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Revision History

Issue	Description of Change	Author	Effective Date
0.1	Draft For Review	Wade VanLandingham	October 1, 2014
1.0	Initial Release	Wade VanLandingham	November 4, 2014
1.1	Converted to TSI document	Wade VanLandingham	February 10, 2015
1.2	Added Introduction and Software Overview	Wade VanLandingham	May 13, 2015
1.3	Updated the data in Appendix A to the correct antenna procedure number and software references	Wade VanLandingham	June 18, 2015
1.4	- Updated numerous references from Scoutek to ThumbNet. - Corrected several mistakes in procedure number call outs. - Removed OSX install section 11.2 as software is reportedly no longer available.	Wade VanLandingham	July 1, 2015
1.5	Error in procedure step 6.1.14	Wade VanLandingham	January 29, 2016

Reference Documents

Document	Title
THS-NA-TSI-SU-01	Document Control List
THS-NA-TSI-SU-02	Definitions and Acronyms

1.0 Purpose

The purpose of this procedure is to help the operator establish and properly setup the ThumbNet earth station, in preparation to downloading data from the ThumbSat space system.

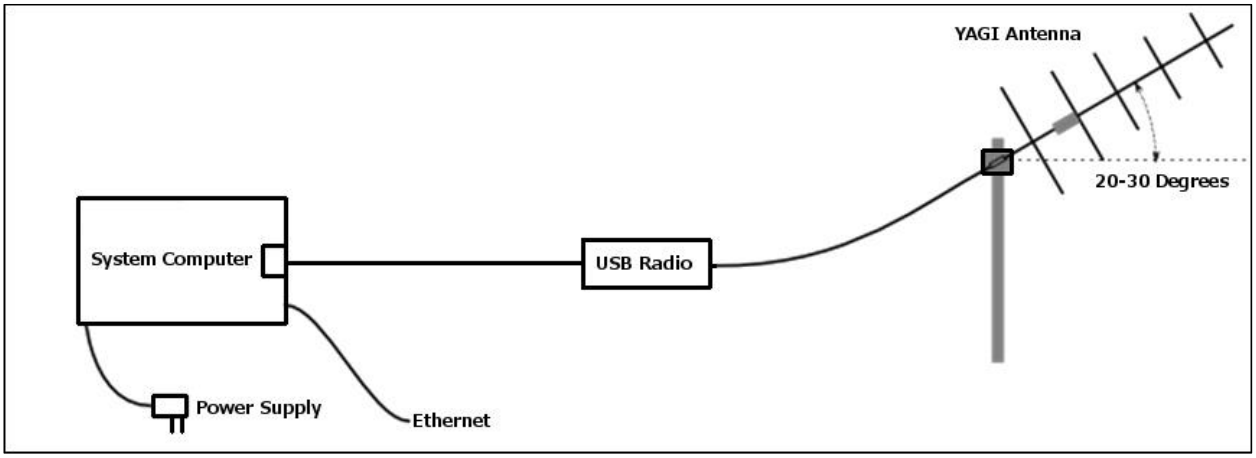


Figure 1 - High level block diagram of the system

2.0 Scope

The procedures outlined in this document should provide all the information needed for a new student to setup and begin operation of the ThumbNet earth station and begin downloading data from ThumbSat or other transmitting satellites.

3.0 Definitions and Acronyms

3.1 Definitions

DL-FLDIGI	DL-FLDIGI is the primary software application used by ThumbNet to capture and transmit the downloaded data from the earth station to the ThumbNet central computer.
Earth Station	A station located either on the Earth's surface or within the major portion of the Earth's atmosphere intended for communication:

	(1) With one or more space stations; or (2) With one or more stations of the same kind by means of one or more reflecting satellites or other objects in space.
Kepler Elements	The input data to a standard mathematical model of spacecraft orbits. By using the correct Kepler Elements data, also called “Two Line Element”, the correct time, and your earth station location, you can compute when the satellite will be in view and where to point your antennas.
Orbitron	Orbitron is the primary software application that is used by ThumbNet to predict and track the location of various satellites in orbit, as well as the ThumbSat space stations.
Space Station	A station located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth's atmosphere.
Space System	Any group of cooperating earth stations and/or space stations employing radio communication for specific purposes.
SDRSharp	SDRSharp (SDR#) is the primary software application used to communicate with the RTL2832U RTL-SDR device.
TLE	The input data to a standard mathematical model of spacecraft orbits. By using the correct Two Line Element data, also called “Kepler Elements”, the correct time, and your station location, you can compute when the satellite will be in view and where to point your antennas.
Virtual Audio Cable	Virtual Audio Cable is the primary software application used by ThumbNet to transfer data between the SDR# software and other applications such as DL-FLDIGI.

3.2 Acronyms

RTL-SDR	Register Transfer Level – Software Defined Radio
TLE	Two Line Elements

4.0 Software Introduction and Overview

This section provides an introduction and overview of each of the major software applications that are used in the ThumbNet suite and what each piece is useful for.

4.1 SDR#

The SDR# software is the software that allows the receiver to act as a radio.

It is like the dial on your car radio, in that you tell it what frequency you want to listen to, and it will let you listen. At its simplest, this is the first step for the students.

1. Plug the ThumbNet receiver into the laptop
2. Open SDR#
3. Set the frequency to a local radio station
4. Listen to the music

There are many lists on the internet for local radio sources that can be monitored. An example can be found here:
https://www.radioreference.com/apps/db/?ctid=370

From that list, if we are in St Augustine, Florida, US, if we set SDR# to **155.22000** Mhz, we will be able to monitor the local marine rescue station. **154.38500** would be the local Fire Dispatch center. **152.46500** would allow us to listen to the transmissions from one of the local schools. And finally, if we want to listen to music, setting to **101.10000** Mhz will let us listen to music radio.

Anything within range that is fixed in location, will be able to be heard with a combination of SDR#, an antenna and a ThumbNet receiver. No other software is required.

However, if you want to listen to a satellite or other moving object, Doppler motion will not let you dial SDR# directly. (Well, you can, but you will have to calculate it and continue to change the frequency manually as the satellite comes and goes.)

4.2 Orbitron

To correct for the Doppler Effect, AND to know where and when to look at the satellite, you will use the Orbitron software.

Orbitron gets data from the internet, about where all the satellites are and calculates where they are going to be. When you select a specific satellite to monitor, Orbitron will tell you where it is going to be in the sky, what time it will be there, and equally useful, what the Doppler corrections are to capture useful data from it. This is where you will find out what part of the sky to aim your antenna at.

Also, it will show how the satellite is moving across the sky, and will help you visualize how to sweep the antenna, to keep it pointed at the satellite as it moves.

Additionally, since Orbitron knows the transmission frequency of the satellite, knows where you are on the earth, and knows the path the satellite will take relative to you, it will do all of the Doppler corrections for you, and will always display the frequency you should be listening to in order to hear the satellite. Now, you can manually change the settings in SDR# to the right frequencies, and hear the satellite, without doing all the math.

But since manually changing the frequency is cumbersome and inefficient, we use section 5.5 of the setup procedure, to allow SDR# to listen to commands from Orbitron directly and automatically adjust the frequency that SDR# monitors. This way, all you have to do is select the correct satellite in Orbitron, point the antenna in the right direction, and SDR# will output the correct sound.

This will be the basis of your system most of the time, for allowing students to work with the system.

To reiterate: For terrestrial radio such as music or airplanes, or police scanners, or even taxi cab radio, you will only need SDR# and a list of local frequencies that are near you, like the one above.

For satellites, you will use SDR#, along with the Yagi antenna pointed in the correct direction and the Orbitron software.

4.3 DL-FLDIGI

Later, when the ThumbSat constellations are flying, you will download the data from the ThumbSats using SDR# and Orbitron in the same manner as any other satellite. However, since we will be transmitting images as well as radio, you will need to capture the image using the DL-FLDIGI software.

This is the software that understands the special protocols being used by the ThumbSat SSDV imaging system. (We will alert all stations to when and what settings to use for the ThumbSat constellations, prior to each mission launch.)

There are other satellite systems that use SSDV and similar protocols for imaging that can be explored as you have time.

4.4 Virtual Audio Cable

And finally, the Virtual Audio Cable software is what will interface the DL-FLDIGI software with SDR# for the DL-FLDIGI software to get the data it needs to decode.

It is actually possible to play the signal coming from SDR# through the speakers of the computer and use another microphone as an input to DL-FLDIGI, but losses are high, and since there is a much better way, we'll use that. ☺

5.0 Requirements

5.1 SDR# Computer System Requirements

5.1.1 The following are the minimum and recommended system requirements to ensure fully functional operation of the SDR# software.

1. Windows XP SP3 or later / Vista / 7 / 8
2. Windows .NET release 3.5.
3. A modern dual-core CPU as found in most laptop or desktop computers, an Intel Atom (e.g. Netbook PC) may struggle.
4. At least 200 MB free memory
5. USB 2.0 hi-speed port essential for TV dongle

NOTE - The RTL2832U R820T RTL-SDR device must be plugged into a USB 2.0 or higher port for proper functionality.

5.1.2 Supporting Software Requirements

NOTE - You must have the Microsoft .NET Distributable installed to use SDRSharp. Most Windows PCs should already have this installed by default, but older PCs running XP may need this to be installed.

Microsoft .NET can be downloaded from:
http://www.microsoft.com/en-us/download/details.aspx?id=26

5.2 Orbitron Computer System Requirements

5.2.1 The following are the minimum and recommended system requirements to ensure fully functional operation of the Orbitron software.

1. Windows 9x/2k/Me/XP/2003/Vista, Linux [with WINE emulation]
2. 150 MHz processor (300 MHz recommended)
3. 16 MB RAM (32 MB recommended)
4. 5 MB free space on hard drive
5. 640x480 screen resolution (800x600x16 bit recommended)

5.3 Virtual Audio Cable System Requirements

5.3.1 Virtual Audio MME, DX, KS, WDM Device Driver supports (XP, VISTA, WIN7, WIN8 32/64 bits)

5.4 DL-FLDIGI System Requirements

5.4.1 The following are the recommended system requirements to ensure proper operation of the DL-FL-DIGI software.

1. At least a 1.2 GHz processor for most digital modes, and at least a 1.6 GHz processor for CPU-intensive modes like DominoEX and Thor. A faster CPU may be needed for multiple PSK decoding.
2. DL-FLDIGI should run on all POSIX/X11 systems (*BSD, Linux, Solaris, etc.). It has also been ported to Mac OS X (10.4 or newer) and Windows (2000 or newer).

