SL-RAT®
by INFOSENSE, INC

Sewer Line Rapid Assessment Tool & Sewer Line Data OrGanizer

User Manual

InfoSense, Inc
Innovating Acoustic Inspection Technology™

Portions of this product produced under license from the University of North Carolina at Charlotte

MADE IN U. S. A.

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1. Introduction

Thank you for purchasing the Sewer Line Rapid Assessment Tool or SL-RAT® device from InfoSense. The SL-RAT® uses a patented technology to quickly provide an assessment of blockage conditions in gravity fed sewer lines. Our device is comprised of two portable components – a transmitter unit (TX) that "yells" and a receiver unit (RX) that "listens." The TX and RX are placed on top of adjacent manholes, requiring no flow contact or confined space entry. Our technology enables you to understand blockage conditions in real-time and aids in effectively deploy cleaning resources.

The associated software, the Sewer Line Data OrGanizer or SL-DOG®, enables quality control and archiving of SL-RAT data. Pipe segment location and length can be verified with the integrated GPS, and acoustic scores can be integrated with GIS data. The full standard practice for prioritizing sewer pipe cleaning operations using transmissive acoustic technology can be found in the F3220-17 ASTM Standard Guide (ASTM International).

2. SL-RAT Overview

2.1. Features

- Low Operational Cost
- Rapid Results – Typically Under 3 minutes/segment
- Safe - No Flow Contact
- Field Tested – Ruggedized Design
- Easy to Use – Train Operators in Minutes
- Onsite Results – Easy to Interpret
- Portable – Transmitter and Receiver Combined Weight Less Than 30 lbs
- GIS Integration - GPS Enabled
- Wireless communication between TX and RX (XBEE)

2.2 Applications

- Focus Cleaning Crews on Dirty Pipes
- Perform Quick & Low Cost "Pre-maintenance" Basin Assessments
- Avoid Downstream Overflows Caused By Upstream Cleaning Activity
- Avoid Repeat Overflows – Identify Hot Spots After Spill Events
- Post-Cleaning – Quality Assurance

2.3 Identify Parts and Controls

The SL-RAT® device is composed of two parts. The transmitter (TX) component is identifiable by its bulkier speaker housing containing a heavy-duty marine grade speaker, and its heavier weight (Figure 1). The receiver (RX) is identifiable by its smaller sensor housing containing a high-quality microphone, and its lighter weight (Figure 2). Each component is also labeled with a "TX" or "RX".

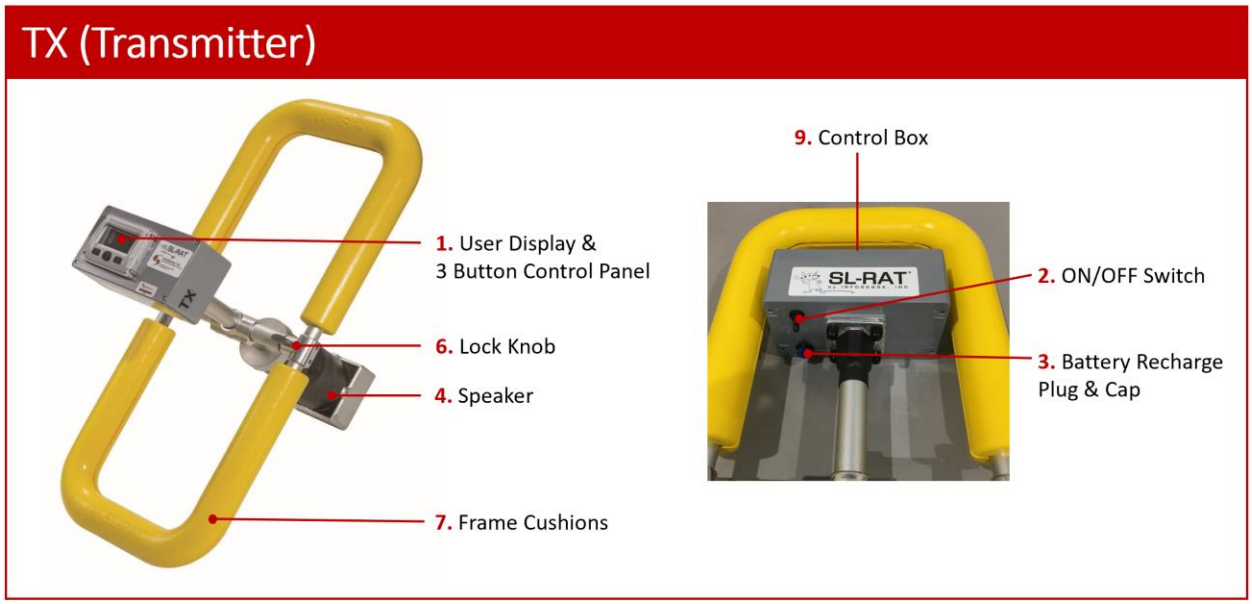


Figure 1 Major sub-components of the SL-RAT® device's Transmitter (TX) Component

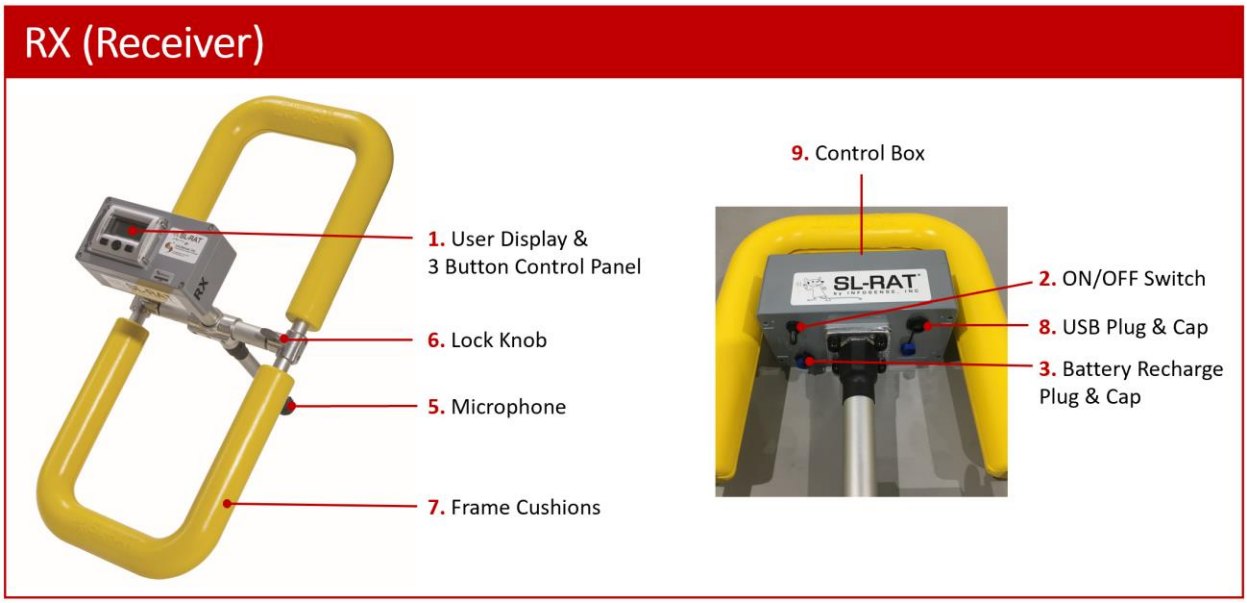


Figure 2 Major sub-components of the SL-RAT® device's Receiver (RX) Component

1. **User Display & 3 Button Control**: (TX & RX) Provides the user interface for making acoustic measurements and obtaining status information from the RX & TX components.
2. **ON/OFF Switch**: (TX & RX) Turn on by moving the toggle switch forward. This provides battery power to the component. When in the on position (Forward), the User display & 3 Button Control will be operational. If you are not planning on using the RX and TX components for an extended period (more than one hour) - Turn off the power by moving the toggle switch back.
3. **Battery Recharge Plug & Cap: (**TX & RX) The battery is recharged by connecting the provided AC adapter's Battery Recharge Jack into the plug. To comply with the SL-RAT warranty, only use the provided Battery Recharger which has been specifically engineered to support the SL-RAT device. When not being charged the Battery Recharge Plug Cover must be securely fastened to prevent moisture & dirt from entering the RX & TX components and to comply with the SL-RAT warranty.
4. **Speaker:** (TX Only) Is a rugged heavy-duty marine-grade speaker used for generating the sound signal received by the RX component. It needs to be inserted below the plane of the manhole but never into waste flow during acoustic measurements. Care should be taken to make sure speaker is not fouled with debris.
5. **Microphone:** (RX Only) Is a rugged harsh environment microphone used for detecting the sound waves generated by the TX component. It needs to be inserted below the plane of the manhole but never into waste flow during acoustic measurements. Care should be taken to make sure microphone is not fouled with debris.
6. **Lock Knobs:** (TX & RX) Two lock knobs per RX & TX component which allow the TX speaker or RX microphone to be transitioned from the open/measurement position to the closed/transport position.
7. **Frame Cushions:** (TX & RX) Used to support the RX & TX component during measurements. Provides limited protection to the electronics case and speaker or microphone during transportation when Transporting directions are correctly followed.
8. **USB Plug & Cap:** (RX Only) Allows acoustic measurements conducted in the field are uploaded to the SL-DOG® Portal via USB Cable. This allows secure historical archiving, and additional analysis. When not being used the USB Plug Cover must be securely fastened to prevent moisture & dirt from entering the RX component and to comply with the SL-RAT warranty.
9. **Control Box:** (TX & RX) Enclosure component that integrates user display and 3 button control, ON/OFF Switch, & Battery Recharge plug & cap.

2.4 Transporting

2.4.1. Transporting by Foot

When transporting the SL-RAT® TX & RX components by foot, follow the procedures in this section to reduce the possibility of damage.

1. Place TX & RX in closed/transport position (see Figure 3)
2. Securely tighten the two Lock Knobs on both the TX & RX (see Figure 3)
3. When transporting the SL-RAT TX and RX by foot over short distances, carry in closed/transport position.

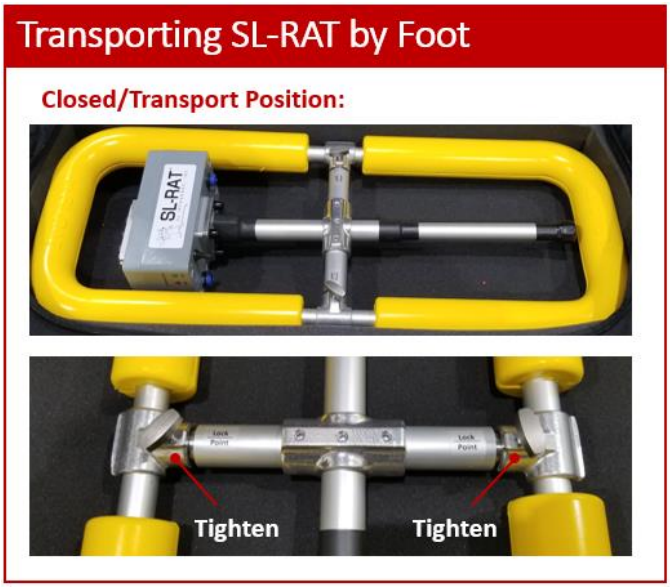


Fig. 3 – Transporting SL-RAT by foot – tighten lock knobs to secure in closed position

2.4.2. Transporting by Vehicle

When transporting the SL-RAT TX & RX components by vehicle the procedures in this section are required to reduce the possibility of damaging the TX & RX components and to comply with the SL-RAT warranty.

