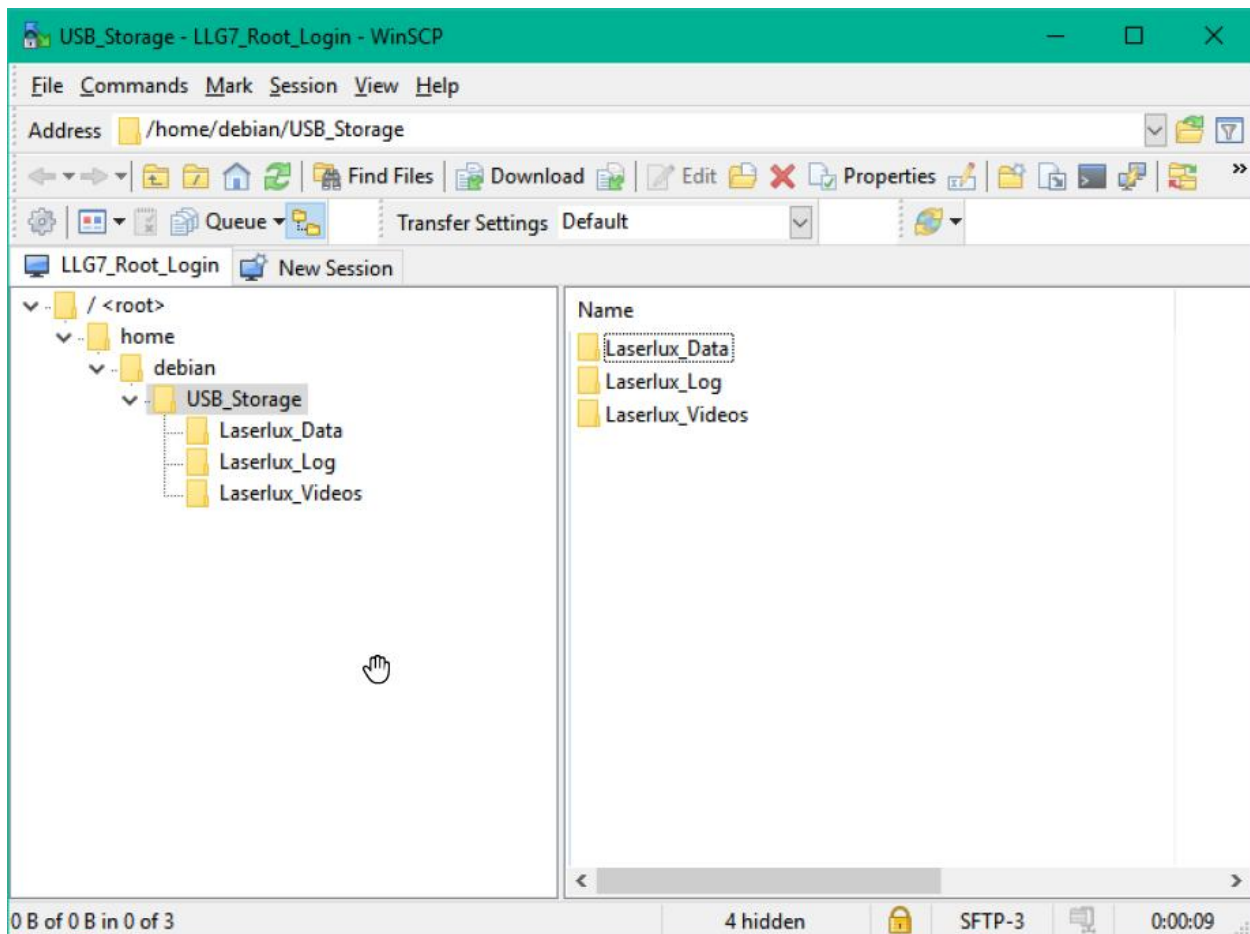
**Figure 28 - WinSCP Login Screen**

To manually configure the login:

File Protocol: SFTP  
Host name: 192.168.88.11  
Port number: 22  
User name: viewer  
Password: Laserlux

Once you are logged in, you will be taken to a window that looks very similar to the Windows Explorer as shown in Figure 29. Click the Refresh icon (two green arrows in a circle).