6.0 Hardware and Software Installation Procedures

NOTE – The software installation procedures below assume an Operating System of Windows 7 or higher. Refer to Appendix B for installation instructions related to Windows XP.

6.1 Install RTL-SDR software and hardware

NOTE - Ensure that the dongle software and drivers have not been previously loaded onto the computer. If they have, please completely uninstall them and restart the computer, leaving the dongle disconnected.

NOTE - It is recommended that you close all other programs that may be running on your computer, before installing SDRSharp.

6.1.1 Copy the ***SDRSharp_Win7.zip*** Install file from the CD to your desktop.

6.1.2 Create the folder ***C:\SDRSharp*** and extract the files from **SDRSharp_Win7.zip** to **C:\SDRSharp**.

6.1.3 Delete the ***SDRSharp_Win7.zip*** Install file from the CD to your desktop.

6.1.4 Plug in the RTL-SDR dongle supplied by ThumbNet to your computer's USB port.

> **NOTE -** There is a high likelihood that Windows 7 will automatically install drivers for the RTL-SDR, although they may not be optimized. It is best to allow Windows to install the drivers, accepting all the default values as we will update them with the ***Zadig*** application in the following steps.

6.1.5 Open the installation directory ***C:\SDRSharp***.

6.1.6 Right click ***ZADIG.EXE*** and select ***RUN AS ADMINISTRATOR***.

6.1.7 When the Zadig application loads, click ***OPTIONS*** and turn on the check mark for ***LIST ALL DEVICES***.

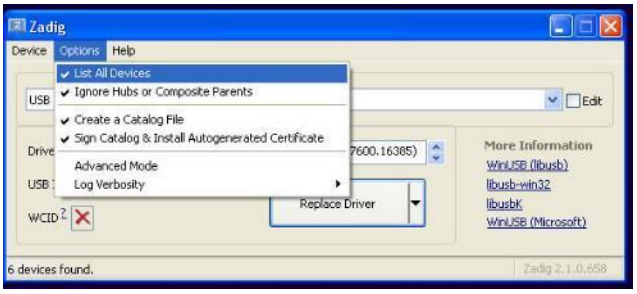


Figure 2 - List All Devices

6.1.8 From the pull down menu, select ***BULK-IN INTERFACE*** or ***RTL2838UHDIR*** as appropriate.

> **NOTE –** The ThumbNet R820T2 SDR Dongle shows up as **RTL2838UHDIR** in Windows 8.1.

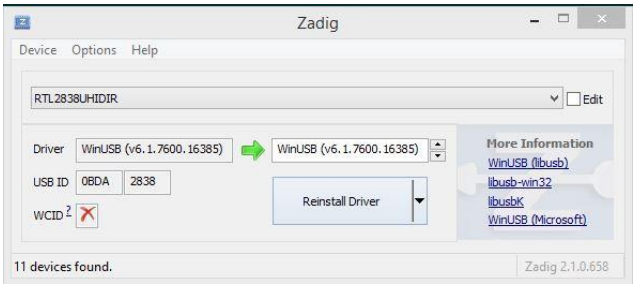


Figure 3 - Select Bulk-In Interface

6.1.9 Click the ***INSTALL DRIVER*** button.

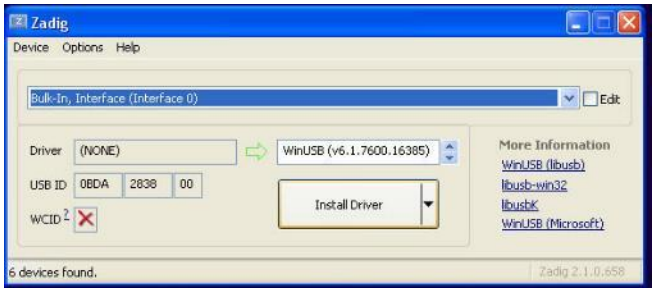


Figure 4 - Install Driver

6.1.10 When driver is successfully installed, close the driver installation pop up window and exit Zadig.

6.1.11 If prompted to restart your computer, click ***YES***.

Figure 5 - Restart System

6.1.12 Open the installation directory ***C:\SDRSharp***.

NOTE – You may want to create a shortcut to the file SDRSHARP.exe to your desktop for ease of use, but this is not required.

6.1.13 Right click SDRSharp.exe and select ***RUN AS ADMINISTRATOR***.

6.1.14 From the ***SOURCE*** drop down menu, select **RTL-SDR / USB**

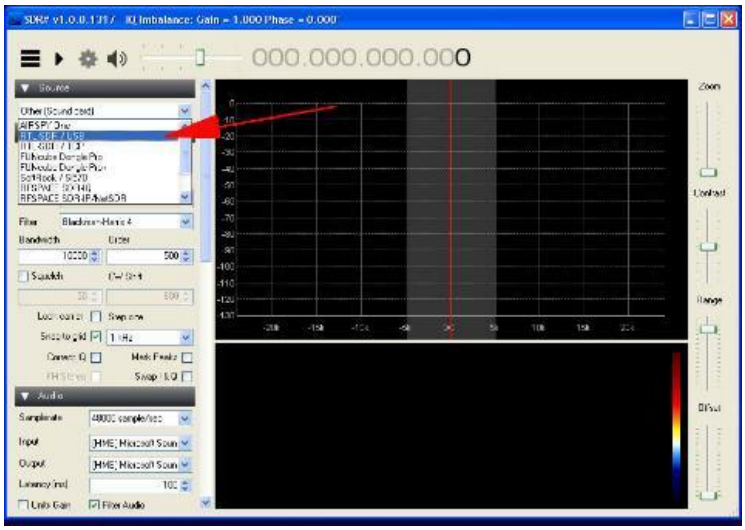


Figure 6 – Select Source

6.1.15 Click the ***RUN*** button to start the application.

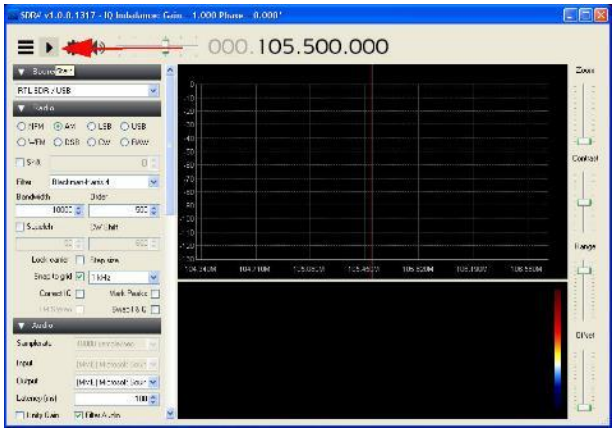


Figure 7 - Start SDR#

6.1.16 Verify that the waterfall display begins updating and frequency data shows up in the Frequency window.

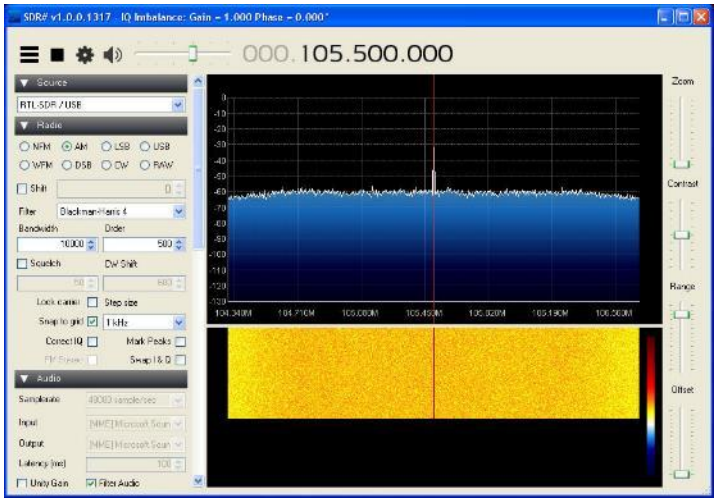


Figure 8 - Verify Operation

6.1.17 Follow the guidelines in section 7.1 for initial software settings.

6.2 Install Orbitron Satellite tracking software

6.2.1 Copy the installation file: ***orbitron_install_3.71.exe*** from the ThumbNet Software CD to your computer's desktop.

> **NOTE -** It is recommended that you close all other programs that may be running on your computer, before installing Orbitron.

6.2.2 Right click on the file: ***orbitron_install_3.71.exe*** and select ***RUN AS ADMINISTRATOR***

6.2.3 Select your preferred language for the software and click ***OK***.

Figure 9 - Software Language

6.2.4 On the Welcome Screen, click ***NEXT***.

Figure 10 - Welcome Screen

6.2.5 If the default installation directory is acceptable, click ***NEXT***, otherwise, enter your preferred installation directory, and then click ***NEXT***.

Figure 11 - Installation Directory

6.2.6 Select your desired installation components from the pull down menu and click ***NEXT***.

Figure 12 - Installation Type

6.2.7 Toggle the checkmarks next to your preferred additional icons.

NOTE - It is best to ensure that ***TURN ON CHECKING FOR UPDATES*** is not checked. This will ensure that the following instructions are relevant to the software version being installed, and not a newer, unknown version.

Once the software is operational, “Check for Updates” can be enabled and bug fixes or newer versions will be downloaded and applied.