1. Place TX & RX in closed/transport position (see Figure 3)
2. Securely tighten the two Lock Knobs on both the TX & RX (see Figure 3)
3. Place TX in the carrying case on top of first Foam Insert (see Figure 4)
4. Place second Foam Insert on top of TX
5. Place RX in the carrying case on top of second Foam Insert (see Figure 4)
6. Place third Foam Insert on top of RX
7. Securely Close the carrying case (see Figure 4)

If dirty, we recommend wiping down the components prior to placing in the carrying case with a nonabrasive cleaning agent or damp cloth (see Section 8.2.1 on General Cleaning Recommendation – pg 34). This will reduce fouling of the Foam Inserts and extend the service life of the carrying case. Additionally, it is a good habit to inspect the components prior to transport for damage, for battery charge level, and for dirt or other foreign material that may have become lodged in the microphone or speaker housings.

Fig. 4 - Transporting SL-RAT by Vehicle

3. Daily Acoustic Operation Process

At the start of each day prior to starting inspections, TX and RX operation should be verified. Use menu to navigate to “Verify Operation” and run one verification test to ensure that units are synced and communicating correctly (see pg.16 or reference ASTM Standard for details). We recommend deploying TX and RX in an “inchworm method” for optimizing data management process. This means moving both the TX and RX, rather than “leapfrogging” by moving only one of the devices to the next manhole (see figure 5).

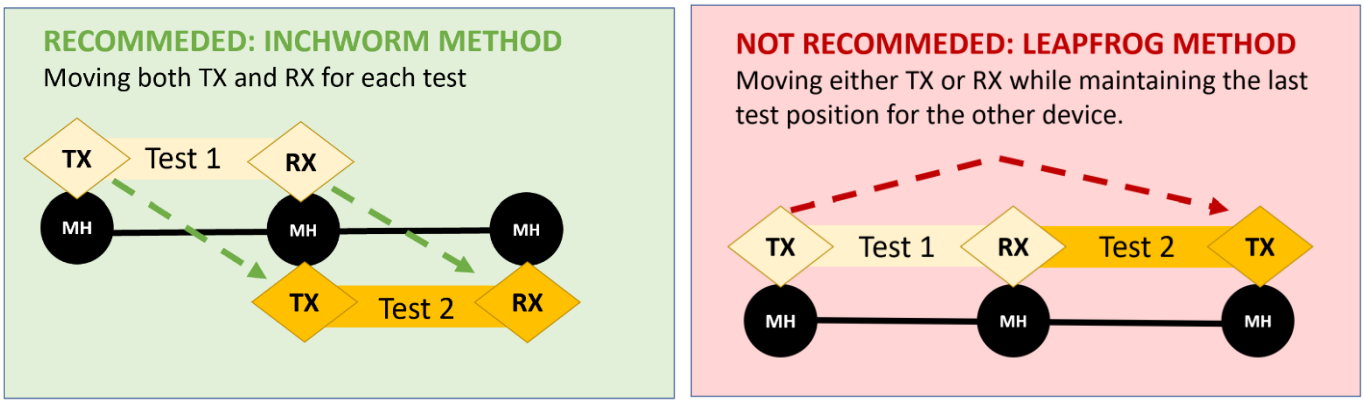


Fig. 5 – When conducting acoustic tests, we recommend using inchworm method of deploying TX and RX rather than leapfrog method to make it easier to manage and edit the data after downloading.

Steps for Using the SL-RAT® - Based on ASTM Standard Verification Process

STEP 1	Turn on both Transmitter (TX) and Receiver (RX) by using toggle switch on the bottom left side of the control boxes. Sync devices and acquire GPS coordinates. Verify Operation by going to menu and selecting "verify operation." (see page 16)
STEP 2	Deploy TX and RX by placing the devices on adjacent manholes (Fig 6). **! Do not knowingly skip manholes**
STEP 3	Prepare RX unit for pipe inspection – do not start test yet.
STEP 4	"Start Test" on TX device. Then press "Start Test" on RX device. **! Remember: Start the TX before you start the RX. "Yell" before you "Listen"**
STEP 5	Test results displayed on the RX once test is complete and the TX's tones will automatically be terminated. If the TX does not automatically stop after score is generated, manually stop test by pressing and holding center button on display

Fig. 6 – SL-RAT deployment for acoustic measurement of the pipe segment between two adjacent manholes.

Once started, the test is automated. The SL-RAT RX displays real time graphics indicating both the test's progress and the performance. The SL-RAT TX displays real time graphics indicating the number of tone sequences completed. The SL-RAT RX & TX control and operation are performed through a series of screens on the User Display and through the 3 Button Control.

! IMPORTANT UPDATES FOR Version 2.8

- You are now required to download measurements when RX unit reaches storage capacity at 500 measurements to protect data. **See SL-DOG Section for more information (page 21)**
- If TX unit states "RX/TX Synch Required," sync devices by turning both TX and RX units off (Step 1; page 8) or going to menu and selecting "Data Sync" (Menu Operations – Pg. 16)

3.1. STEP 1. Turn on both TX and RX Devices

The SL-RAT TX and RX components are provided as a pair. They are factory calibrated to operate as a single device when performing an acoustic measurement.

The TX and RX automatically go through a series of initializing screens on the user display when both devices are turned on (toggle switch is turned to the "on" position) and positioned close to each other (less than 50 ft). They will synchronize data and acquire GPS. It is best practice to turn devices on outside, with a clear view of the sky, so GPS coordinates can be easily acquired.

Once initializing is complete, operators see respective start up screens in step 2 (RX) and step 3 (TX).

Verify Operation should be done once a day at the start of the day. Select menu (see page 16 or reference ASTM Standard for details).

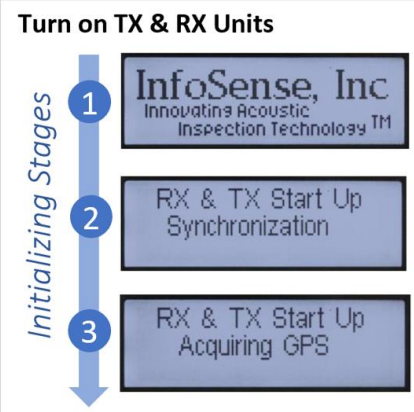
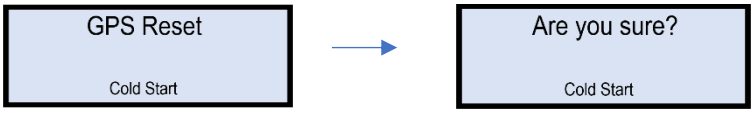


Fig 7. Devices will automatically go through the initializing stages of synchronizing and acquiring GPS when turned on.

! TROUBLESHOOTING – GPS Reset/Cold Start

If a device cannot acquire GPS within three minutes, the operator is given the option of resetting the GPS, by pressing the <Cold Start> button. Operator must verify that they wish to reset the GPS.



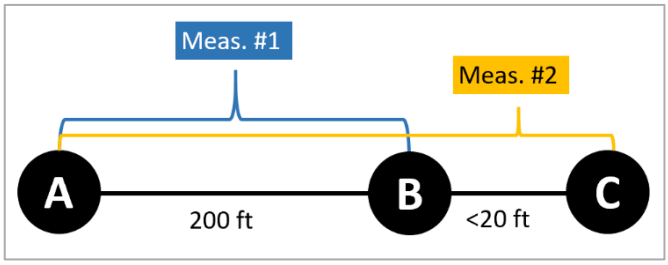
Please note, resetting the GPS takes 15-30 minutes. The device will continue to search for GPS when the "GPS Reset" screen populates, so operator can choose to wait for device to acquire GPS without cold starting, if desired.

3.2. STEP 2. Deploy TX and RX units over Adjacent Manholes

An acoustic measurement is typically conducted by deploying the TX and RX components in adjacent manholes. The following guidelines should be followed with Figures 7 and 8 illustrating typical deployments.

! Do not knowing skip manholes in this process – see #5 below for exception case

1. Reasonable care should be used when deploying and removing TX and RX components from the manhole to prevent damaging the speaker or microphone.
2. Deploy the RX & TX by setting the component on an open manhole in the Open/Measurement position (See figures 8 & 9). The frame should rest securely on the frame/manhole cover when deployed.
3. Speaker/microphone should be approximately one foot below the plane of the manhole.
4. Speaker/microphone should be approximately centered within the manhole entrance. The area below the speaker/microphone should have at least one-foot clearance from any obstruction within the manhole.
5. If the distance between adjacent manholes is less than 20 feet (6m), then the acoustic measurement for the short segment should be coupled together with the next adjacent segment. For example, if the distance between A and B is 200ft, and the distance between B and C is <20ft, then two measurements should be made.



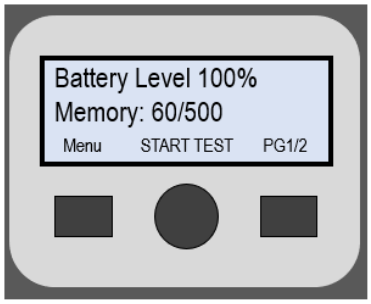
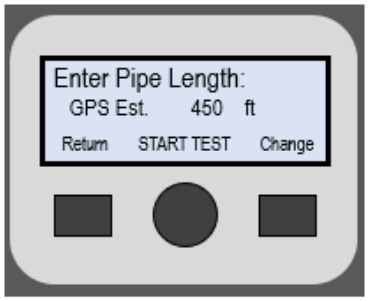
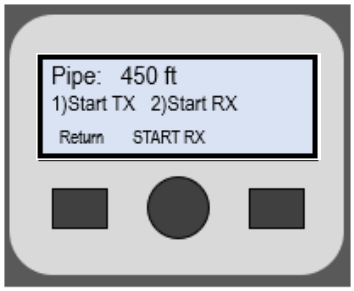
   1. First measurement should be between manholes A and B for the 200ft (61m) segment.
   2. Second measurement should be between manholes A and C for the combined 200ft + <20ft where B is skipped.
6. Measurements can be conducted with or without the manhole cover fully removed, as illustrated in the Figures 8 and 9.
7. Once the acoustic measurement is completed, carefully remove the components from the manhole and deploy to the next segment. (See Page 8, Figure 5 for recommended “inchworm” deployment method.)

Fig 8. SL-RAT RX in Open/Measurement position - deployed with microphone centered and one foot below pane of manhole. Manhole cover removed for measurement.

Fig 9. SL-RAT TX in Open/Measurement position - deployment with manhole cover only partially removed for the measurement.

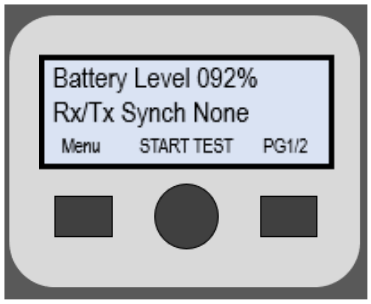
3.3 STEP 3. Prepare RX (Receiver) Unit for Inspection

During an acoustic inspection for a pipe segment, the RX component receives the sound signal generated by the TX component. Based on the characteristics of the received signal, it assesses the condition of the pipe segment between the TX location and the RX location. After correctly deploying the RX, the steps for operating the RX are as follows:

Ref #	User Display	Description
RX1	RX Startup (1/2) 	From the RX Startup Screen, start the RX acoustic measurement operation by pressing the center button **<START TEST>**. **Memory** indicates how many acoustic measurements are stored on the device. **! The RX will require that records be uploaded to a computer when it reaches storage capacity at 500 measurements.**
RX2	Pipe Length Menu 	The next screen is the Pipe Length Menu. If the RX and TX are sufficiently close to each other, then the distance between the components is estimated based on GPS. The initial pipe length displayed on the screen will indicate if it is a GPS Est. (GPS Estimate) or the Default value (350 feet). Operator should verify or change this value as needed. • Press the right key **<Change>** to cycle through range of values (50ft to 750ft) in 100-foot increments. • Press the center key **<Start Test>** to proceed. • Press the left key **<Return>** to return to Startup Screen. **! It is important for the operator to record accurate pipe length distances to obtain accurate field assessment results**
RX3	RX Ready 	By verifying the pipe length, the RX is ready for the TX unit to begin test. Indicate to operator with TX to begin test – this is typically done via hand signal or walkie talkie. **! Remember: Start the TX before you start the RX. "Yell" before you "Listen"** As soon as TX begins tone sequence (end of Step 4), press center button <**START RX**>.