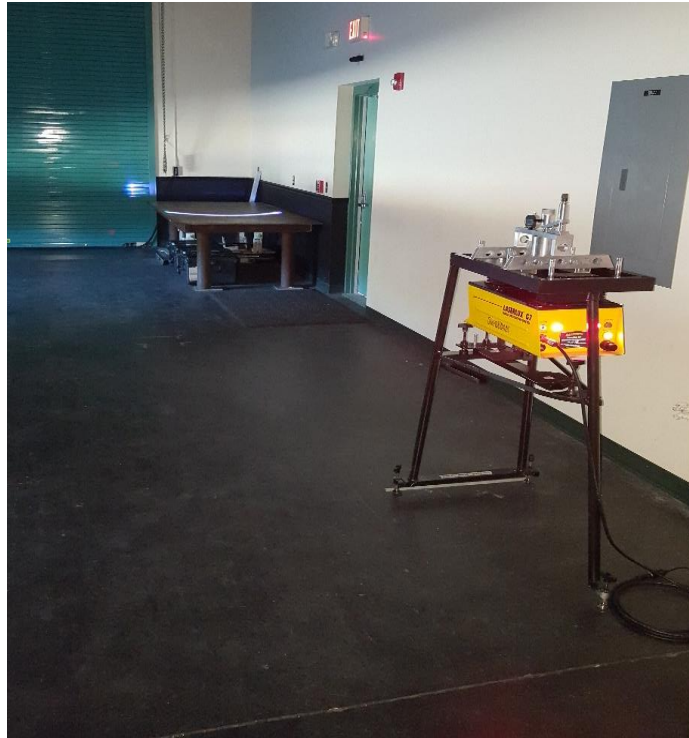
**Figure 29 - WinSCP file access screen**

The data is placed into three separate folders on the USB drive.

1. **Laserlux\_Log:** This folder contains log files for diagnostics that are not normally needed other than to troubleshoot problems you may have. A RoadVista service engineer may request you to send these files should you ever need to call for support.
2. **Laserlux\_Videos:** The recorded video files will all be saved to this folder and named with the file name as entered in the main user interface screen with a data and time stamp.
3. **Laserlux\_Data:** The folder is where the CSV data files and KML map files are saved. For every measurement run, there are 3 files created.
  - a. CSV file for the stripe and road data
  - b. KML for the color-coded Google Earth Map
  - c. CSV file for the experimental raised pavement marker data collection. These data file names will all end with "RPM" to distinguish them from the standard road data files.

## 6 MAINTENANCE

Florida Department of Transportation (FDOT) conduct a series of laboratory and field tests at the State Materials Office (SMO) located in Gainesville, Florida. The laboratory testing consists of a series of experiments that are conducted in a controlled environment (see Figure 30). Field evaluations are conducted on a series of roadways in Alachua County, Florida, with various pavement markings and pavement types. Table 1 [HC19] are the laboratory and field test requirements to be followed by the MRU Contractor for collecting data for the Pavement Marking Management System.