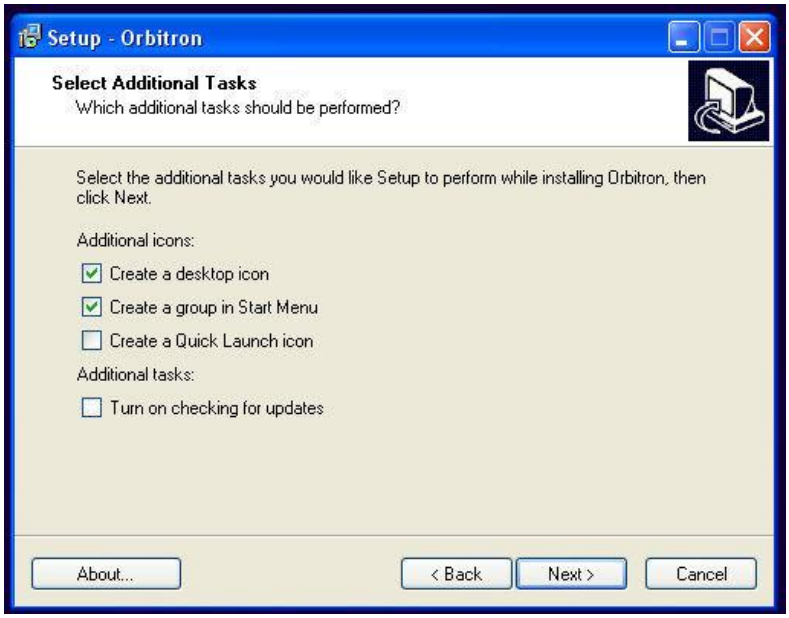


Figure 13 - Additional Tasks

6.2.8 Click the ***NEXT*** Button.

6.2.9 After reviewing the settings that have been selected, click the ***INSTALL*** button.

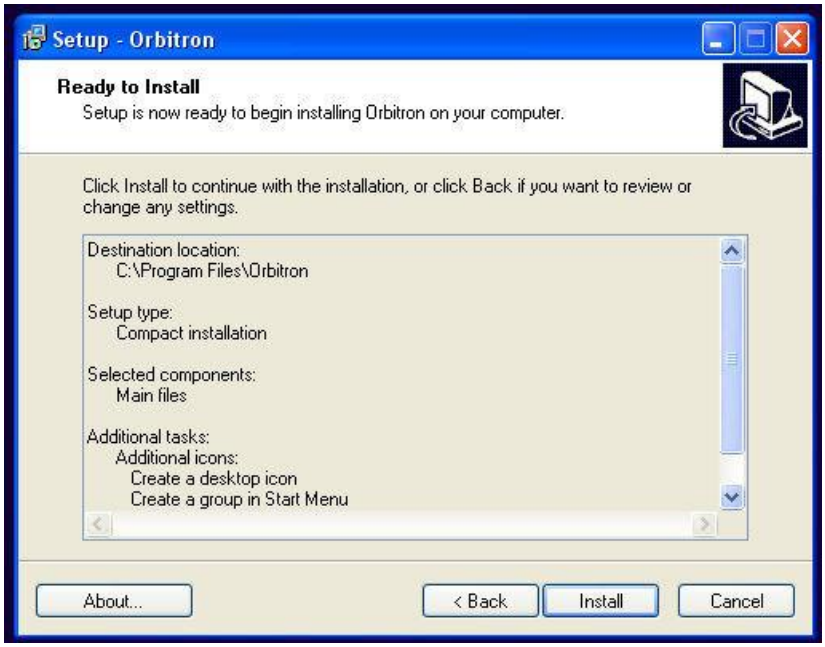


Figure 14 - Installation Finalization

6.2.10 When the installation is complete, click the ***FINISH*** button.

Figure 15 - Installation Complete

6.2.11 Follow the guidelines in section 7.2 for initial software settings.

6.3 Install Virtual Audio Cable software

6.3.1 Copy the ***Virtual Audio Cable.zip*** file to your computer's desktop from the ThumbNet Software CD.

6.3.2 Unzip the ***Virtual Audio Cable.zip*** file to your computer's desktop and open the newly created folder.

6.3.3 Right click the installation file: ***VBCABLE_Setup.exe*** and select ***RUN AS ADMINISTRATOR***.

6.3.4 On the splash screen click ***INSTALL DRIVER***.

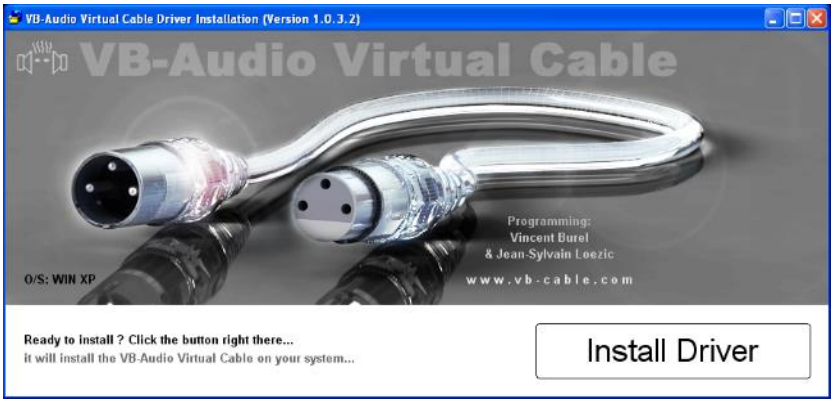


Figure 16 - Install Driver

NOTE - If installing the Virtual Cable on Windows XP, a pop up warning may appear that the VB Audio Virtual Cable has not passed Windows Logo testing to verify it's compatibility with Windows XP. No reports of malfunctions have been received for WinXP systems.

6.3.5 Click the ***CONTINUE ANYWAY***.

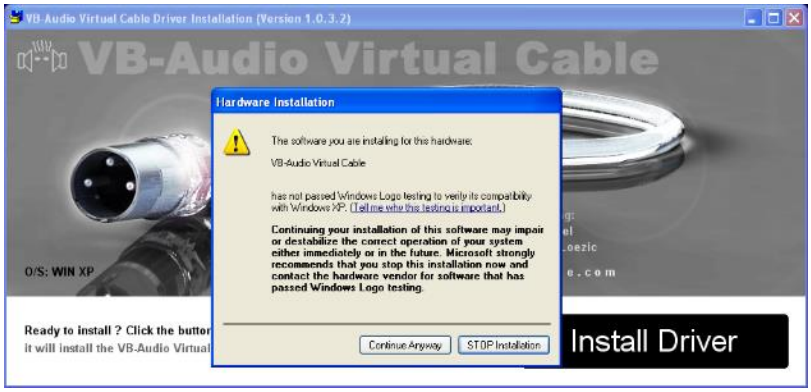


Figure 17 - Continue

6.3.6 At the ***INSTALLATION COMPLETE AND SUCCESSFUL*** pop up, click ***OK*** to complete the installation.

6.3.7 Delete the setup files from your computer's desktop.

6.3.8 Reboot your computer.

Figure 18 - Restart

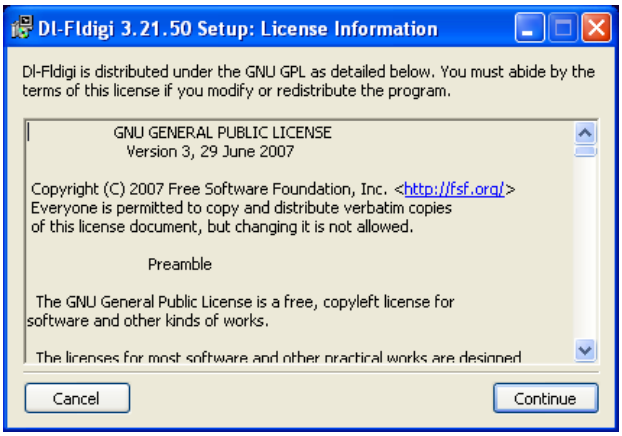
6.4 Install DL-FLDIGI image reconstruction software

6.4.1 Copy the ***dl-fldigi.exe*** file to your computer's desktop from the ThumbNet Software CD.

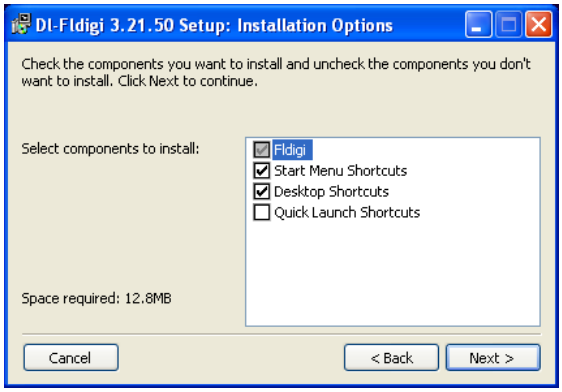
6.4.2 Right click the installation file: ***dl-fldigi.exe*** and select ***RUN AS ADMINISTRATOR***.

NOTE - VB Audio needs to be installed prior to DL-FLDIGI can be used for ThumbNet operation. It is recommended that you use section 5.3 and install Virtual Audio Cable prior to installing DL-FLDIGI.

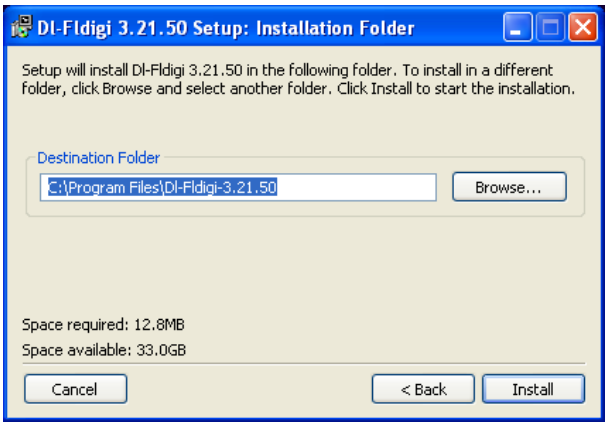
6.4.3 On the license screen, click ***CONTINUE***.



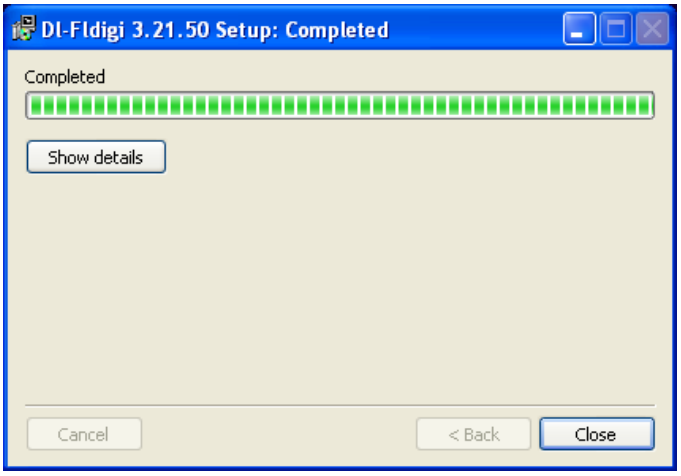
6.4.4 Select your shortcut options and click ***NEXT***.



6.4.5 Verify your installation directory and click ***INSTALL***.



6.4.6 On the installation complete screen, click ***CLOSE***.



6.4.7 Proceed to section 6.4 to complete initial software setup.

6.5 SDR# / Orbitron Interconnect

6.5.1 Plugin Installation

6.5.1.1 Copy the file ***Orbitron Satellite Tracker.zip*** to your computer's desktop from the ThumbNet Software CD.

6.5.1.2 Extract the files from ***Orbitron Satellite Tracker.zip*** and move them to the installation directory containing the ***SDRSharp.exe*** file, ***C:\SDRSharp***.