3.4. STEP 4. Start Test on TX unit, then Start Test on RX unit

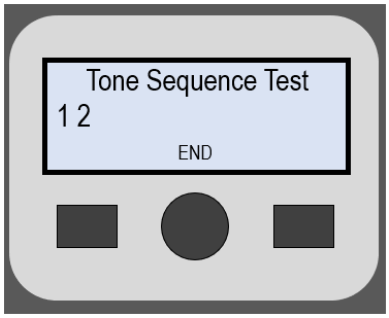
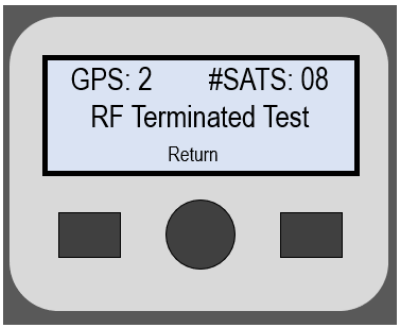
During an acoustic inspection for a pipe segment, the TX transmits a sequence of tones and this sequence is repeated up to 12 times over the duration of the measurement. The TX needs to be started prior to starting the RX. After correctly deploying the TX, the steps for operating the TX are as follows:

Ref #	User Display	Description
TX1	TX Startup (1/2) 	From the TX Startup Screen, start the TX acoustic measurement operation by pressing the center button **<START TEST>**. **Rx/Tx Synch Status** indicates whether RX and TX need to synch. The devices automatically sync every time they are turned on. **! The TX will require synch if it reaches 200 unsynchronized records. Status can be as follows:** • **RX/TX Synch None:** All measurements are synched • **RX/TX Synch Ready:** 1-150 measurements waiting to synch • **RX/TX Synch Warning:** 150-199 measurements waiting to synch • **RX/TX Synch Required:** Data must be synced to continue operation. Devices have reached capacity at 200 unsynchronized measurements.
TX2	TX Start Test 	Once operator with RX signals that RX is ready, press the right button <**Start**>. Operator with RX can press <**Start RX**> as soon as the TX begins emitting sound tones (Ref #RX3).

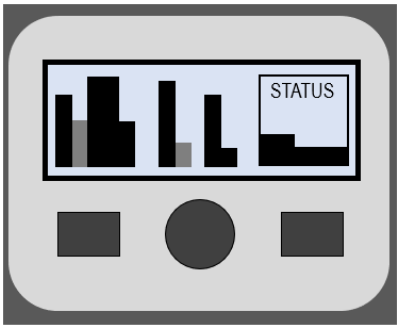
3.5. STEP 5. Complete Test

The following screens will display as the test is being conducted. The TX will go through a series of tones 6 to 12 times. The test is complete once the RX provides an acoustic blockage assessment score (GOOD, FAIR, POOR, BLOCK):

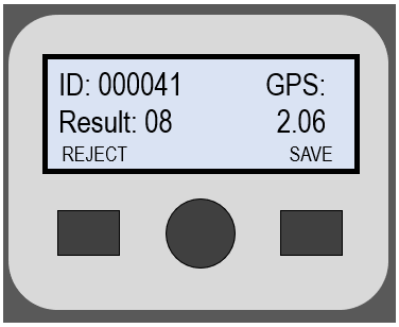
During Testing: TX Display Screen

Ref #	User Display	Description
TX3	TX Real Time Display 	The TX Real Time Display counts tone sequences transmitted. If TX and RX are able to communicate wirelessly, the TX should automatically stop producing tones once RX displays score (Ref #RX5). If it does not, operator can manually stop test by pressing and holding down center button <**END**>. At a maximum, the TX automatically ends the transmission after 12 tone sequences. While it is best to "END" the TX operation to maximize battery life once RX has reached an assessment, running through additional tone sequences does not impact the assessment score.
TX4	TX Results 	TX Results screen shows how the test was terminated, and what the GPS and Satellites • GPS Status (0 – no estimate; 1 – normal; 2 – differential; Other value – tracking modes, typically with limited or no satellites in view) • #SATS: Number of satellites used to estimate TX location • Indicates how the test was terminated (User, RX via RF interface, or Normal) Press <**Return**> to go back to startup screen

During Testing: RX Display Screen

Ref #	User Display	Description
RX4	RX Real-time Display 	The RX Real-Time Display will provide graphics to indicate the RX is in test mode. The status bar on the right is incremented at one second intervals. After 16 seconds, a graphical display appears, which provides measurement status for individual components used in assessing the pipe status.

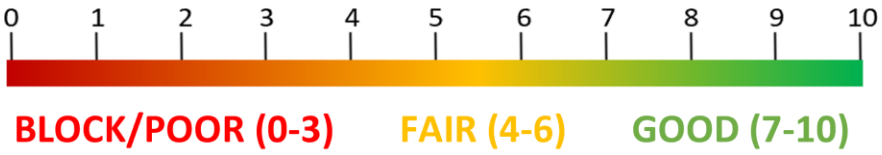
3.6. STEP 6. View Test Result on RX

Ref #	User Display	Description
RX5	Pipe Segment Classification 	Once the testing is complete, the Pipe Segment Classification (see figure 9) is displayed first. The classification can be one of the following five possibilities: • GOOD (Pipe Segment Assessment from 7 to 10) • FAIR (4 to 7) • POOR (1 to 3) • BLOCK (0) • NOISE – indicates that noise impairment was enough to invalidate test. If this occurs, it may be possible to either repeat the test and/or to swap the locations of the TX and RX. • CLOSE - The SL-RAT transmitter unit (TX) and the SL-RAT receiving unit (RX) were too close during the measurement. The Pipe assessment may be corrupted. If the TX is continuing to produce sound (Ref #TX3) after RX displays pipe segment classification, manually stop test. Press <Return> to proceed to Pipe Assessment Details
RX6	Pipe Assessment Details 	The Pipe Assessment Details shows the following: • Measurement ID: a unique ID number for the test • Result: Numeric result from 0 to 10 • GPS: The first number indicates GPS Status, and the second number (following the decimal) indicates number of satellites. The GPS Status can be any of the following: 0 – no estimate; 1 – normal; 2 – differential; Other value – tracking modes, typically with limited or no satellites in view. Operator can press <SAVE> to save measurement data. By pressing <REJECT>, operator still saves measurement but flags the data as being rejected by operator. ! For data protection purposes, there is no way to delete measurements on device. They can be removed for viewing purposes in SL-DOG.

To view collected acoustic data, download data then go to www.sl-dog.com and log in to access data in a secure, cloud-based web portal. Operators must create an account to access data. See Sewer Line Data OrGanizer (SL-DOG) Section in Manual for more information (See page 20).

Assessment	Typical Condition / Interpretation
10	No significant obstructions within the pipe
7-9	Minor impediments within the pipe such as joint offsets, partial sags, protruding laterals, debris, minor grease, and/or minor root fibers.
4-6	Impediments within the pipe such as joint offsets, partial sags, protruding laterals, debris, grease, and/or root fibers. Single or multiple occurrences.
1-3	Significant impediments within the pipe such as multiple joint offsets, near full pipe sag, multiple protruding laterals, significant debris, significant grease, significant root fibers and/or root balls. Single or multiple occurrences.
0	Full pipe sag; single or multiple obstructions within the pipe reaching or nearly reaching the flow.

Table 1. Description of typical conditions for each acoustic assessment score.



4. General Operations

4.1 Menu Operations

The menu can be accessed by pressing the left button <**Menu**> on the Startup Screen. Menu list is displayed in Figure 10. The left key is used to scroll through the options.

To select, bring desired option to the top line by using left key and press right button <**Select**>. A test can be started by returning to the startup screen by pressing the center button <**Return**>.

To return to menu after selecting an item, press the center button <**Return**>. Each option is described below, and is available on both TX and RX, unless noted otherwise:

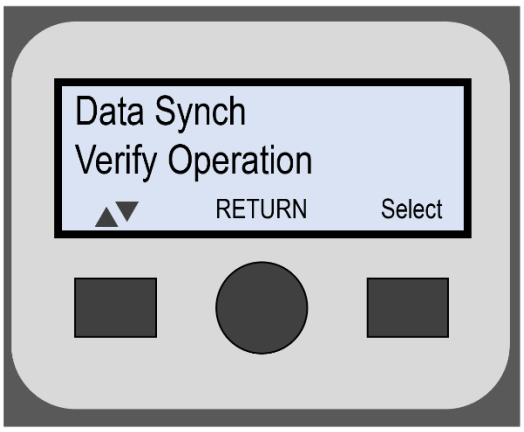


Fig 10 - The Menu can be accessed by pressing the left button, <Menu>, on the Startup screen of both TX and RX units

Data Synch: (RX Only) Initiates data synchronization between the TX and RX, if they are in communication range of each other (less than 50' and free of obstructions between) and should remain close while the transfer takes place). Once the transfer is completed, both displays will automatically return to the Startup screen. The time required for data synchronization depends on the number of measurements conducted since the last synchronization. We recommend Data Synch to be conducted at least once every 10 measurements. Synchronization allows measurements to be validated. Table 2 lists the possible outcomes for the measurement validation process and the measurement condition which causes the outcome.

Table 2. Data Synch Status and descriptions

Measurement Status	Condition
Valid	No anomalies in the measurement conditions were detected
Early	The SL-RAT transmitter unit (TX) was stopped prior to the SL-RAT receiving unit (RX) completed its processing. The Pipe assessment may be corrupted.
Late	The SL-RAT transmitter unit (TX) was started after the SL-RAT receiving unit (RX). The Pipe assessment may be corrupted.
No TX	The SL-RAT transmitter unit (TX) was not turned on during SL-RAT receiving unit (RX) measurement. **The Pipe assessment is corrupted.**

Verify Operation: Provides method for verifying the TX and RX functional operation. The test is conductied with the TX tone sequence at a lower sound pressure level (-16 dB from normal test). To conduct a Verify Operation Test – the TX and RX should be located within one foot of each other. To start the test select Verify Operations on first the TX and then the RX .

Operator ID: Allows the operator to select/change the Operator ID recorded for each measurement. Operator ID values range from 1 to 30. The button on the left and right provide up and down scroll directions to change the Operator ID value. Center button returns to the Main Menu and selects the current value displayed as the Operator ID.

Review Results: Previous measurements can be reviewed. The RX & TX components can store up to 500 measurements. Once 500 measurements are reached, the RX will require that records be uploaded to a computer. The button on the left and right provide up and down scroll directions, respectfully.

- **RX Display**: Unique ID, Measurement Classification, Measurement Status (Synch – if the TX & RX have not been synchronized), Measurement's Date & Time, Pipe Length, Measurement Assessment.
- **TX Display**: Unique ID, Temperature, Measurement's Date & Time, Measurement Duration, Termination Condition (User Terminated, Normal, Low Battery).

System Info: The button on the left and right provide up and down scroll directions, respectfully.