**Figure 30 – FDOT MRU Calibration Bay**

**Table 2 - Summary Requirements of Laboratory and Field Quality Assurance Test**

Type of Test		Key Item Check	Required Criteria	Testing Frequency
Setup and Visual Inspection		Distance	<ul style="list-style-type: none"> <li>• Accurate 30-meter geometry</li> <li>• <math>\geq 38</math>" lateral data collection area</li> <li>• <math>\leq 40</math>" longitudinal variation</li> </ul>	65 days
Verification Test		R <sub>L</sub>	$\pm 15.0\%$ of certified R <sub>L</sub> values	65 days
Background Noise Test		R <sub>L</sub>	$\pm 5.0\%$ of calibration panel	1 Year
Equipment Dynamics	Lateral	R <sub>L</sub>	$\pm 10.0\%$ from the center position value	65 days
DMI and GPS Accuracy	DMI (Mechanical)	Distance	$\pm 0.1\%$ ( $\pm 5.280$ feet) of a 1.0-mile surveyed section	65 days
	DMI (GPS-based)	Distance	$\pm 0.2\%$ ( $\pm 10.560$ feet) of a 1.0-mile surveyed section	65 days
	GPS	Position	$\pm 10.0$ feet of a surveyed point	65 days
Precision Test		R <sub>L</sub>	$\pm 10.0\%$ for repeatability and $\pm 15.0\%$ for reproducibility	65 days
Reflectivity Stability with Speed Test		R <sub>L</sub>	$\pm 10.0\%$ difference between two tests running at 35 mph and 55 mph	1 Year
Reflectivity Stability with Temperature Test		R <sub>L</sub>	$\pm 10.0\%$ difference from two tests running at two different temperatures within the day	1 Year
Operator Competency		R <sub>L</sub>	$\pm 75$ R <sub>L</sub> for the running mile comparisons between FDOT and the Contractor	2 Years

The details information about the types of test can be found at [..\Quality Assurance\FDOT Quality Assurance for MRU Testing. \[HC20\]](#)

The set up and calibration procedure is described in the link below.

[..\Special Requests\2018\SMO\MRU Calibration Study\MRU Calibration Report 5.2.18.docx \[HC21\]](#)

## 7 TROUBLESHOOTING

**Table 3 - Troubleshooting**

Problem	Troubleshooting Steps
Red lights on the back of the LLG7 are constant red and not blinking	This is a normal part of the power on process but can also indicate a problem. When first powered on, the lights will remain solid for 45-60 seconds before they start blinking. If they do not start blinking about 60 seconds, or if they were blinking, but then stop, there has been a power glitch that has caused the LLG7 to go into safety shutdown mode. Unplug the power cable from the cigarette lighter plug and wait 2 minutes. After 2 minutes, plug the cable back in, making sure it is firmly in place and power the unit on again.
Computer will not connect to the LLG7	Check to make sure you are connected to the Roadvista_XXXX or Roadvista_XXXX-5G. Connect if necessary. Check to make sure you are entering the correct address in your web browser. It should be 192.168.88.11 Check to make the red status lights on the rear panel of the LLG7 are on and blinking. If they are not on, check the power connections and power on the instrument. If they are on but are solid red, follow procedure above to resolve constant red lights.
Laser does not turn on	Make sure the laser power key switch is in the on position.
LLG7 is reading road stripes too low or inconsistent	Check to make sure the LLG7 is in Auto-Level mode. Check to make sure the front window is clean and clear of any dirt, bugs, or debris. If it is dirty, remove the front window and clean thoroughly using Windex and a microfiber cloth, or replace with a new, clean window.
Auto-Level indicator reports an error	Height sensor windows may be dirty. Clean then if they are. LLG7 may be mounted too high above the ground. The LLG7 has a range of 2.75" (7.0 cm) of vertical travel adjustment. From the home position 7" (17.8 cm) above the ground, to the measurement position 4.5" (11.4 cm) above the ground leaves only about 0.25" (0.6 cm) of travel left to adjust. If the road has a large crown to it, or the road drops off on the edge, you may need to lower the home position to 6.75" or 6.5" (17.1 or 16.5 cm).