6.5.2 Edit SDR Configuration

6.5.2.1 Open the SDR# Installation directory ***C:\SDRSharp***.

6.5.2.2 Open the ***Plugins.xml*** file with a text editor such as Windows Notepad.

6.5.2.3 Add the following line to the ***<sharpPlugins>*** section:

<add key="SatelliteTracker" value="SDRSharp.SatelliteTracker.SatelliteTrackerPlugin,SDRSharp.SatelliteTracker" />

6.5.2.4 Save ***Plugins.xml*** file and exit the text editor.

6.5.3 Edit Orbitron Configuration:

6.5.3.1 Open the Orbitron installation directory

6.5.3.2 Open the **CONFIG** directory.

6.5.3.3 Open the ***Setup.cfg*** file with a text editor such as Windows Notepad.

6.5.3.4 Add the following at the end of the file after the section titled [Satellites]:

```
[Drivers]
SDRSharp=SDRSharp.exe
```

6.5.3.5 Save the ***Setup.cfg*** file and exit the text editor.

6.5.4 Install DDE Drivers

6.5.4.1 Copy the ***Orbitron Satellite Tracker.zip*** file to your computer's desktop.

6.5.4.2 Unzip the file to your desktop.

6.5.4.3 Move the extracted files into the SDR# installation directory.

6.5.4.4 Delete the ***Orbitron Satellite Tracker.zip*** file from your computer's desktop.

6.5.5 Verify Setup and Operation

6.5.5.1 Start the SDR# application.

6.5.5.2 Verify that a new plugin module has been loaded called ***SATELLITE TRACKER****.

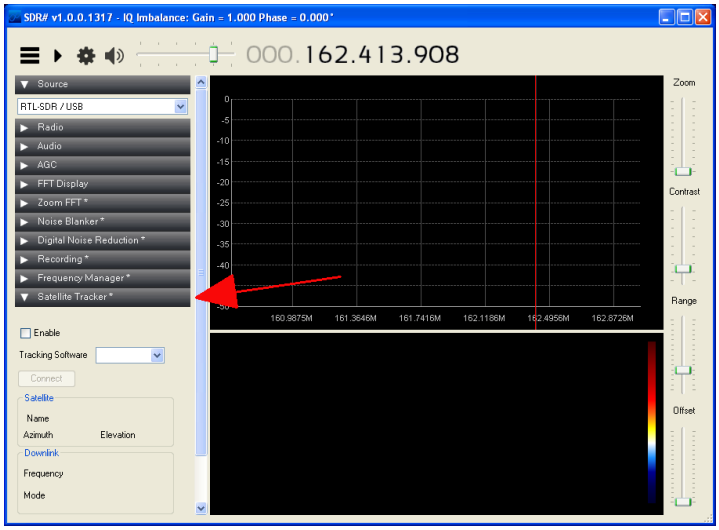


Figure 19 - Verify Plugin Installation

6.5.5.3 Start Orbitron application

6.5.5.4 Click the ***LOAD LTE*** button and select ***NOAA.TXT*** from the list, then click ***OPEN***.

6.5.5.5 In the Satellite Select window, check the box next to the satellite named ***NOAA 19[+]***.

6.5.5.6 Click ***Rotor/Radio*** tab and select ***SDRSharp*** for the driver.

6.5.5.7 Click the ***RUN SELECTED DRIVER AND START SENDING DATA*** button.

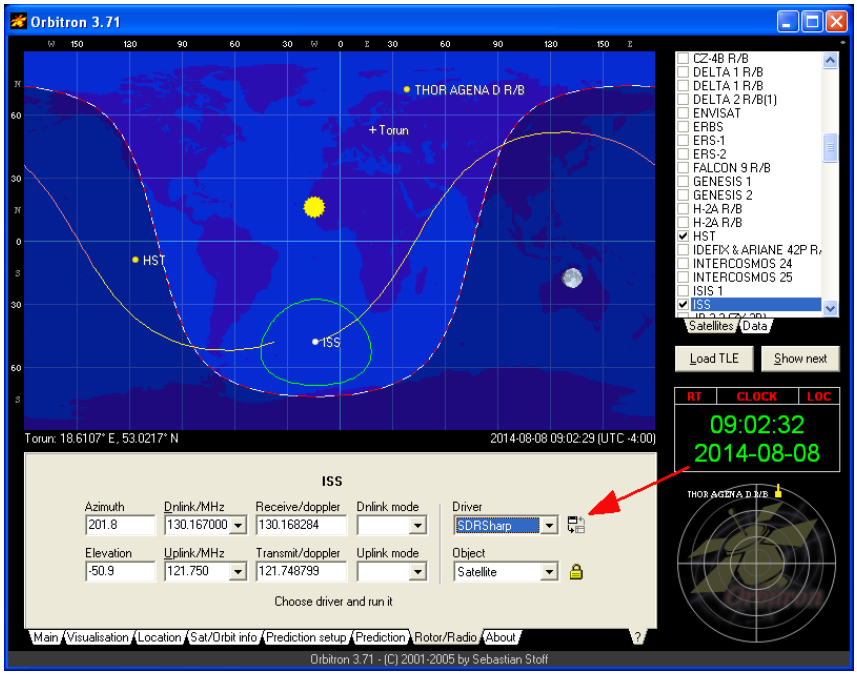


Figure 20 - Run Driver and Send Data

NOTE - The first time the software is run, Orbitron software will normally produce a warning pop up that the SDRSHARP driver is not found. If the warning does not pop up, skip to step 5.5.5.9

6.5.5.8 On the Driver Not Found warning box, click ***YES***.

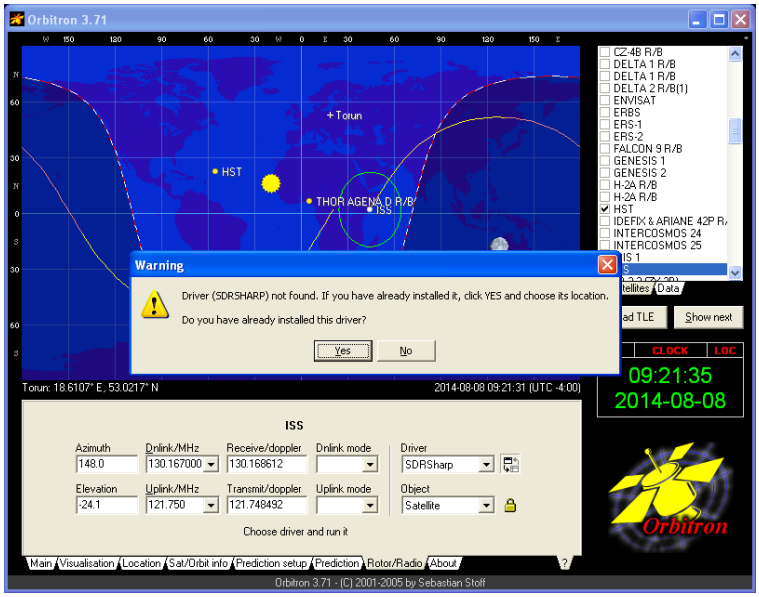


Figure 21 - Driver Not Found

6.5.5.9 Navigate to the SDR# installation directory and select the file ***SDRSharp.exe***, then click ***OPEN***.

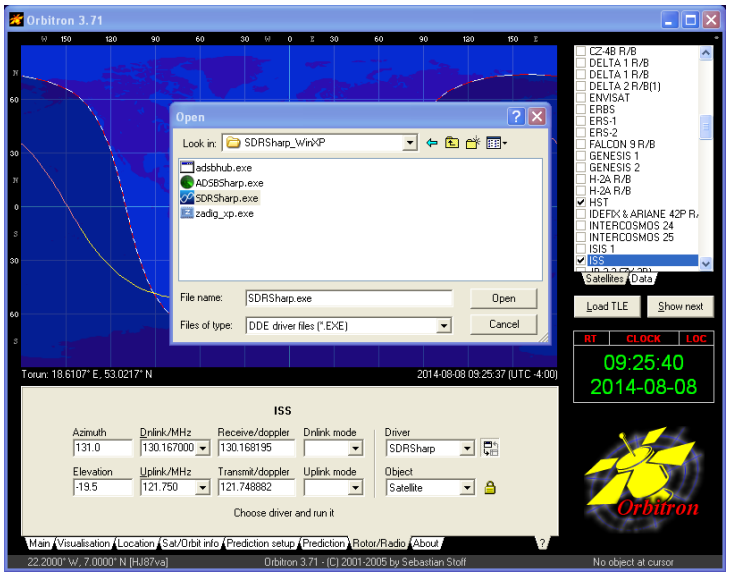


Figure 22 - Select File

NOTE - Orbitron should automatically begin sending data out to the SDR# application.

6.5.5.10 In the SDR# application expand the ***SATELLITE TRACKER**** plugin window and check the box labeled ***ENABLED***.

6.5.5.11 In the ***TRACKING SOFTWARE*** pull down menu, select ***ORBITRON***.

6.5.5.12 Click the ***CONNECT*** button.

6.5.5.13 Verify that the Satellite Name is updated as NOAA 19[+] and that Azimuth and Elevation data is being updated.

6.5.5.14 Verify that the Downlink Frequency data is populated and updating slowly. This is confirmation that the Orbitron software is sending Doppler corrected data to the SDR# application.

NOTE - Once the SDR# and Orbitron software are communicating, you can now update the TLE data for the ThumbSat Satellite.

You are now ready to begin downloading data the next time the satellite passes within view of your earth station's antenna!

6.6 Downloading the SDR# Software from original source

It may be desirable for the earth station operator to download a copy of the SDR# software from the internet, instead of using the files provided on the ThumbNet Software CD.

The following procedure will guide you through the process.

6.6.1 Copy the file ***SDRSharp_Get_Files.zip*** from the ThumbNet Software CD to your computer's desktop.

6.6.2 Unzip the file ***SDRSharp_Get_Files.zip*** to your desktop.

6.6.3 Ensure you have an active internet connection.

6.6.4 Open the ***sdr-install*** directory.

6.6.5 Double click on the ***unzip.exe*** file.

6.6.6 Double click on the ***install.bat*** file.

6.6.7 Press any key to continue when complete.

6.6.8 Open the newly created ***sdr-install*** directory inside the old directory, and run the installation procedures for your version of Windows.

6.7 Additional Plugins for SDR#

6.7.1 Additional functionality can be gained within the SDR# software package, by installing other plugins as desired by the user. A useful list of available plugins can be found at the following website: http://www.rtl-sdr.com/sdrsharp-plugins/ .