- **RX Display**: Battery Level, RX Operator ID, Number Measurement Conducted on the RX, RX component serial number (Corresponds to the Face Plate SN), TX component serial number, Number of test requiring synchronization between the RX and TX, RX Firmware Version Number, RX Hardware Version Number, RX Build Date.
- **TX Display**: Battery Level, TX Operator ID, Number Measurement Conducted on the TX, TX component serial number (Corresponds to the Face Plate SN), TX Firmware Version Number, TX Hardware Version Number, TX Build Date.

Options:

- **XBEE Disable Option:** The XBEE refers to the wireless protocol between devices. To disable the XBEE, scroll down to the "XBEE Disable" Option and change to yes <Y>. To disable or enable the XBEEs, both TX and RX need to have their XBEE modules disabled. Disabling the XBEE will impact numerous operations. For more information on XBEE, reference page 18, Startup Menu (2/2) – XBEE Status & GPS

Power Save: Allows the operator to place units in power save mode when selected. In addition, the RX & TX components will automatically enter power save mode if left idle for 2 minutes. When in power save mode, screen will periodically remind operator the RX and/or TX component is still turned on. To exit power save mode, press the center key. Operator should turn off the SL-RAT if it is not in use for an extended period of time (more than one hour).

Contrast & Brightness: The contrast & brightness on user display can be adjusted to improve visibility. Every time the device is turned off and on, display returns to the default settings (132). Changing the contrast value too far from the default can cause the screen to blank or saturate. Increasing brightness can improve visibility in reduced light setting (e.g. indoors or at night). If the SL-RAT is being used outdoors during the day, reducing the brightness can typically improve battery performance. The button on the left is used to cycle between fields within the contrast & brightness. The button on the right is used to change the selected field.

Date & Time: Current date and time are provided based on GPS.

GPS Monitor: Provides the current GPS location data for the component. The GPS location is updated at 15 second intervals.

- **RX Display**: RX Latitude & Longitude specified in degrees, minutes, estimated distance to TX; RX and TX GPS status indicating both the type of GPS tracking and the number of satellites.

- **TX Display**: TX Latitude & Longitude specified in degrees, minutes, TX GPS status indicating type of GPS tracking and the number of satellites.

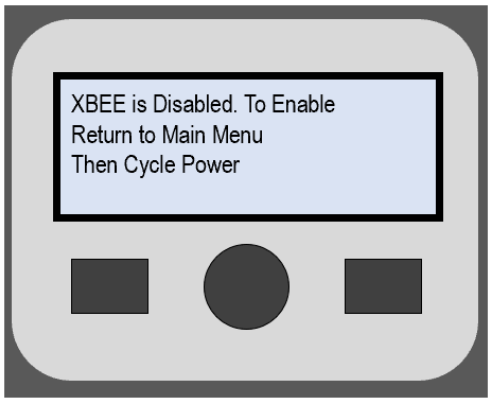
4.2. Startup Menu (2/2) – XBEE Status & GPS

The startup menu display is switched from page 1 to 2 by pressing the right bottom button <**1/2**>. The second startup menu displays the GPS Status and the XBEE status.

GPS Status: The first number indicates the operation status, and the values after the decimal indicate the number of satellites the GPS module is tracking. The operation status is as follows: (0 – no estimate; 1 – normal; 2 – differential; Other value – tracking modes, typically with limited or no satellites in view)

XBEE Status: Indicates the status of the wireless communication between the RX and TX devices. The XBEE status can be reported as GOOD, FAIR, LOW, Out of Range, and Disabled. Disabled is displayed for the XBEE status if the operator of the unit has disabled the XBEE through the options menu.

XBEE Disable Option: To disable the XBEE, operator must select Options from the Menu and scroll down to the "XBEE Disable" Option and change to yes <Y>. When the option is set to yes, the unit will display the following message:



! To disable or enable the XBEEs, both the TX and RX need to have their XBEE modules disabled.

To re-enable the XBEE, power both RX and TX devices off and on. For correct operation, the unit should first be returned to the Startup Menu at least once, prior to turning the device off.

! If the XBEE is disabled, the following operations no longer function:

1. Data Synch – warning message displayed on the RX
2. GPS based pipe length estimate made at the start of a blockage assessment. Pipe length estimate is set to the default 350 feet.
3. On the RX GPS Monitor, the distance estimate and TX GPS information is invalid.
4. Blockage assessment tests will not be automatically ended

4.3. Battery

The SL-RAT RX and TX are powered by a 11.1v Li-Ion battery pack rated at 44.4 Wh, 10A rate. The following directions are essential for correct operation and to avoid damage or loss caused by misuse.

1. Prior to using the SL-RAT RX and TX components in the field, verify the Battery levels are sufficient for the day's planned number of acoustic measurements.
2. To maximize use of battery, the device should not be consistently operated at low battery levels. It is recommended that device should be fully charged each time it is charged.
3. A Low Battery Warning occurs when the battery can no longer support additional measurements without being recharged. When a low battery warning occurs, the component should be turned off and recharged. Failure to do so can cause damage to both the battery and the component's electronics.
4. Only use the battery charger provided to recharge the units. Failure to do so can result in battery pack overheating and potentially catching fire.
5. The battery recharger jack is keyed to the plug on the RX & TX components. Make sure the keys are correctly aligned and do not force the connection. Failure to do so can result in battery pack overheating and potentially catching fire.
6. Prior to using the battery recharger visually inspect the wires for any damage. If damage is observed do not use, contact manufacture for a replacement battery recharger. Failure to do so can result in battery pack overheating and potentially catching fire.
7. Battery Recharger is for indoor use only. Do not expose the battery recharger to moisture or water.
8. Do not recharge battery while RX & TX are in the SL-RAT carrying case.
9. Do not open the cover of the battery recharger – High Voltage inside the charger can cause serious injury.
10. Do not operate the SL-RAT while recharging the batteries.
11. Do not use the battery charger to charge any other battery or battery pack.
12. In order to maximize the use of the battery, it is strongly recommended to disconnect the power plug from the wall socket after the battery is charged. The battery should be recharged every three months when it is not used.
13. If at any time you witness smoke, discontinue charging process immediately, disconnect the battery charger and observe the component in a safe place for approximately 15 minutes. Smoke maybe an indication of battery failure, and the reaction with air may cause the chemicals to ignite, resulting in fire.
14. Since delayed chemical reaction can occur, it is best to observe the battery as a safety precaution. Observation should occur in a safe area outside of any building or vehicle and away from any combustible material.
15. Never store or charge battery pack inside your car in extreme temperatures, since extreme temperature could lead to overheating of the battery and potential cause a fire. When transporting or temporarily storing in a vehicle, temperature range should be greater than 20 degrees F but no more than 150 degrees F.
16. Store battery at room temperature between 40- and 80-degrees Fahrenheit for best results.
17. Storing battery at temperatures greater than 170 degrees F for extended periods of time (more than 2 hours) may cause damage to battery and possible fire.

5. Sewer Line Data OrGanizer (SL-DOG®)

The Sewer Line Data Organizer, or SL-DOG, is a secure, cloud-based web portal that compliments the SL-RAT. By uploading acoustic inspection data, the SL-DOG enables productivity tracking, data quality management, error checking, editing, and integration with asset management workflows.

5.1. Required Items for SL-DOG Access

- PC with Windows Installed (XP, 7, 8, 10)
- Supported browser (Chrome, Internet Explorer)
- USB cable (provided with SL-RAT)
- Log in credentials to www.sl-dog.com
- Active internet connection

> ! Please Note, we have stopped distributing client download files in CD format. All updates should be made with links provided at www.sl-dog.com under Support Documents.

5.2. Desktop App Installation Instructions

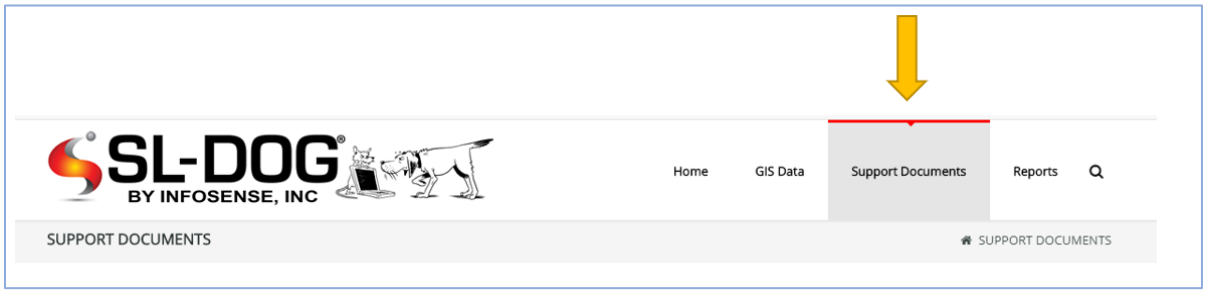
The desktop app (or local client) allows the SL-RAT to communicate with your personal computer. The desktop application is always free to download. Access to the web portal is a premium feature, and fee is required after first year of access.

Step 1 – Log into your SL-DOG Portal

Got to www.sl-dog.com in supported browser (Chrome, Internet Explorer) and log in using your username and password. If you do not have a username or password, please create an account by contacting InfoSense at sales@infosense.com

Step 2 – Go to Support Documents

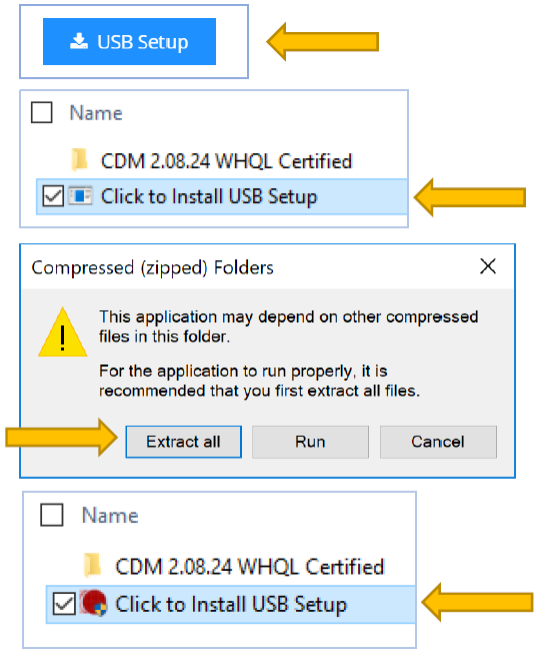
Navigate to Support Documents after logging into your portal.



> ! Anti-virus software could prevent installation from happening or require additional administrative information to initiate download. If user does not have permission to install and download fails, user will be notified in dialog box.

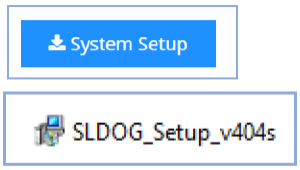
Step 3 – Install USB Driver

- Click <**USB Setup**> under "Required Downloads for SL-DOG"
- Once compressed file downloads, double-click **<Click to Install USB Setup>** to extract files.
- Click <**Extract all**> – this will download the compressed files to your computer.
- Once files are extracted, double-click **<Click to Install USB Setup>** to complete download



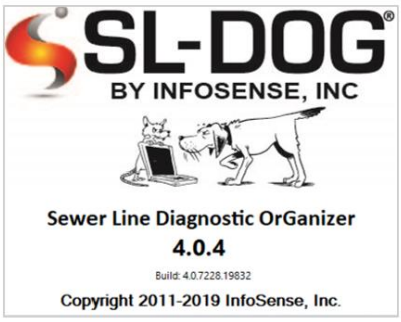
Step 4 – Install System Setup

- Click <**System Setup**> under "Required Downloads for SL-DOG"
- Once file downloads, select file <SLDOG_Setup_v404s> to initiate update



Step 5 – Verify Publisher and Run Program

Depending on your virus protection software or PC configurations, Windows may signal a warning. Please select <**More Info**> and ensure that the Publisher is InfoSense, Inc. and select <**Run anyway**> as needed. Follow installation steps. Download time depends on the user's internet speed and connection. We anticipate the update should not take more than a few minutes in most cases.