## APPENDIX A: SPECIFICATIONS<sub>[HC22]</sub>

**Table 4 - Specifications of Laserlux G7**

<b>Geometry</b>	<b>CEN 30-meter</b>	<b>15-meter</b>
Entrance Angle	88.76° ± 0.01° (ASTM E1710)	86.50° ± 0.01°
Illumination Angle	1.24° ± 0.01° (EN1436)	N/A
Observation Angle	1.05° ± 0.01° (ASTM E1710)	1.50° ± 0.01°
Observation Angle	2.29° ± 0.01° (EN1436)	N/A
Receiver Aperture	0.24°	0.24°
Measurement Distance	6 meters (19 feet, 8.22 inches)	4.2 meters (13 feet, 9.35 inches)
Measurement Width	1 meter (39.4 inches)	
Operating Temperature Range	-7 to 50°C (20 to 122°F)	
Operating Humidity Range	5 to 95% R.H. non-condensing	
Measurement Rate	400+ measurements per second of a line	
Longitudinal Resolution of Measurement	Better than 3 inches at speeds up to 100 km/h (62 mph)	
Wireless Control via any PC, Tablet, or Smart Phone	iPad, Android, Windows, etc.	
Vehicle Platform	Mounts to almost any vehicle using removable mounting bracket	
Size	10" X 10.5" X 20" (255mm X 265mm X 505mm)	
Weight	Less than 12 kg (26.4 lbs)	
Additional Readings	Measures and counts Raised Pavement Markers (cat eyes, road studs, RPM's)	

Geometry	CEN 30-meter	15-meter
	Measures double lines individually with separate RL values for each line	
	Measures the night-time perceived pavement marking line width	
	High Definition video recording	
Options	Infrared retroreflectivity measurements for machine vision	
	Night-time color measurement	

## APPENDIX B: PHYSICAL MODEL

### 7.1 Laserlux Geometry

The Laserlux operates on the principal of 1/5 of the CEN prescribed 30-meter geometry. This means that all of the geometry is maintained, but the distance that the Laserlux is measuring is set at 6 meters. This geometry setup is equivalent to an average passenger car driver viewing 30 meters ahead of the vehicle. The observation angle (angle between light out and light in) of the Laserlux is  $1.05^\circ$  and the co-entrance angle is  $1.24^\circ$ . These angles conform to the specifications set forth in EN 1446 and ASTM 4061. The Laserlux uses a laser to simulate headlight illumination and retroreflectance. See the figure below for a schematic of the MRU geometry.

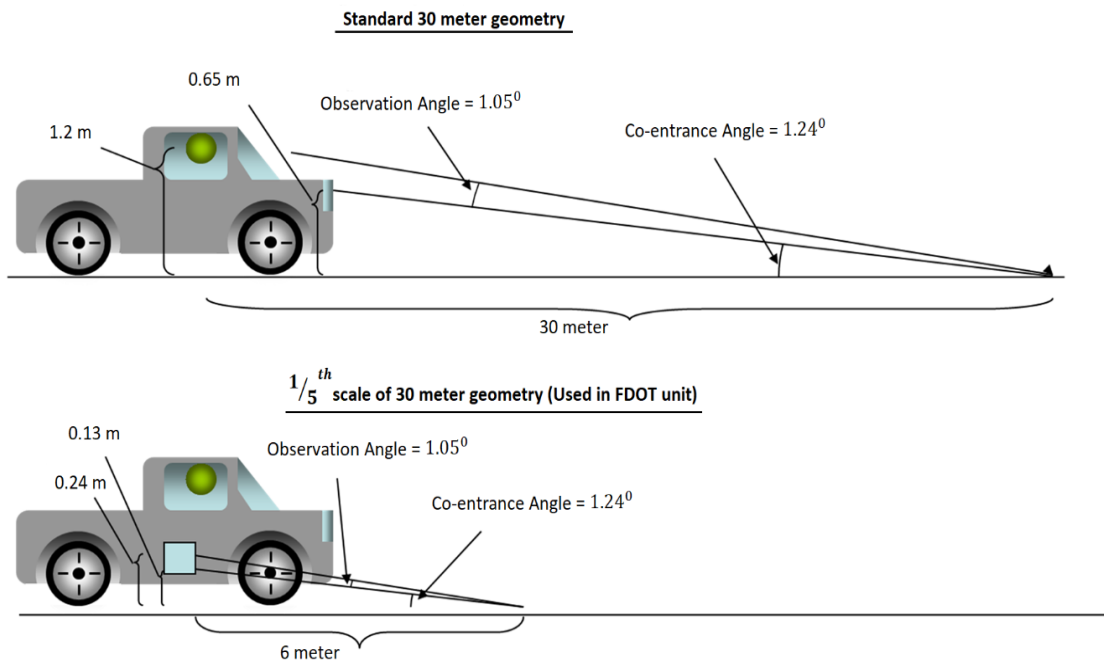


Figure 31 - Standardized CEN Geometry

### 7.2 Hardware

The Laserlux has a complex array of optical equipment inside that allows the manipulation of the laser light going out and being received. A detailed discussion of the physics and mechanics of the internal workings of the Laserlux is beyond the scope of this manual, but a schematic is provided in the figure below for reference.