7.0 Initial Software Settings

7.1 SDR# Initial Software Setup

7.1.1 Initial Configuration Settings

7.1.1.1 Click the ***CONFIGURE*** button on the panel of SDR#.

7.1.1.2 Ensure that the ***DEVICE*** is listed as ***Generic RTL2832U OEM***.

7.1.1.3 Set the ***SAMPLE RATE*** to ***2.4 MSPS.***

> **NOTE –** Most modern CPU's will easily handle a Sampling Rate of 2.4MSPS (Megasamples per second (millions of samples per second)), however if you experience "stuttering" or other inconsistent audio or graphics updates with SDR#, it is possible that the Sampling Rate is too high for your processor. To correct the problem, begin stepping the Sampling Rate down to a slower speed.
>
> Additionally, you can increase the Sampling Rate if the software is working smoothly, and you will possibly get better resolution and apparently sensitivity.

7.1.1.4 Ensure the ***Sampling Mode*** is set to ***Quadrature sampling***.

7.1.1.5 ***Offset Tuning*** should be unchecked.

7.1.1.6 ***RTL AGC*** should be checked.

7.1.1.7 ***Tuner AGC*** should be checked.

7.1.1.8 ***Frequency Correction (ppm)*** should be set to ***0***.

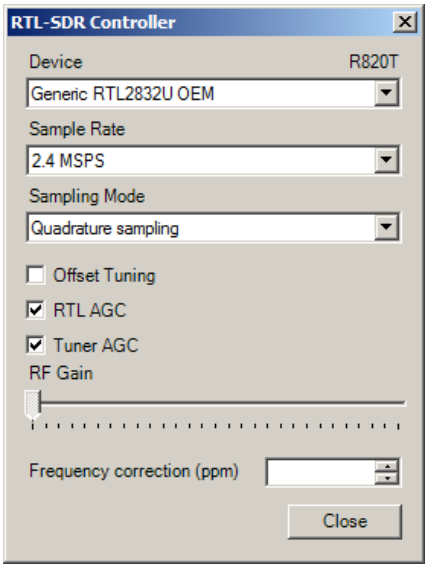


Figure 23 - SDR# Configuration Settings

7.1.1.9 Close the ***CONFIGURATION*** pop up box.

7.1.2 Setting RF Gain

7.1.2.1 When tuning the RF gain you are trying to get the signal as strong as possible, whilst keeping the noise floor as low as possible. Start with a low gain setting, and slowly increase the gain slider. Watch in the frequency spectrum as the signal strength increases, but stop just before the point at which the noise floor starts to rise.

NOTE - The noise floor is the part of the frequency spectrum where there are no signals.

7.1.3 Set RADIO MODE to USB. (Upper Side Band)

7.1.4 Under the Audio tab, "Filter Audio" reduces noise. If you are going to pass audio to a digital decoder then untick this box.

7.1.5 Under the Audio tab, WITH THE SOFTWARE STOPPED, click OUTPUT and select ***MME CABLE INPUT (VB-AUDIO VIRTUAL CABLE)***

7.2 Orbitron Initial Software Setup

7.2.1 Update Satellite LTE files.

NOTE - The first time you run the Orbitron software, the system will inform you that the installed TLE data files for the satellite positions are older than 30 days, and will ask you if you want to run the TLE Updater. It is highly recommended that you click ***YES*** and update the data files.

7.2.1.1 From the pull down menu, select the appropriate data group you want to download. ThumbNet recommends starting with the group titled: **WWW.CELESTRAK.COM – ALL**

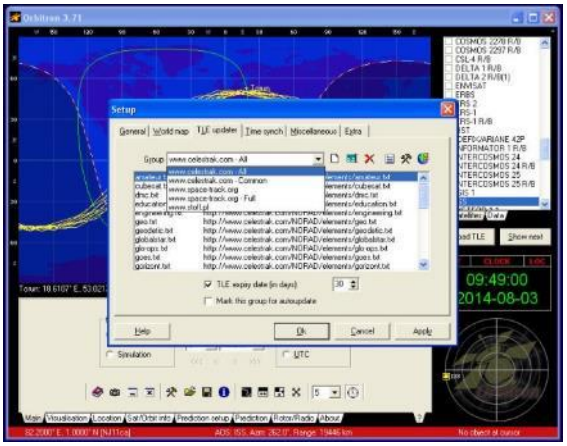


Figure 24 - Update LTE

7.2.1.2 Once the group is selected, you can review the files that will be downloaded in the scrollable window.

7.2.1.3 When you are confident that you have the correct files selected, click the ***UPDATE LTE FILES FROM GROUP VIA INTERNET*** button to the upper right to begin the download.

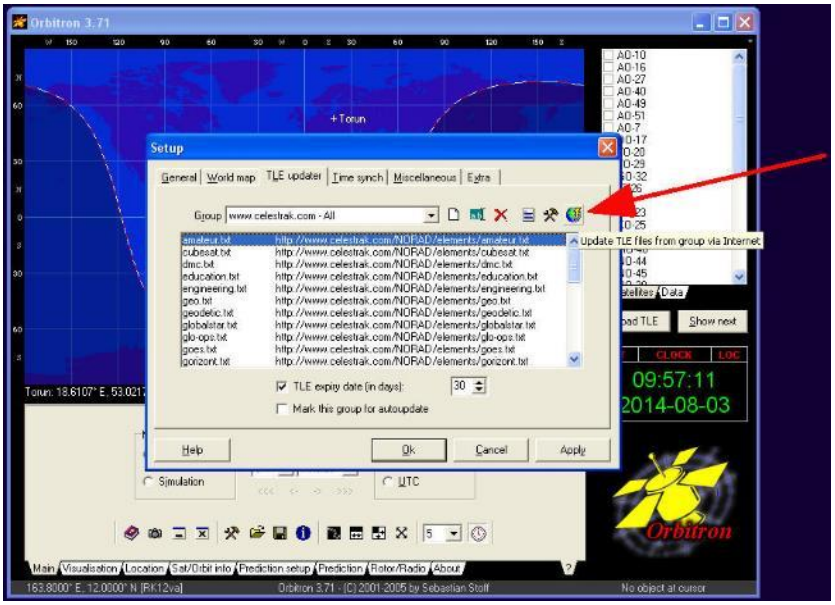


Figure 25 - Download LTE Update

7.2.1.4 When the update is complete, click ***OK*.**

7.2.1.5 On the Setup screen, click ***APPLY*** and then ***OK***.

NOTE - To exit the full screen mode of Orbitron, hold the **ALT** key and press ***ENTER*** or click on the MENU button in the extreme upper right and uncheck ***FULL SCREEN*.**

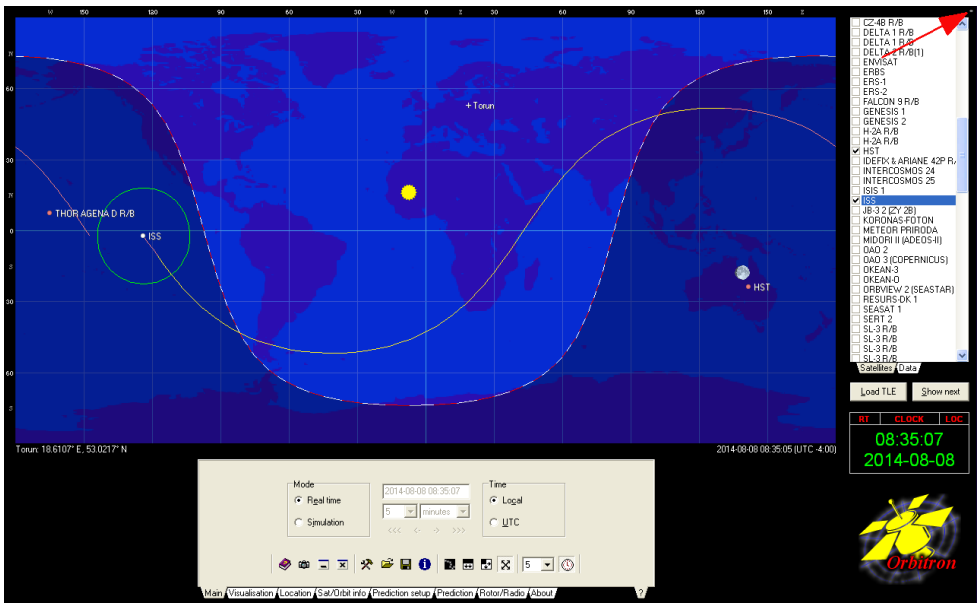


Figure 26 - Orbitron Menu Button

7.2.1.6 Delete the install file from your desktop.

7.2.2 Update Earth station location

7.2.2.1 From the main screen, select the ***LOCATION*** tab.

> **NOTE -** In the ***WORLD*** box, you can type the name of the nearest, large city to your earth station and select it to auto populate the data for your area. This is acceptable for most locations in the world, as long as the distance is less than apx 100 kilometers.
>
> In general, ThumbNet recommends that you enter your specific latitude and longitude information into the LOCATION tab, to ensure the highest possible tracking accuracy.

7.2.2.2 Enter your Latitude and Longitude into the appropriate fields on the ***LOCATION*** tab and click ***CHOOSE***.

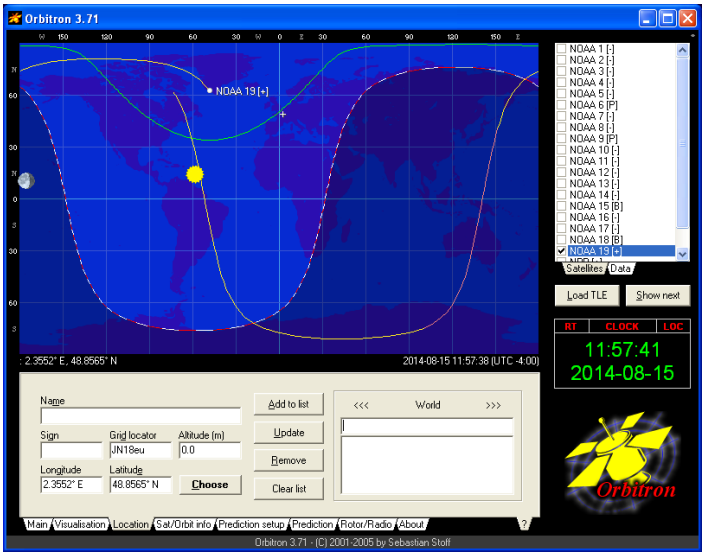


Figure 27 - Set Earth Station Location

NOTE - The application should now be ready to use. Place a check mark next to the satellite that you want to monitor in the right hand window, and begin enjoying the thrill of predicting when various satellites will be within line of sight of your antenna.

NOTE – ThumbNet will issue an advisory memo prior to the launch of each satellite constellation, which will have the information necessary to track the constellation for each particular mission.