5.3. Uploading Measurements from SL-RAT

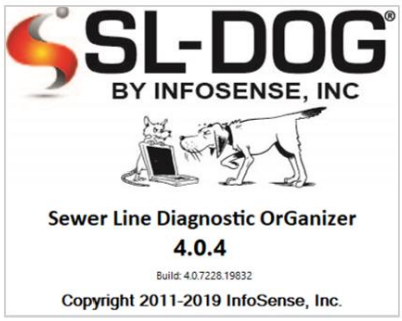
Once you have successfully installed the USB Setup and System Setup, you are ready to upload measurements. After collecting measurements in the field, follow the instructions below to transfer raw data from your SL-RAT to your SL-DOG portal.

To upload measurements, turn the SL-RAT RX unit on. Plug in the USB cable. The USB port is located on the bottom of the SL-RAT unit.

> ! Ensure SL-RAT RX and TX units are synched before plugging in RX. This can be done by turning both units off and on.

The display screen on the SL-RAT should show the following:

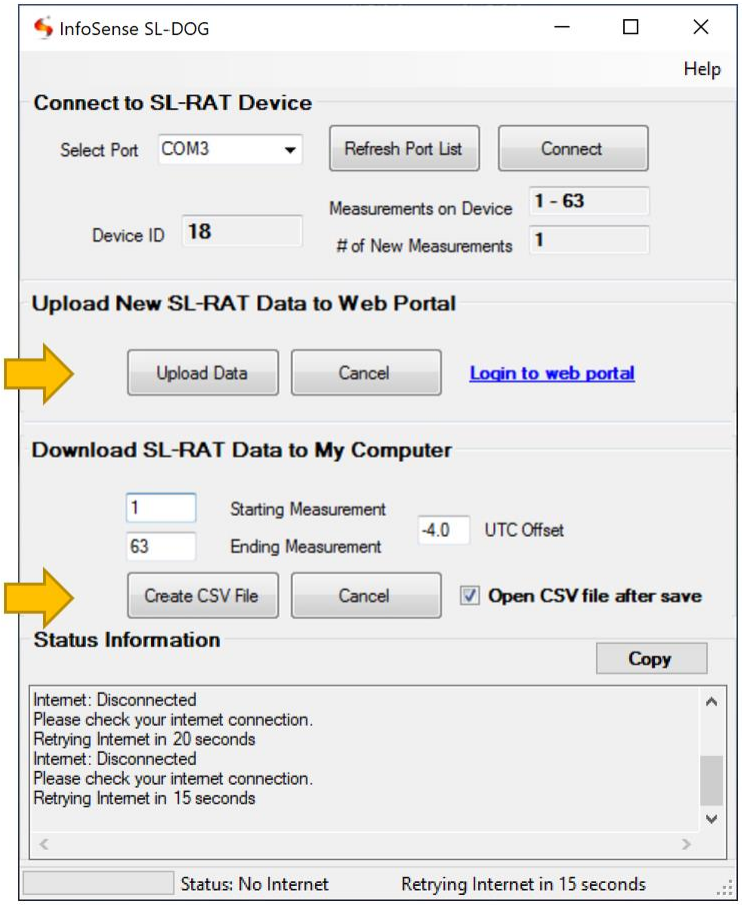
Click on your SL-DOG desktop app (generated during installation) on your desktop.



If the SL-RAT RX is properly connected (turned on, data synched with TX) and Internet is connected, the SL-RAT device will communicate with the server and determine what measurements are on the device. Select <Connect> to auto populate fields (Device ID, Measurements on Device, # of New Measurements), and you will be able to view the data in two ways:

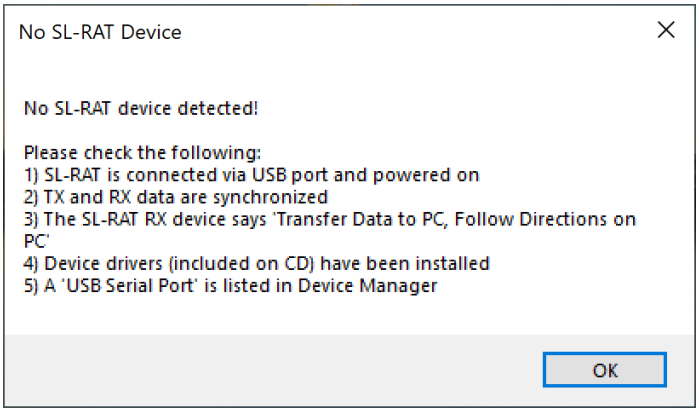
Upload New SL-RAT Data to Web Portal pushes data to the web portal, which you can access at http://www.sl-dog.com. From there, data can be exported into various formats such as PDF, CSV (Excel), KML (Google Earth) or SHP (ArcGIS)

Download SL-RAT Data to My Computer creates a CSV file (Microsoft Excel) of the SL-RAT measurements contained on the device. This option also automatically uploads data to the web portal.

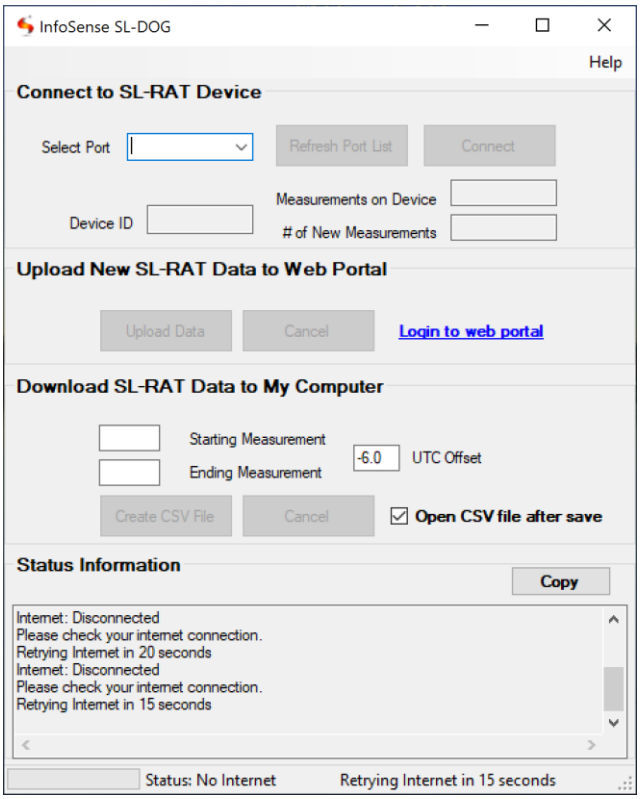


5.3.1. Troubleshooting Issues with Uploading SL-RAT Data

If the software cannot find an SL-RAT device, you will see the following window. Follow steps described in window to troubleshoot device detection issues:



If there is no internet, the program will indicate this in the bottom left-hand corner of the window & the Status Information area in the bottom.



5.4. Operating SL-DOG Web Portal

After measurements have been uploaded using the SL-DOG Desktop App, the data is pushed to and securely stored in a cloud-based web portal. To view this data, you can navigate to www.sl-dog.com and enter your log in credentials to view your portal. If you do not have log in credentials, please contact InfoSense at sales@infosense.com or 877-747-3245 to set up a user account. Access to the portal is free for the first year and requires a paid subscription for continued access.

From the SL-DOG Portal, users can navigate to the following pages through the menu:

HOME: View list of all devices in a user's portal. Navigate to measurements for each device and view details regarding each SL-RAT acoustic tests. Notes or User Field details can be added to each measurement and the GPS coordinates can be edited for accuracy. The measurements and be exported as CSV, KML, SHP or PDF files for easy integration with industry standard programs.

MEASUREMENT SEARCH: Use Ad hoc search to filter for measurements based on device, measurement status, pipe status, dates, assessment scores, pipe lengths, user fields, or proximity to identified latitude and longitude (Figure 11). For detailed instructions, please visit Online SL-DOG User Resource at https://www.manula.com/manuals/infosense/sl-dog-users-manual/1/en/topic/measurement-filter

SUPPORT DOCUMENTS: Find downloadable files (such as for desktop app or USB System Set up), User's manual, reference guides and additional resources.

REPORT: View a histogram of SL-RAT assessment results

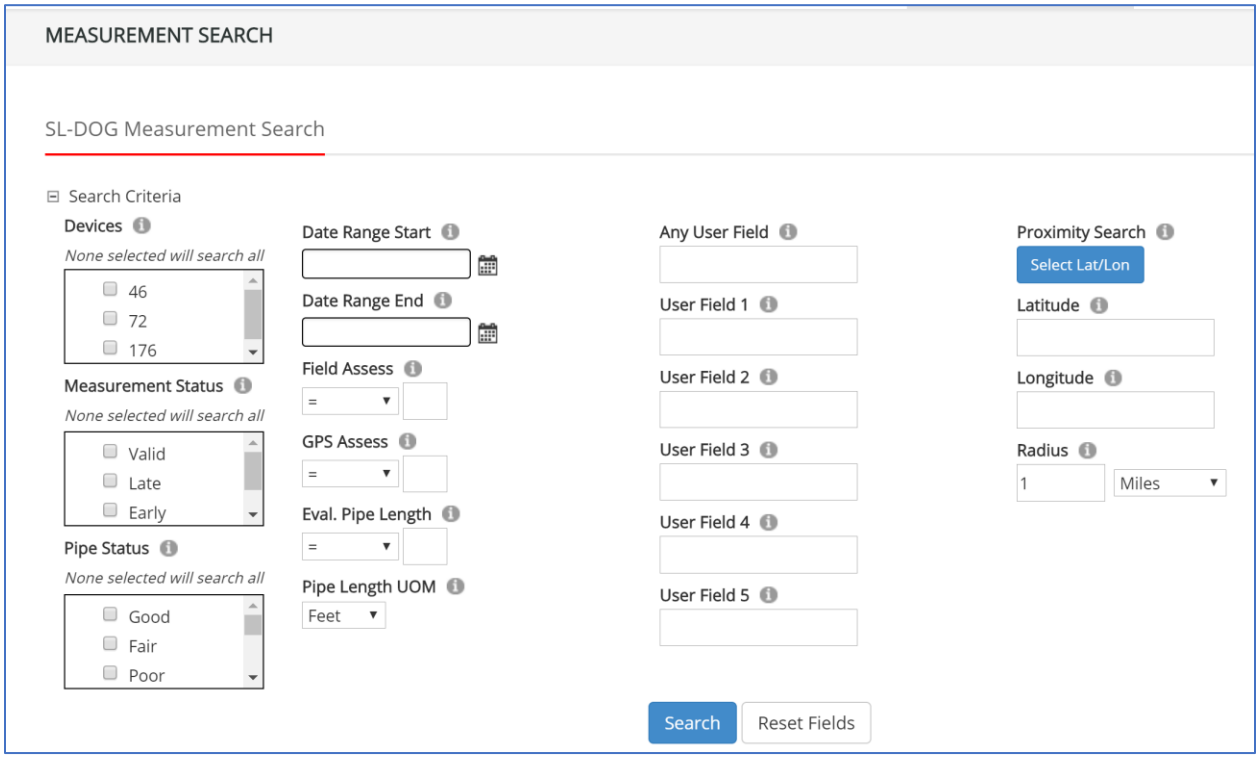


Fig 11. Measurement Search allows user to filter measurements in their portal based on Devices, Measurement status, pipe status, dates, assessments, user fields, or proximity to an identified latitude and longitude.