## G7 Major Components

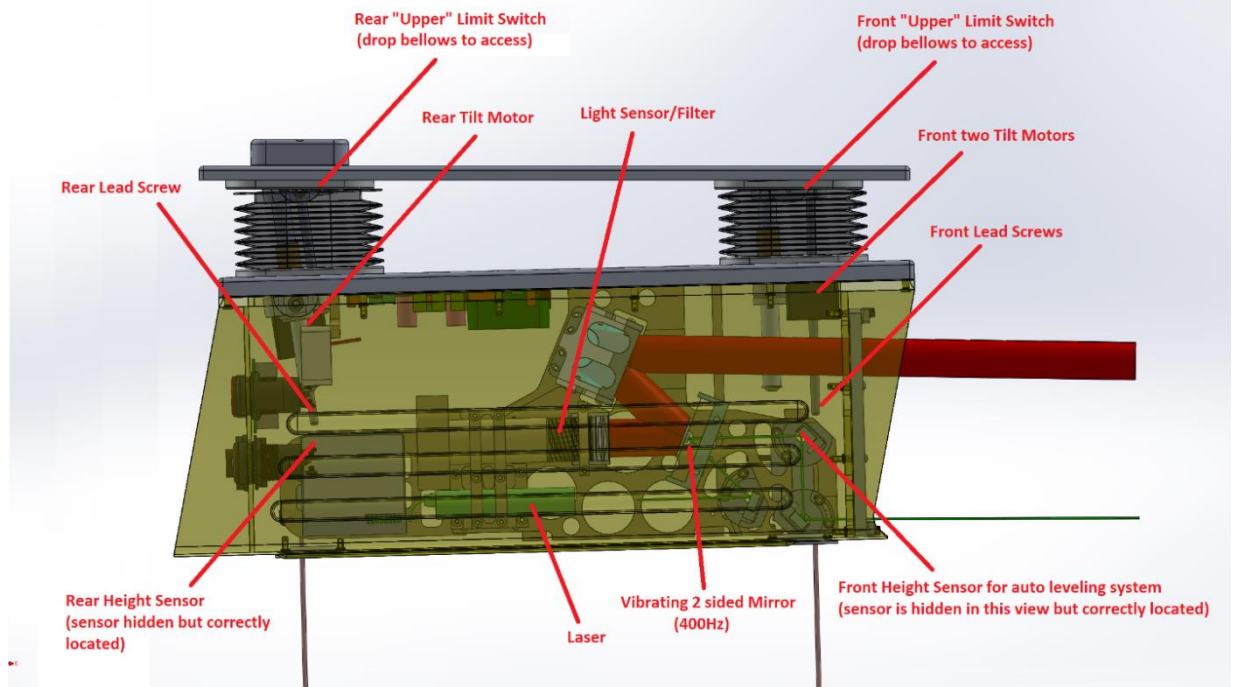
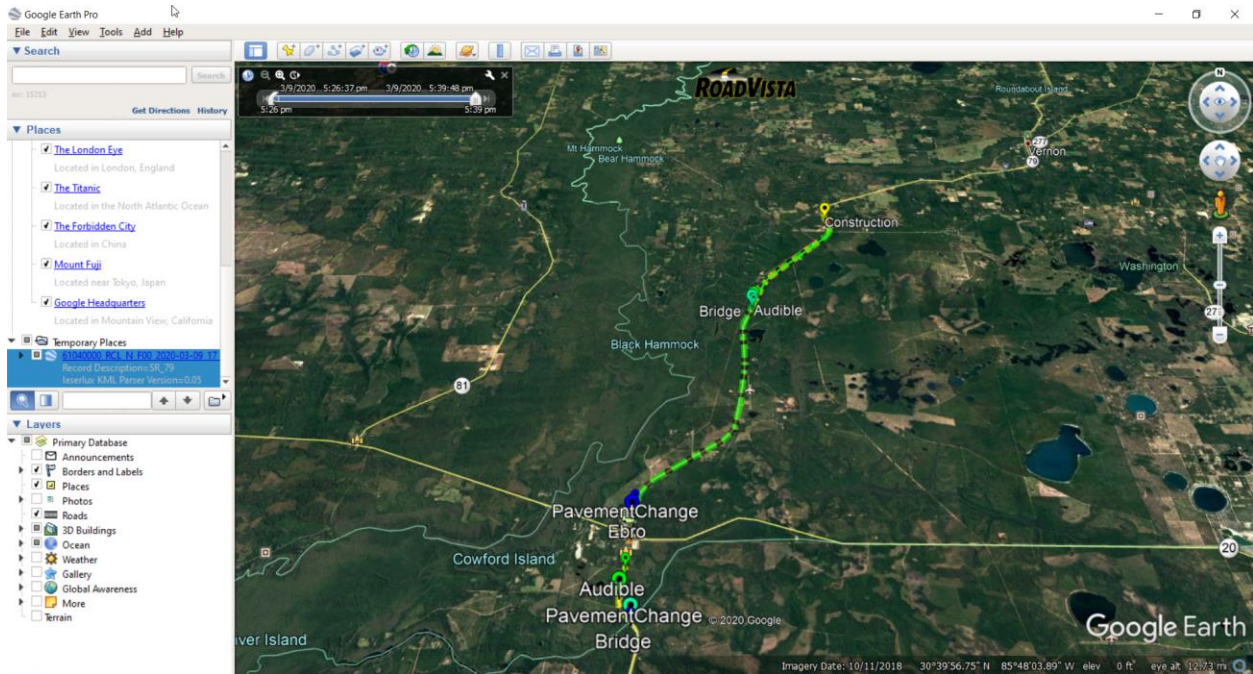