7.3 Virtual Audio Cable Initial Setup

7.3.1 There are no initial setup steps for the Virtual Audio Cable software beyond the default settings.

7.4 DL-FLDIGI Initial Setup

NOTE - VB Audio needs to be installed prior to DL-FLDIGI can be used for ThumbNet operation. It is recommended that you use section 5.3 and install Virtual Audio Cable prior to running DL-FLDIGI for the first time.

7.4.1 Start the DL-FLDIGI software normally.

NOTE - The first time you start the DL-FLDIGI software, the Configuration Wizard will appear. Accept all of the default settings for the software for this wizard.

DL-FLDIGI will not work correctly with all of the default settings from this wizard, but the correct configuration settings will be created in the following steps of this procedure.

7.4.2 On the Welcome screen, click ***NEXT***.

7.4.3 On the Operator Information screen, click ***NEXT***.

7.4.4 On the Audio Devices screen, click ***NEXT***.

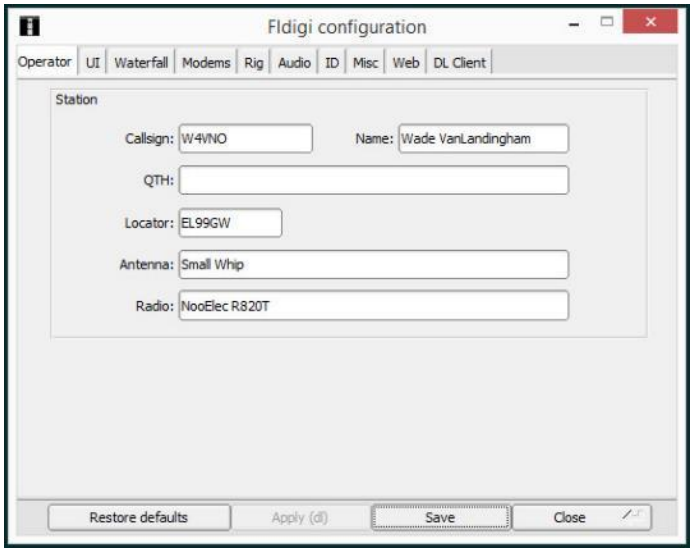
7.4.5 Accept all default settings on the Transceiver Control screen and click ***FINISH***.

NOTE - DL-FLDIGI HAB defaults to online.

To avoid overloading the system, turn off the check mark next to the ONLINE box when testing the system.

For a ThumbSat mission, you will want to make sure that there **IS** a check mark in this field, to ensure that data is being transmitted back to ThumbNet.

7.4.6 Under the CONFIGURE menu, click ***OPERATOR***.



7.4.7 Ensure that the OPERATOR tab is highlighted and enter your amateur radio call-sign or your ThumbNet station ID (ie: TN002) in the box labeled ***CALLSIGN***.

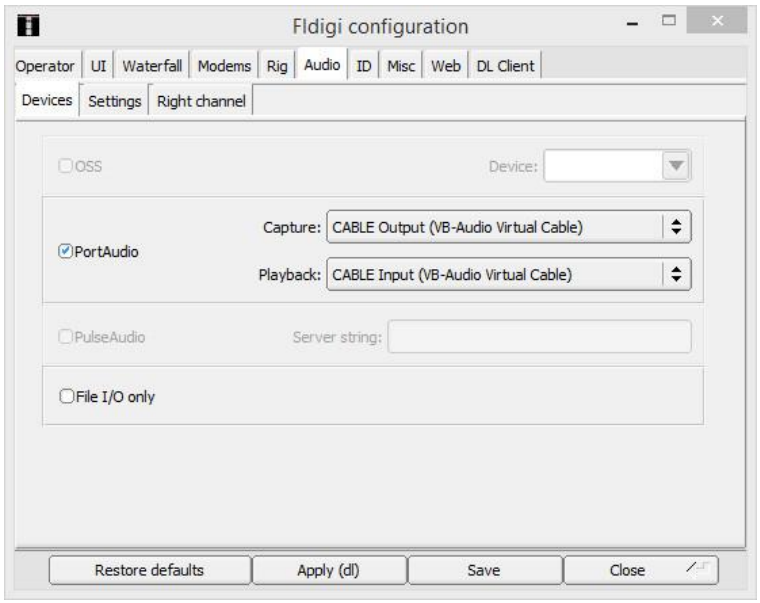
7.4.8 Go to the URL: http://qthlocator.free.fr/ and click on your location, to get the Maidenhead Locator data required for the field ***LOCATOR***.

7.4.9 Set remaining fields as appropriate.

7.4.10 Click ***APPLY***.

7.4.11 Click ***SAVE***.

7.4.12 Click the ***AUDIO*** tab.



7.4.13 Click the ***DEVICES*** sub-tab.

7.4.14 Ensure ***PORT AUDIO*** is selected.

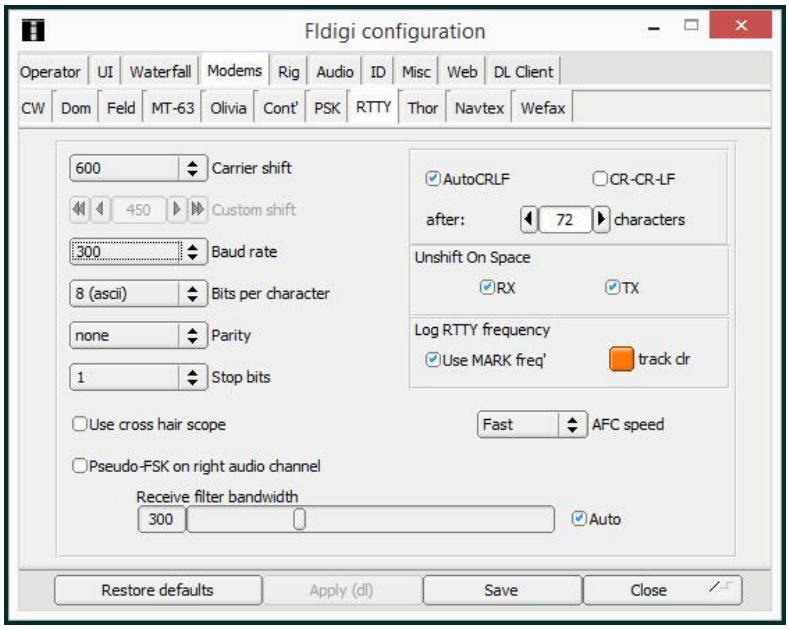
7.4.15 Under the CAPTURE menu, select ***CABLE OUTPUT (VB-AUDIO VIRTUAL CABLE)***

7.4.16 Under the PLAYBACK menu, select ***CABLE INPUT (VB-AUDIO VIRTUAL CABLE)***

NOTE – In rare cases, ThumbSat missions may transmit at a communication profile different from the one outlined in the following steps. For example, the transmit rate may be 600 instead of 300 bits per second or the stops bits may change.

ThumbNet will publish the mission characteristics for each launch and the ThumbNet operator may have to change settings in the MODEMS tab, for a particular mission.

7.4.17 Click the ***MODEMS*** tab.



7.4.18 Click the ***RTTY*** sub-tab.

7.4.19 Click ***BAUD RATE*** and select ***300***.

7.4.20 Click ***CARRIER SHIFT*** and select ***600***.

7.4.21 Click ***BITS PER CHARACTER*** and select ***8(ASCII)***.

7.4.22 Click ***PARITY*** and select ***NONE***.

7.4.23 Click ***STOP BITS*** and select ***1***.

7.4.24 In the section labeled ***RECEIVE FILTER BANDWIDTH*** check the box labeled ***AUTO***.

> **NOTE -** If you experience problems with the trackers not locking onto the signal and the auto function sets this value lower than about 300, then uncheck the AUTO box, and set the bandwidth manually to 600.

7.4.25 Set ***AFC SPEED*** to ***FAST***.

7.4.26 Click the ***DL CLIENT*** tab.

7.4.27 Click the ***ENABLE*** subtab.

7.4.28 In the text box labeled ***COUCH URI***, enter the following string:

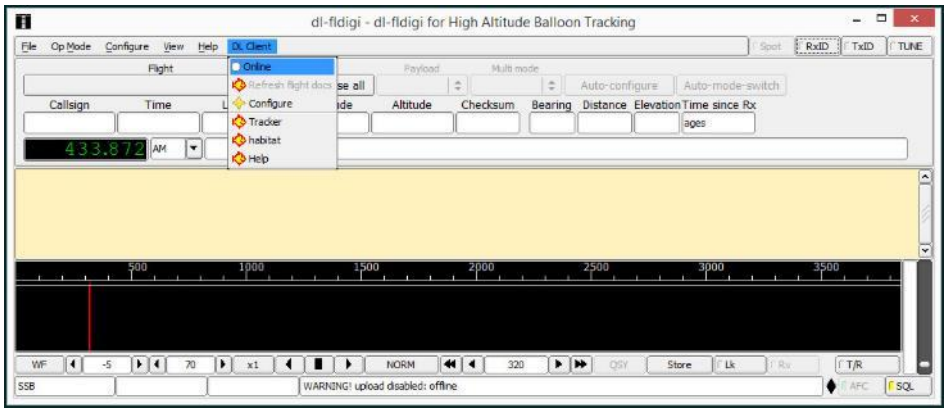
http://habitat.thumbsat.com

7.4.29 If you would like to save copies of the SSDV images to your local drive, ensure that the ***SAVE IMAGES*** box is checked and enter an appropriate local hard drive folder, such as ***C:\Temp***, in the ***LOCATION*** box.

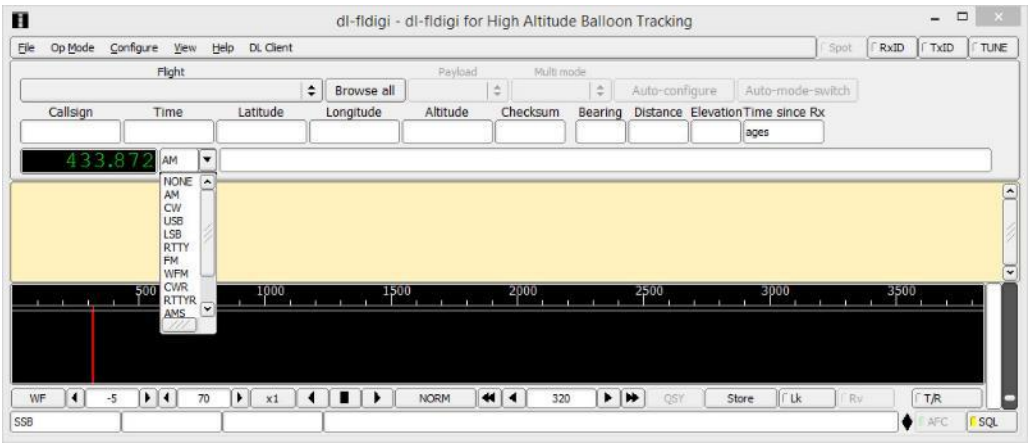
7.4.30 Click ***SAVE*** to save the configuration changes you've made.