5.5. SL-DOG Term Definitions

From the SL-DOG Portal, users can view details regarding each SL-RAT acoustic test. The terms are defined below:

Record Number – Unique Identification number for assessments (for each device).

RX Operator ID – (Receiver Operator ID) Operator ID entered by the operator into the SL-RAT receiving unit (RX) when conducting tests.

RX Device Num - Receiver Hardware ID - Unique serial number assigned by InfoSense to the SL-RAT receiving unit (RX); RX serial numbers are even.

TX Operator ID - (Transmitter Operator ID) Operator ID entered by the operator into the SL-RAT transmitter unit (RX) when conducting tests.

TX Device Num - (Transmitter Hardware ID) Unique serial number assigned by InfoSense to the SL-RAT transmitter unit (TX); TX serial numbers are odd.

Measurement Time – Date and time of the SL-RAT measurement – based on indicated SL-RAT time zone.

Test Duration – Duration of the measurement as recorded by the SL-RAT receiver (RX). Measurement duration is in seconds.

Pipe Length – (Operator Pipe Length) Pipe length as entered by the SL-RAT receiver operator. This value is used in the pipe segment assessment. Pipe length is in feet.

Eval Pipe Length – (Evaluated Pipe Length) Pipe length estimated by the SL-RAT unit.

Measurement Status – (Measurement Status) the SL-RAT receiving unit (RX) evaluates the conditions under which the pipe assessment is conducted and provides a warning concerning possible limitations in the measurement as follows:

Measurement Status	Condition
Valid	No anomalies in the measurement conditions were detected
Early	The SL-RAT transmitter unit (TX) was stopped prior to the SL-RAT receiving unit (RX) completed its processing. The Pipe assessment maybe corrupted.
Late	The SL-RAT transmitter unit (TX) was started after the SL-RAT receiving unit (RX). The Pipe assessment maybe corrupted.
No TX	The SL-RAT transmitter unit (TX) was not turned on during SL-RAT receiving unit (RX) measurement. **The Pipe assessment is corrupted.**

Assessment – Pipe assessment scaled from 0 to 10, calculated based on the pipe length indicated by the operator. The assessment scores can be interpreted as the following:

Assessment	Assessment Text	Typical Condition / Interpretation
10	GOOD	No significant obstructions within the pipe
7-9	GOOD	Minor impediments within the pipe such as joint offsets, partial sags, protruding laterals, debris, minor grease, and/or minor root fibers.
4-6	FAIR	Impediments within the pipe such as joint offsets, partial sags, protruding laterals, debris, grease, and/or root fibers. Single or multiple occurrences.
1-3	POOR	Significant impediments within the pipe such as multiple joint offsets, near full pipe sag, multiple protruding laterals, significant debris, significant grease, significant root fibers and/or root balls. Single or multiple occurrences.
0	BLOCK	Full pipe sag; single or multiple obstructions within the pipe reaching or nearly reaching the flow.

GPS Assessment – Pipe assessment scaled from 0 to 10, calculated based on the pipe length calculated by SL-RAT units using GPS. The assessment scores can be interpreted as same as the 'Assessment' scale (above).

Pipe Status - The Pipe Segment classification based on the Pipe Segment Assessment. It is also used to report the test type and condition. The Pipe Status can be one of the following eight possibilities:

Pipe Status	Condition
GOOD	Pipe Segment Assessment from 7 to 10
FAIR	Pipe Segment Assessment from 4 to 7
POOR	Pipe Segment Assessment from 1 to 4
BLOCK	Pipe Segment Assessment from 0 to 1
CLOSE	The SL-RAT transmitter unit (TX) and the SL-RAT receiving unit (RX) were too close during the measurement. The Pipe assessment maybe corrupted.
NOISE	The SL-RAT receiver (RX) detected noise conditions which may impact the measurement. The Pipe assessment maybe corrupted
VERIFY	Verify SL-RAT RX & SL-RAT TX Operational Test
REJECT	Indicates the RX operator rejected the measurement

RX Latitude – Global position system (GPS) latitude at the SL-RAT receiver (RX) unit at the time of the measurement; GPS RX measurement is in decimal degrees.

RX Longitude - Global position system (GPS) longitude at the SL-RAT receiver (RX) unit at the time of the measurement; GPS RX measurement is in decimal degrees.

TX Latitude - Global position system (GPS) latitude at the SL-RAT transmitter (TX) unit at the time of the measurement; GPS TX measurement is in decimal degrees.

TX Longitude - Global position system (GPS) longitude at the SL-RAT transmitter (TX) unit at the time of the measurement; GPS TX measurement is in decimal degrees.

Notes – Additional notes associated with each measurement – can be entered through the portal, or through the Mobile App

User Fields 1 through 5 – Additional fields associated with each measurement. User fields can be used for consistent data entry (example usage include Segment ID, Basin ID, etc)

GPS Coordinates Edited – TRUE indicates that GPS Coordinates were edited through the SL-DOG portal. FALSE indicates that GPS Coordinates are not modified from the coordinates indicated by SL-RAT RX and TX devices.

5.6. Exporting SL-DOG Reports

The acoustic inspection scores and details can be exported in numerous formats for easy integration with industry standard programs. Access to external programs mentioned, such as Microsoft Excel, ArcGIS, Adobe PDF or Google Earth, are not provided as part of the SL-DOG package. Other programs may be compatible for viewing the exported file formats. Data can be exported based on SL-RAT device(s) – this can be executed by selecting device(s) from the homepage (Figure 12) and selecting the desired Export file format. Data can also be exported based on measurements – this can be executed from the View Measurements Page (Figure 13).

Acoustic scores can be exported in the following formats, and definitions of terms are provided above (pages 25-27):

- CSV – file can be viewed with Microsoft Excel or other programs that are CSV file compatible. Sample report is provided on page 29 (Table 3)
- KML – file can be viewed with Google Earth. Sample report is provided on page 30 (Figure 14)
- PDF – file can be viewed with Adobe PDF or other programs that are PDF file compatible. Sample report is provided on page 31. (Figure 15)
- SHP – file can be viewed with ArcGIS or other programs that are SHP file compatible.

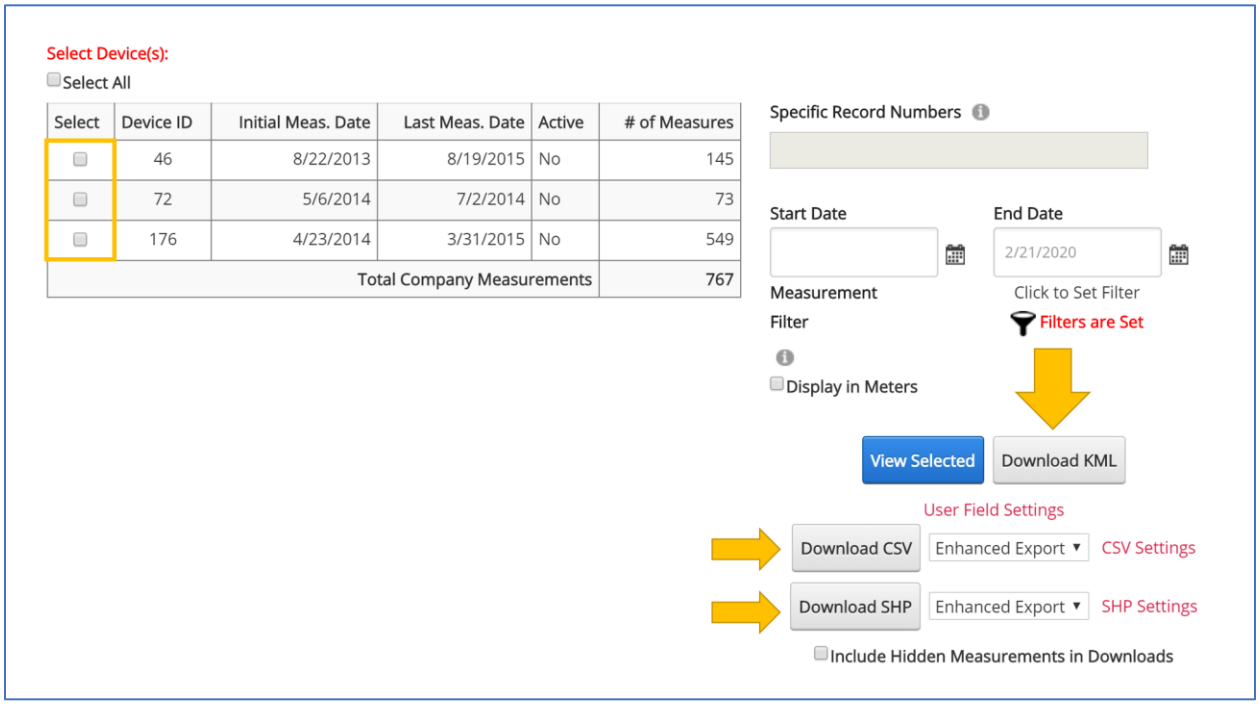


Fig 12. From the homepage, data can be exported for entire SL-RAT device. Select device and select the download file format desired.

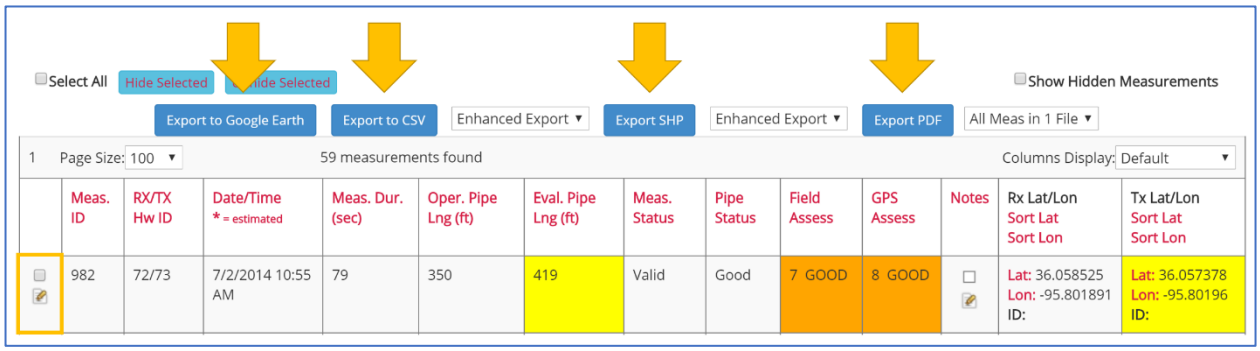


Fig 13. From the View Measurement page (select a device and select "View Selected" – Figure 11), user can select specific measurements to export and select the export file format desired.

5.6.1. Sample Report from CSV File (Excel)

The user can select acoustic data in their portal to be exported as a Comma-Separated Values (CSV) file. The file can be viewed directly using Microsoft Office Excel and/or imported into a Microsoft Office Word report template. Please note, access to Microsoft products such as Word or Excel are not provided as part of SL-DOG package. Table 3 is an example export as viewed in Microsoft Excel (the following fields were hidden for formatting purposes but they are included in exports: RX Operator ID, RX Device Num, TX Operator ID, TX Device num, Notes, User Fields 1-5, GPS Coordinates Edited). For definition of terms, please reference pages 25-27.