Figure 32 - MRU Schematic Diagram







**Figure 34 - Sample KML Map file**

**VIDEO FILE:**

The video files are saved in MPG format which can be viewed by most video players. The video files are broken into 5 minute segments by default to make it easier to locate the segment of video that corresponds to specific points in the data. The time length can be changed by the user if desired.

## **APPENDIX D: OPERATOR CHECKLISTS**

The following three checklists are here for operator reference. The start testing and end testing checklists should be performed each day of testing.

### Pre-Test Checklist

- Weekly Random QA MRU testing list
- County workbooks for all counties being tested
- ARA production data for comparison
- Tablet or laptop with chargers
- Wi-Fi hotspot with charger
- MRU LaserluxG7
- MRU power cord
- Forward facing camera
- MRU glass window
- MRU calibration panel
- Wrench for MRU mounting and removal
- Mounting bracket security pins
- Level
- Extra glass windows
- Window cleaner
- Clean microfiber cleaning cloth
- Can of compressed air
- Vehicle mileage logbook
- Fuel Card
- SunPass Transponder sticker
- Safety vest
- Mount Laserlux to vehicle - adjust for level and orientation - tighten
- Inspect cable ends and connect from vehicle to Laserlux
- Turn on vehicle
- Turn on Laserlux and allow it to warm up
- Connect computer to Laserlux and open browser to ensure proper connection
- Check glass for cleanliness (clean or replace as needed)
- Perform calibration and verification (repeat as necessary)

### Post-Test Checklist

- Save Files to computer and flash drive
- Remove Laserlux
- Store cables and Laserlux
- Rinse off vehicle to remove bugs and dirt