7.4.31 Click ***CLOSE*** to exit the configuration menu

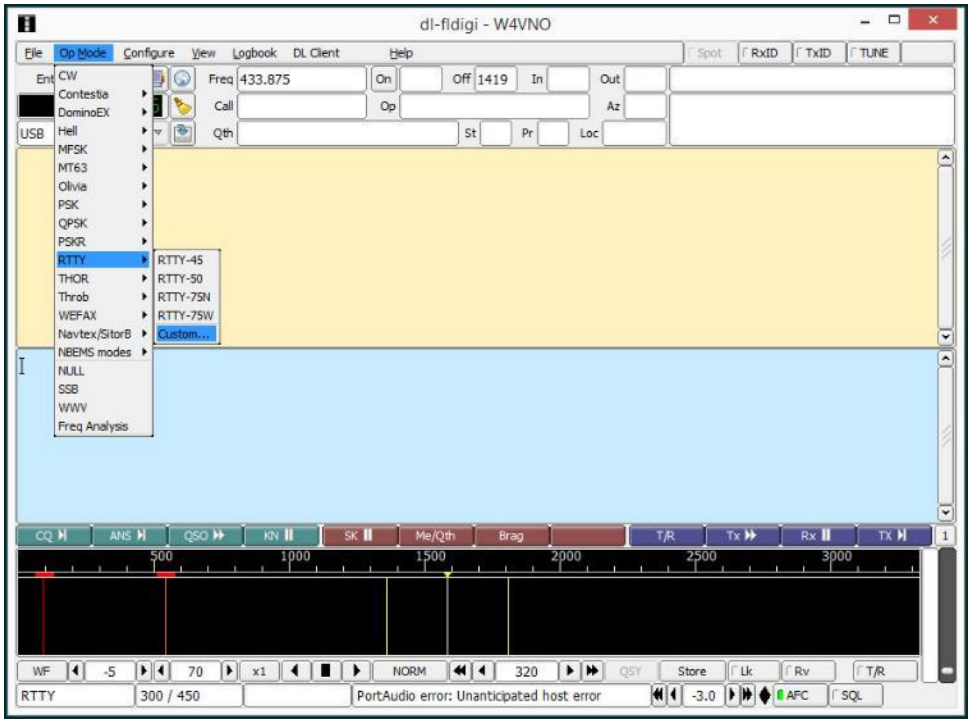
7.4.32 To enable internet uploading, on the ***DL CLIENT*** pull-down menu, select ***ONLINE***. To avoid overloading the server, turn this off for testing.



7.4.33 From the drop down box, of the main screen of DL-FLDIGI, select ***USB***.



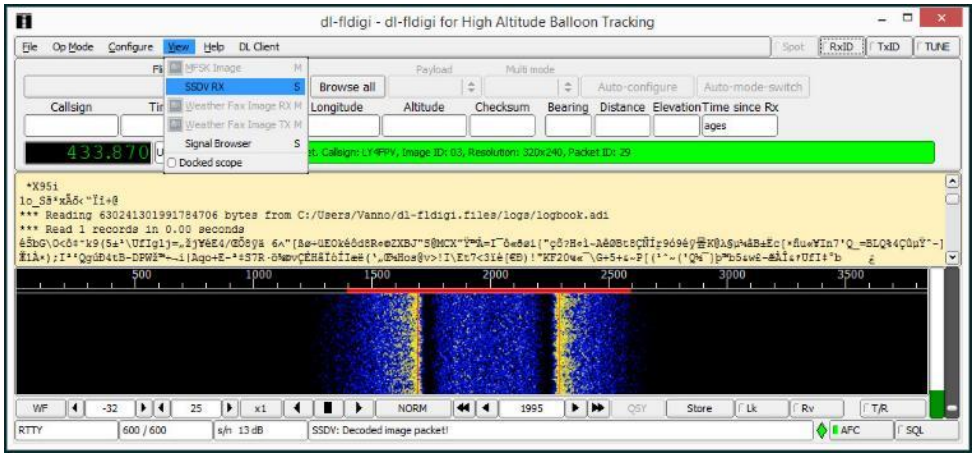
7.4.34 From the ***OP MODE*** menu, select ***RTTY*** and then ***CUSTOM***.



Select save

Select close.

7.4.35 From the ***VIEW*** menu, select ***SSDV RX***.



8.0 Testing

8.1 SDR# / DL-FLDIGI Interface Testing

NOTE - The steps that follow, load a recording of a ThumbSat transmission and allow the user to do a fully functional test and ensure that the SDR# software is interfacing properly with the DL-FLDIGI software and that an image can be captured.

8.1.1 Save a copy of the file ***Test IQ Signal.zip*** from the Software CD to your computer desktop.

8.1.2 Unzip the file to produce the new file: ***Test IQ Signal.wav***

8.1.3 Open the SDR# application

8.1.4 Open the DL-FLDIGI application.

8.1.5 In DL-FLDIGI, under the ***CONFIGURE*** menu, click ***MODEMS***, then select the ***RTTY*** subtab.

8.1.6 Change the ***BAUD RATE*** to ***600***.

8.1.7 Click ***SAVE***.

8.1.8 Click ***CLOSE***.

8.1.9 Under the ***VIEW*** menu, click ***SSDV RX***.

8.1.10 In SDR#, click the ***SOURCE*** menu.

8.1.11 From the pull down menu, select ***IQ FILE (*.WAV)***

8.1.12 Navigate to your computer's desktop and select the file ***Test IQ Signal.wav***.

8.1.13 Click ***OPEN***.

8.1.14 Click the ***PLAY*** button in SDR#.

8.1.15 Click on the frequency spike and you should immediately see data in the waterfall display screen in DL-FLDIGI. At the same time, the SSDV RX window, should begin displaying the ThumbSat logo image.

NOTE - When using a wav file as an input to SDR#, the SDR# software will continue to play the file in a loop as long as the play button is pressed. This is useful if you want to vary settings in either SDR# or DL-FLDIGI and see how the results will affect the reception of the ThumbSat signal.

NOTE - It will appear that the SSDV RX screen is not refreshing, due to the fact that identical data is being fed back into the DL_FLDIGI application. In order to see the screen data refreshing, you must exit DL-FLDIGI and restart the application.

NOTE - The displayed frequency in SDR# while playing the TEST IQ SIGNAL file is approximately 169 kilohertz, instead of the expected 433.870 megahertz. This is a function of the recording process and can be safely disregarded.

NOTE - Remember to change the BAUD RATE back to 300 for normal ThumbSat tracking.

9.0 Troubleshooting

9.1 Troubleshooting SDR#

9.1.1 Zadig takes a long time to install the driver, then fails.

9.1.1.1 You have probably not run Zadig in administrator mode. Make sure to right click Zadig, and select ***Run as Administrator***.

9.1.2 I don't see ***Bulk-In, Interface (Interface 0)***.

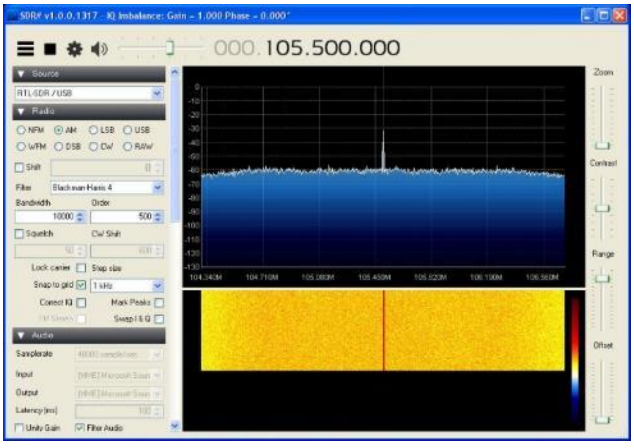
9.1.2.1 Ensure ***Options***->***List All Devices*** is checked. Some people report seeing something else other than the bulk in interface. It may also show up as the brand of your dongle or something prefixed with "rtl". This option should work too.

9.1.3 Zadig gives "System policy has been modified to reject unsigned drivers" error in Windows 8

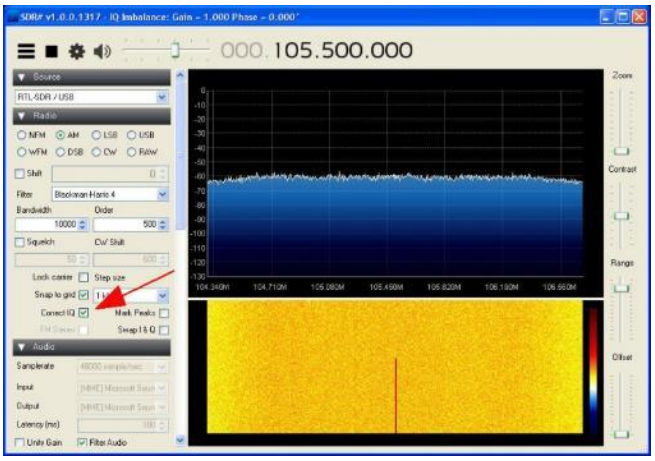
9.1.3.1 Windows 8 can cause signed driver issues with Zadig. Some users report getting the error "*System policy has been modified to reject unsigned drivers".* A possible solution has been posted here in the SDRSharp Yahoo Group.

9.1.4 Well defined spike shows up in the center of the frequency window, regardless of what frequency is selected.

9.1.4.1 When you run SDR# it is possible that a very well defined spike will show up in the middle of the frequency window. There is a complicated set of events going on related to the USB receiver and the SDR# Software. See **Appendix C** for details.



9.1.4.2 To correct the problem, ensure that the check mark next to ***CORRECT IQ*** is turned on. The spike should disappear.



9.1.5 "Application failed to initialize properly (0xc0000135). Click OK to terminate." error message when trying to run SDRSharp.exe

9.1.5.1 Microsoft .NET Framework 3.5 is not installed.

9.1.5.2 Close all applications and install Microsoft .NET Framework 3.5 or higher. You can down the Microsoft .NET 3.5 Framework at the following page:
http://www.microsoft.com/en-gb/download/details.aspx?id=21

9.1.6 "Object reference not set to an instance of an object" error message.