Table 3. Sample Report from SL-DOG Generated CSV File

Record Number	Measurement Time	Test Duration	Pipe Length	Eval Pipe Length	Meas. Status	Meas. Status Text	Assessment	Assessment Text	GPS Assessment	GPS Assessment Text	Pipe Status	Current RxLat	Current RxLon	Current TxLat	Current TxLon
336	6/18/2015 14:45	79	150	106	1	Valid	10	GOOD	10	GOOD	Reject	41.754103	-88.350225	41.754063	-88.35061
335	6/18/2015 14:41	80	150	106	1	Valid	10	GOOD	10	GOOD	Good	41.754103	-88.350225	41.754063	-88.35061
334	6/18/2015 14:03	111	50	98	2	Late	10	GOOD	10	GOOD	Reject	41.754115	-88.350261	41.754098	-88.350621
333	6/18/2015 13:59	80	150	98	1	Valid	10	GOOD	9	GOOD	Reject	41.754115	-88.350261	41.754098	-88.350621
332	6/18/2015 13:52	79	50	79	1	Valid	4	FAIR	4	FAIR	Close	41.754071	-88.350706	41.753973	-88.350965
331	3/26/2015 9:51	80	250	293	1	Valid	8	GOOD	8	GOOD	Good	41.825467	-88.089827	41.825056	-88.088901
330	3/26/2015 8:54	79	250	293	1	Valid	1	POOR	1	POOR	Poor	41.825525	-88.089826	41.825106	-88.088906
329	3/26/2015 8:47	111	450	293	1	Valid	2	POOR	1	POOR	Poor	41.825525	-88.089826	41.825106	-88.088906
328	3/26/2015 8:32	79	250	234	1	Valid	7	GOOD	7	GOOD	Good	41.823533	-88.09129	41.822893	-88.09128
327	3/26/2015 8:25	80	50	82	1	Valid	6	FAIR	6	FAIR	Fair	41.82289	-88.091225	41.822686	-88.091099

5.6.2. Sample Report from KML File (Google Earth)

The user can select acoustic data in their portal to be exported as a Keyhole Markup Language (KML) file. The file can be viewed directly using Google Earth. Please note, access to Google Earth is not provided as part of SL-DOG package – however, Google Earth can be downloaded for free from https://www.google.com/earth/. Figure 14 is an example export as viewed in Google Earth. For definition of terms, please reference pages 25-27.

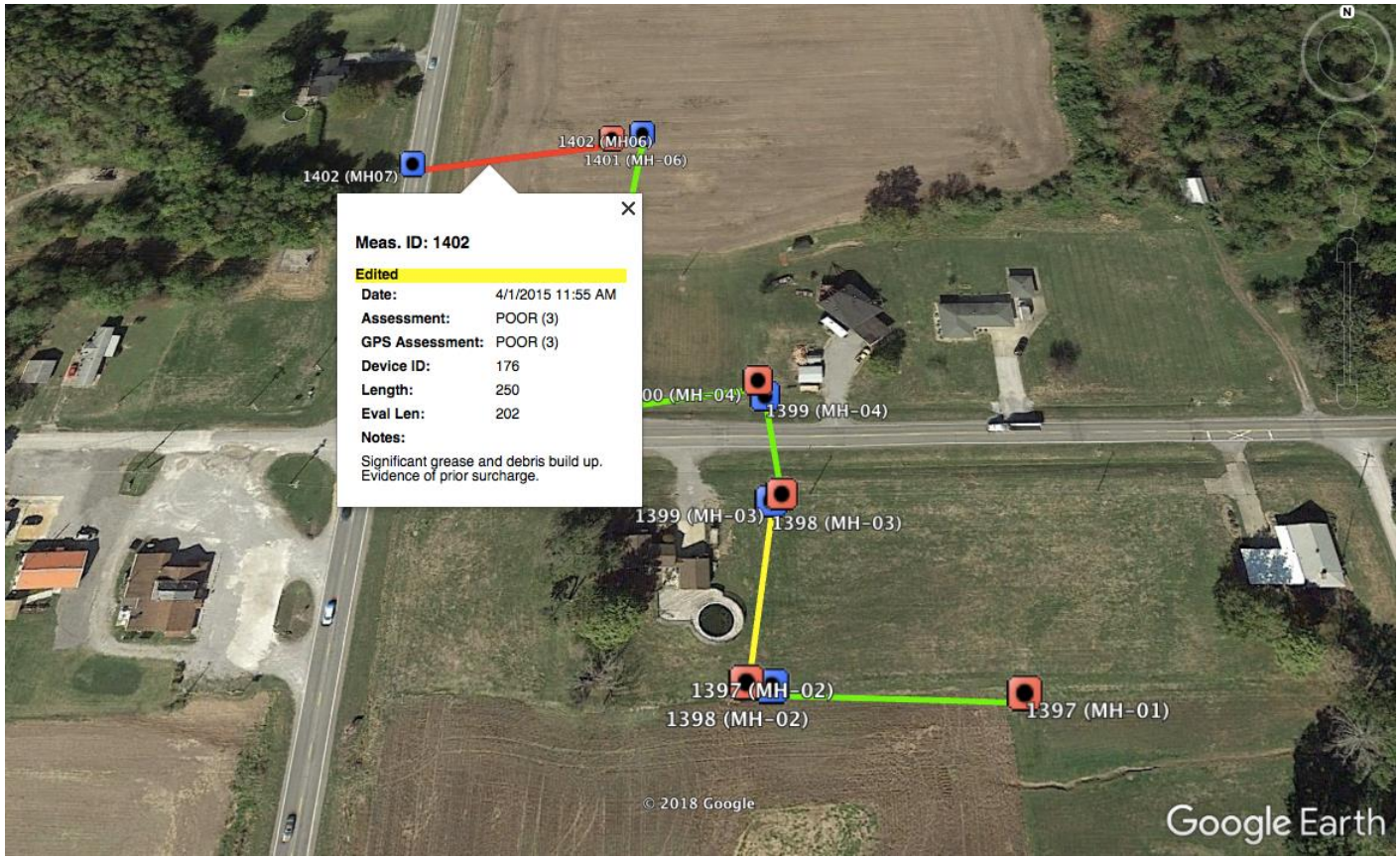


Fig 14. SL-RAT data exported as a KML File can be viewed in Google Earth. Segments are color coded based on assessment scores, and details regarding the measurement can be expanded by clicking on the segment, as shown.

5.6.3. Sample Report from PDF File

The user can select acoustic data in their portal to be exported as a Portable Document Format (PDF) file. The PDF File can be viewed using any program that is PDF compatible. Figure 14 is an example of a PDF report for one measurement. Please note, the download may take several minutes for PDF exports – navigating away from the page will disrupt and cancel the download in progress. Please wait until download completes before navigating to another page.

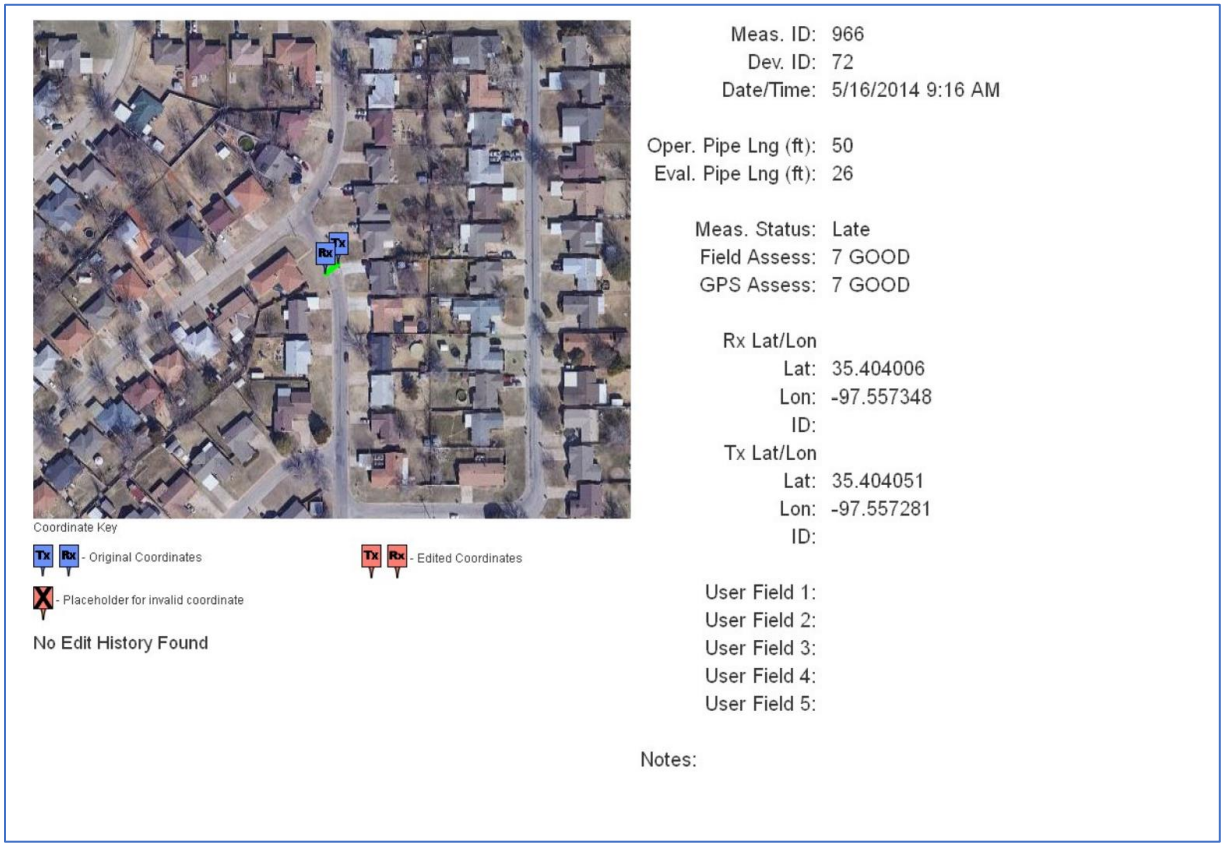


Fig 15. SL-RAT data exported as a PDF File details notes in a single-page, print-friendly format.

6. SL-DOG® Mobile App (optional)

The SL-DOG Application is a free iOS and Android app that allows operators to add asset data as they collect acoustic scores in the field (Figure 16). Users can add User Fields (such as Basin ID, or Segment ID) to add valuable information to each acoustic test. The User Fields can be renamed in the SL-DOG portal for consistent data entry. See online SL-DOG User Resource for more information on how to do this: https://www.manula.com/manuals/infosense/sl-dog-users-manual/1/en/topic/edit-user-field-column-headings

For more information on how to download and utilize the SL-DOG app, download SL-DOG App Quick Start Guide from the Support Documents page in the portal.