## APPENDIX E: RELEVANT SPECIFICATIONS AND STANDARDS

### 7.3 American Society for Testing and Materials (ASTM)

\*Please refer to the latest version of each specification

*Retroreflection Specifications:*

- D7585/D7585M: *Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments*
- E1710: *Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN- Prescribed Geometry Using a Portable Retroreflectometer* [K023]
- E2177: *Standard Test Method for Measuring the Coefficient of Retroreflected Luminance ( $R_L$ ) of Pavement Markings in a Standard Condition of Wetness*
- E2832: *Standard Test Method for Measuring the Coefficient of Retroreflected Luminance ( $R_L$ ) of Pavement Markings in a Standard Condition of Continuous Wetting*
- E808: *Standard Practice for Describing Retroreflection*
- E284: *Standard Terminology of Appearance*
- D4061: *Standard Test Method for Retroreflectance of Horizontal Coatings*

*Pavement Marking Material Specifications:*

- D2369: *Standard Test Method for Volatile Content of Coatings*
- D1214: *Standard Test Method for Sieve Analysis of Glass Spheres*
- D1155: *Standard Test Method for Roundness of Glass Spheres*
- D92: *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*
- D256: *Standard Test Method for Determining the Izod Pendulum Impact Resistance of Plastics*
- D2240: *Standard Test Method for Rubber Property – Durometer Hardness*
- D36: *Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)*
- D570: *Standard Test Method for Water Absorption of Plastics*

- D1210: *Standard Test method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage*
- D562: *Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer*
- D1475: *Standard Test Method for Density of Liquid Coatings, Inks, and Related Products*
- D3960: *Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings*
- D476: *Standard Classification for Dry Pigmentary Titanium Dioxide Products*
- D3723: *Standard Test Method for Pigment Content of Water-Emulsion Paints by Low-Temperature Ashing*
- D6628: *Standard Specification for Color of Pavement Marking Materials*

#### **7.4 American Association of State Highway and Transportation Officials (AASHTO)**

- M247: *Standard Specification for Glass Beads Used in Traffic Paints*
- T250: *Standard Method to Test for Thermoplastic Traffic Line Material*

#### **7.5 Florida Method**

- 5-541: *Florida Method of Test for Traffic Marking Field Test*
- 5-579: *Florida Method of Test for Traffic Striping Retroreflectivity*
- 5-600: *Florida Test Method for Determining the Retroreflectivity of Pavement Marking Materials Using Mobile Retroreflectivity Unit*

#### **7.6 FDOT Standard Specifications for Bridge and Road Construction**

- Section 706: *Raised Pavement Markers and Marker Adhesive*
- Section 709: *Two Reactive Components Pavement Marking*
- Section 710: *Painted Pavement Markings*
- Section 711: *Thermoplastic Pavement Markings*
- Section 713: *Permanent Tape Pavement Markings*
- Section 970: *Materials for Raised Pavement Markers and Adhesive*
- Section 971: *Pavement Marking Materials*

## APPENDIX F: MRU CONTACTS

### Gamma Scientific/Road Vista/UDT

<i>Contact</i>	<i>Position</i>	<i>Phone #</i>	<i>Email</i>
Eric Nelson	Director	888-279-8034	<a href="mailto:enelson@gamma-sci.com">enelson@gamma-sci.com</a>
Mike Batinica	Software Development	-	<a href="mailto:mjbatinica@aol.com">mjbatinica@aol.com</a>
Todd Heimer	East Coast Sales/Tech	781-420-2277	<a href="mailto:theimer@gamma-sci.com">theimer@gamma-sci.com</a>
Kong Loh	Mechanical Engineer	888-637-2758	<a href="mailto:kloh@gamma-sci.com">kloh@gamma-sci.com</a>
Julie Atzen	Customer Service Mgr.	888-637-2758	<a href="mailto:jatzen@gamma-sci.com">jatzen@gamma-sci.com</a>
Quinn Adler	Sales	888-637-2758	<a href="mailto:qadler@gamma-sci.com">qadler@gamma-sci.com</a>

### University of North Florida

<i>Contact</i>	<i>Position</i>	<i>Phone #</i>	<i>Email</i>
Dr. Jim Fletcher	Principal Investigator	904-620-1844	<a href="mailto:jfletch@unf.edu">jfletch@unf.edu</a>