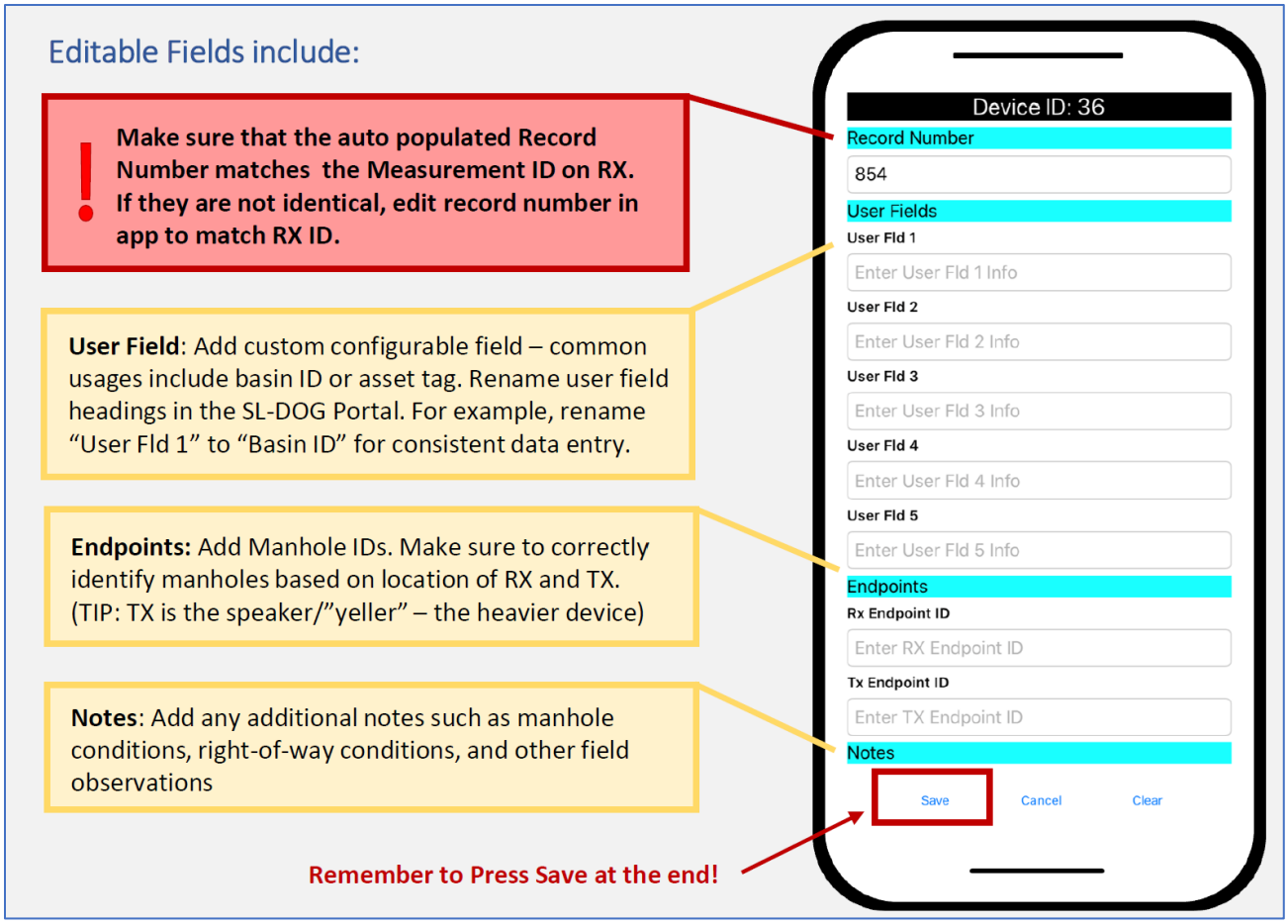


Fig 16. SL-DOG Mobile App allows operators to add asset data as they collect acoustic scores in the field.

7. SL-RAT, SL-DOG & Mobile App Workflow

Use the suite of products provided by InfoSense to optimize the SL-RAT workflow. Get quick insights on pipe conditions using the SL-RAT, then add meaningful notes using the mobile app. Finally, view and manage the SL-RAT data using the SL-DOG web portal. Export reports to integrate with other systems and processes (Figure 17).

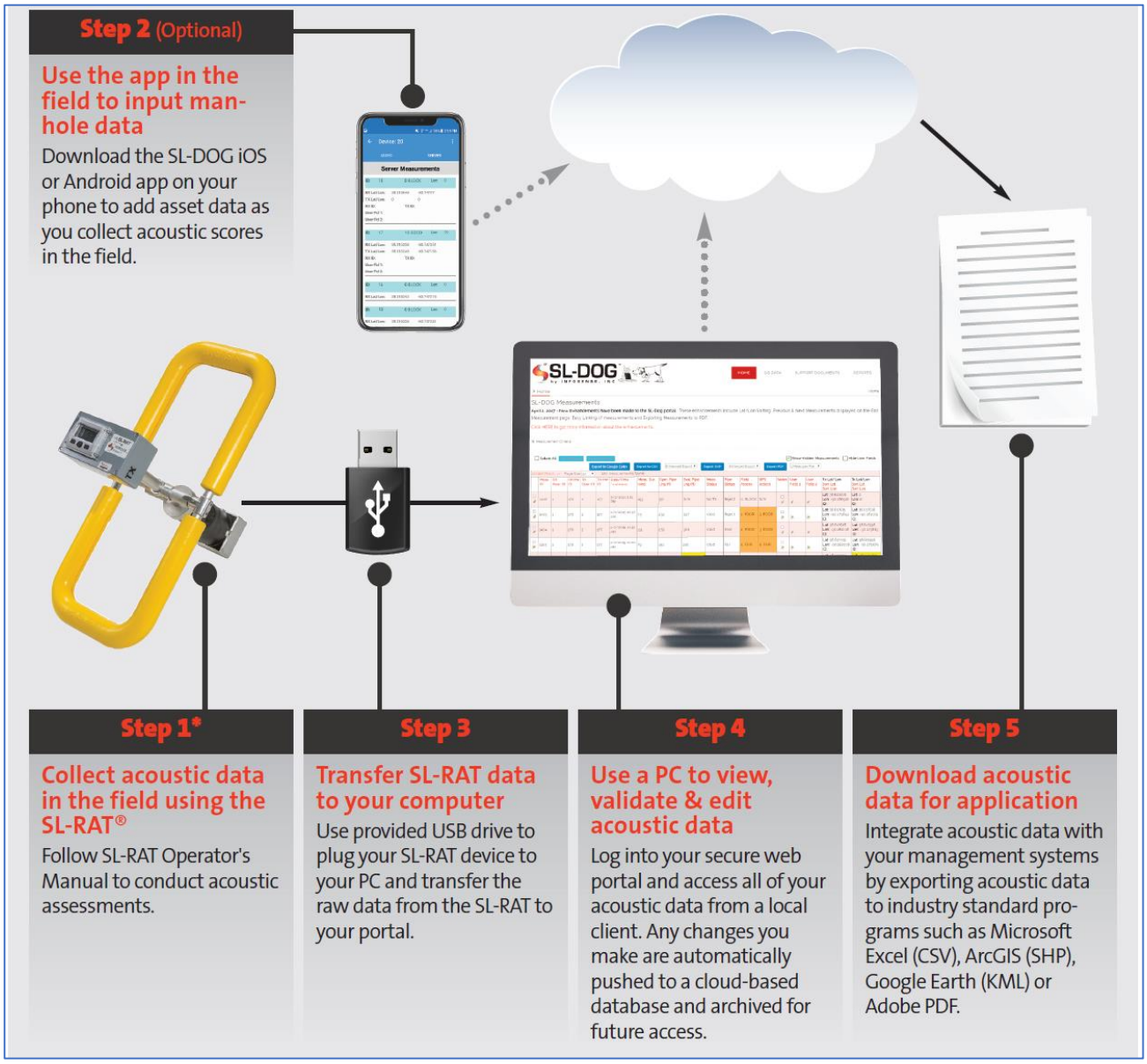


Fig 17. Use the SL-DOG mobile app and web portal to optimize SL-RAT workflow and data management.

8. Additional Information

8.1. Wireless Device

Contains FCC ID: OUR-XBEE/OUR-XBEEPRO

The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference
2. This device must accept any interference received, including interference that may cause undesired operation.

8.2. Maintenance

8.2.1. General Cleaning Recommendation

Under recommended operation of the SL-RAT device, maintenance should be minimal. It is recommended to clean the exterior of the SL-RAT device with a mild disinfecting wipe or a mild general purpose cleaner after each daily use. Do not use harsh chemicals on the exterior. Do not open Electronic Case, remove TX Speaker and/or remove RX Microphone in order to perform maintenance - cleaning or otherwise.

8.2.2. TX Speaker & RX Microphone

User maintenance is required if the TX Speaker or RX Microphone are fouled with debris, dirt or have been exposed to harsh chemicals airborne or otherwise. Under any of these conditions, they are required to be cleaned.

Cleaning - DO NOT USE CLEANERS OR CHEMICALS. Use a mild liquid dish soap and water mixture on a clean rag to clean the exterior of the TX Speaker or RX Microphone.

If the SL-RAT™ device is regularly exposed to harsh environments, then the SL-RAT™ TX and RX should be returned to the factory at least one time per year to provide more extensive cleaning, inspection of seals, cables, and electronics.

Opening the electronics' case will void the warranty. All repairs requiring opening of the electronics' case, should only be performed by factory trained technicians.

8.2.3. Lock Knob Maintenance

The two lock knobs (Figures 1 & 2) on both the SL-RAT™ RX and TX should be oiled at least once per year more often if the device is regularly exposed to wet weather, wet environments and/or harsh environments.

8.2.4. Battery

The rechargeable Li-ion battery is not customer replaceable. Please return the RX or TX component to the Manufacturer for battery replacement.

9. Specifications

9.1. General

- Dimensions: 33" x 14" x 5.5"
- Weight: TX 15 lbs; RX 10 lbs (weight without optional frame cushions)
- Operating Temperature: -20 to 60 degrees Celsius (-4 to 140 degrees Fahrenheit)

- Storage Temperature: -20 to 60 degrees Celsius (-4 to 140 degrees Fahrenheit); For best results store between 5 to 20 degrees Celsius (41 to 68 degrees Fahrenheit)
- Environmental Resistance: Components used are at least NEMA 4x compliant

9.2. Power

- Battery LiMNNi 11.1v 4Ah
- Battery Cycle Life: 80% of initial capacity at 1000 charge cycles
- Time to charge battery: 3.5 hours
- Temperature range for charging: 0 to 45 degrees Celsius (32 to 113 degrees Fahrenheit)
- Number of TX Measurements starting with fully charged battery: approximately 40
- Number of RX Measurements starting with fully charged battery: greater than 80

9.3. Operational

- Recommended Minimum Pipe Segment Length: 20 ft.
- Recommended Maximum Pipe Segment Length: 800 ft.
- Recommended Pipe Flow Levels: Typically less than 50%; Measurements in higher flow levels may also work, but are likely to produce lower pipe assessments.
- Pipe Diameters: 6” to 12”; Measurements in larger & smaller diameter pipes may also work but have not been explicitly included in the current blockage assessment algorithms.
- Pipe Material: PVC, HDPE, Ductile Iron, Concrete, Vitrified Clay; and others.

10. Document Revision History

Document Number	Date	Revision List
6-12	6/14/2012	Original Document
8-12	8/7/2012	1. Corrected Measurement Status Table 2. Test classifications added to the Pipe Status: Close & Verify 3. Pipe Status Table added 4. New Menu option Verify Operation 5. TX Measurement termination through RX wireless signal
	8/28/2012	6. General Cleaning Recommendation
1-13	1/3/2013	7. Lock Knob Maintenance 8. USB Cable (SL-DOG Operation Overview 6.c) 9. Reinstalling USB device driver 10. Augmenting Measurement Test Screens with GPS Status
8-19	8/6/2019	11. Updated with changes for V2.8 – new requirements for uploading measurements; new requirements for synch requirements; XBEE status; GPS reset 12. Tables and graphics updated 13. SL-DOG section updated
2-20	2/21/2020	14. Updated fonts and table of contents 15. Updated SL-DOG Section with Sample PDF report and Google Earth Report 16. Installation guides included for SL-DOG section 17. Added definition of terms for SL-DOG 18. Added mobile app section
2-27	2/27/2020	19. Minor wording edits 20. Integrated numbering to table of contents
3-05	3/05/2020	21. Minor wording edits finalized