9.1.6.1 Check that you have installed the audio driver for your PC

9.1.7 USB ports

9.1.7.1 Be aware that not all USB ports are equal. For example, you may need a USB 2.0 hi-speed port to talk to a TV USB receiver stick, but USB 2.0 full-speed actually isn't fast enough. Some USB drivers have bugs, so if a USB 3.0 port doesn't work, try a USB 2.0 port instead.

9.1.8 Other References

9.1.8.1 More general user information and troubleshooting ideas can be found at the SDRSharp Wiki found at: http://sdrsharp.pbworks.com/w/page/62589136/FrontPage

9.1.8.2 A good guide to learning how to use SDRSharp and what all the options do can be at: http://www.atouk.com/SDRSharpQuickStart.html .

9.2 Troubleshooting Orbitron

9.2.1 No Satellites on Display

9.2.1.1 Ensure that you have run the TLE Update per section 6.2.1 of this procedure and that you have at least one satellite selected from the list.

9.2.2 Orbits not accurate

9.2.2.1 Ensure that you have run the TLE Update per section 6.2.1 of this procedure.

9.3 Troubleshooting DL-FLDIGI

9.3.1 DL-FLDIGI crashes after upgrading on Windows

9.3.1.1 Seems to be a common complaint and usually caused by trying to upgrade and skip several version changes. fldigi maintains its configuration (long term settings) and status (state on last execution) files in its own files folder.

On XP C:\"Documents and Settings\<urlogin>\fldigi.files\"
On W2K C:\"Documents and Settings\<urlogin>\fldigi.files\"
On Vista/Win7 C:\User\<urlogin>\fldigi.files\
On OS X /home/<login_name>/.fldigi
On Linux /home/<login_name>/.fldigi

Delete these two files located in the files folder: fldigi_def.xml and fldigi.prefs

It is not necessary to delete any other files or folders. If you do then you will probably lose your macro and logbook files.

Start the new fldigi and you will be presented with the start-up wizard.

10.0 Appendix A – Earth station Component Overview

Component	Notes
70cm High Gain (Yagi) antenna.	Constructed on site. See procedure THS-NA-TSI-PR-02 Minimum 10dB gain required
RTL2832U + R820T USB Television tuner dongle	Supplied by ThumbSat / ThumbNet
USB cable Extender	Used to increase distance between tuner and laptop/power supply to reduce electrical noise.
Laptop or smartphone	With internet access. USB 2.0 ports required.
Software Defined Radio software	SDR# software package supplied by ThumbSat on USB drive. Other software is available online if preferred by the user.
Orbital prediction software	Orbitron software package supplied by ThumbSat on USB drive. Other software is available online if preferred by the user.
Audio cable or Virtual Audio Cable	VB-Audio Cable used to interconnect the SDR software output signals to the digital modem inputs
Digital Modem Program	dl-fldigi software package supplied by ThumbSat on USB drive. Other software is available online if preferred by the user.
Image-specific software	SSDV
Antenna pointing software and hardware	Hand held antenna at the moment. To be defined and developed in the future.

11.0 Appendix B – Software Installation Non- Windows 7 Machines

11.1 SDR# Software Installation Windows XP

NOTE - Ensure that the dongle software and drivers have not been previously loaded onto the computer. If they have, please completely uninstall them and restart the computer, leaving the dongle disconnected.

11.1.1 Copy the ***SDRSharp_WinXP.zip*** Install file from the CD to your desktop.

11.1.2 Unzip the file to the folder ***C:\Program Files\SDRSharp***.

11.1.3 Delete the ***SDRSharp_WinXP.zip*** Install file from the CD to your desktop.

11.1.4 Plug in the RTL-SDR dongle supplied by ThumbNet to your desktop.

11.1.5 Click ***NEXT*** when the Hardware Wizard for Windows XP automatically attempts to find and install drivers for the RTL-SDR dongle.

11.1.6 When the Hardware Wizard says that it cannot install this hardware, click ***FINISH***.

11.1.7 A second Hardware Wizard will pop up asking to install the drivers for *BULK-IN, INTERFACE*. Ensure that the *INSTALL FROM SOFTWARE AUTOMATICALLY (Recommended)* is selected then click ***CONTINUE***.

11.1.8 The hardware Wizard should show a pop up that says ***HID Infrared Remote Receiver*** installed successfully.

Figure 28 - Windows XP Hardware Wizard

> **NOTE -** If a balloon pops up saying that there was a problem with the new hardware, close the balloon. This problem will be solved by updating the drivers in the following steps.

11.1.9 In WinXP Double click the file ***zadig_xp.exe***

11.1.10 In Zadig, go to ***Options*** and make sure there is a check mark next to ***List All Devices***. If not, click to check.

11.1.11 In Zadig, Select "***Bulk-In, Interface (Interface 0)***" from the drop down list. Ensure that WinUSB is selected in the box next to where it says Driver.

11.1.12 Click ***Install Driver***. This will install the drivers necessary to run the dongle as a software defined radio.

> **NOTE -** You may need to run zadig.exe again if you move the dongle to another USB port, or want to use two or more dongles together.

11.1.13 If prompted, select ***YES*** to restart the computer.

11.1.14 Launch the SDR# application with the file ***SDRSharp.exe.***

11.1.15 From the ***SOURCE*** drop down menu, select ***RTL-SDR / USB***.

> **NOTE -** When the screen refreshes, your Software Defined Radio is ready to begin receiving radio signals from ThumbSat!

11.1.16 Click the ***START*** button at the top of the screen, and the frequency window should show levels and the waterfall section should begin cascading.

11.1.17 Follow the guidelines in section 6.1 for initial software settings.

12.0 Appendix C - Discussion of Central Noise Spike in SDR#

NOTE - The following is copied from a web discussion here:

http://sdrsharp.pbworks.com/w/page/62635276/Central%20spike

It is provided here for informational purposes only, and as insurance against the web page being taken down over time. Any errors or omissions belong to the author. ThumbNet has made a reasonable effort to ensure the validity of the comments, but cannot be responsible for mistakes or incorrect information.

There are several components to that central spike.

First be aware that once the data gets out of the USB port into the SDRSharp software the -127.5 to 127.5 step range (or -128 to 127 depending on the A/D converter biases) is converted to floating point. So in the discussion below I'll first take you through the manual method of balancing and then my description of how I'd balance at least some of it automatically.

The first and most obvious component, perhaps, is DC balance. You can, with patience, adequate adjustment range, and adequate resolution digitally balance out the central spike by inserting artificial offset virtual voltages . You tweak the setting until the sharp spike at zero vanishes into the noise using a VERY fine grained FFT and a lot of patience. You must balance both channels to get good results. You must go from I to Q to I to Q iteratively until the best possible balance can be achieved or your patience runs out. This is important for both the central spike minimization and opposite side spurious reduction.

*The second and not quite so obvious component is the precise amplitude rendition of the two A/D converters. They're not perfect and therein lies **o**pposite **s**ide **i**mages, which I'll call OSI. (Not office of special investigations. That's a different milieu entirely.) If the two sides are not balanced then you cannot balance out the OSI. The difference in amplitude is directly related to the OSI amplitude.*

The third, related, component is the phase quadrature of the two sample streams. If they are not pure quadrature then even if the amplitudes are identical the phase difference will prevent proper cancellation. This is directly related to the so called phasing mode of SSB detection or generation. (Heathkit used this in their 6 meter SSB transmitter from aeons ago. I still have mine, slightly doctored, of course.)

So the amplitude balance can be obtained by multiplying I or Q by 1 + d, d being a very small delta that runs to both plus and minus values. And using a cheat and a property of the sine and cosine functions you can tweak the apparent phase of I and Q by injecting a VERY small amount of Q into I. After all in the world of radian angles the sin of a tiny angle is equal to the angle. This is only good at small angles equivalent to a couple degrees or less, but that's plenty for usual needs. And the approximation is good enough the amplitude "precision" is not affected up to angles in at least the plus to minus 10

degrees range.

So this is another pair of pots or sliders on the screen. After the DC is balanced you set-up a reasonably strong but not limiting signal that shows the OSI. Tune the VFO, but not the LO, to that OSI. Then tweak amplitude and phase balance to null the image. This is another annoying iterative process, but with practice it goes relatively fast . There is a slight interaction of this adjustment with the DC balance adjustments.

All four adjustments need to be "just right" to completely eliminate the spike and the image . The spike can be automatically eliminated by using a very low pass filter on I and Q independently and nulling each one of the outputs. There is a hazard with an automatic adjustment that you might be honestly zero beat with a real signal and find yourself nulling it out. Move the LO slightly to make sure that's not the case.

The image nulling is a little more complex, but the approach I'd take is multiply the high side signal by the low side signal and use the correlation of the two as the driver to null the OSI. Just make sure it is the OSI you are nulling. {^_-} I believe this is rather roughly what SDRSharp is doing. I've not analysed the code. I will someday and I will then see if I guessed right.

When the signal is multiplied by the OSI the two are highly correlated. So the long term average is non-zero. That non-zero value is what you drive to zero to make it all null properly. If there is no OSI present then the multiplication of signal and noise or noise and noise will average zero, they are not correlated.

As I say, this needs some clean-up. But hopefully it helps understanding. The image nulling trigonometry is probably a subject for an appendix to this article. I'm too lazy to do it now. Other messages and paying work are pressing.

Joanne Dow, W6MKU

13.0 Appendix D - References and Continued Reading

13.1.1 Free eBook on Digital Signal Processing http://www.dspguide.com/

14.0 Appendix E – Alternative Software

14.1 Other SDR Windows Software Compatible with RTL-SDR

14.1.1 **HDSDR** – An advanced version of the WinRad SDR software. A free software defined radio package that can be found at: http://www.hdsdr.de/

14.1.2 **SDR-Radio v2** – A Windows console for software defined radio which can be found at: http://v2.sdr-radio.com/ .

14.2 Other Software Capable of Satellite Tracking

14.2.1 **WXTrack**

14.2.2 **Gpredict**

Gpredict is a very rich, full featured satellite tracking application that meets all of the needs of a ThumbNet station operator. There are versions for Windows, Mac OSX and Linux.

If there is a limitation to the software for the purposes of ThumbNet, it is the fact that it will not interface directly to SDR# through a DDE or TCP/IP connection to control the receiver frequency shifting due to Doppler Shift, in the same way that Orbitron does. Aside from that, for hand held direction finding, on a non-Windows computer, Gpredict is an excellent program.

NOTE - The following procedure was written for a Windows 7 installation of Gpredict version 1.4. Your installation may differ slightly. Contact ThumbNet with any problems or questions and we will try to help.

NOTE - If you install Gpredict on an OS other than Windows, we would appreciate it if you kept notes of the install and passed them on to us, so we can share them with others.

14.2.3 **Installing Gpredict**

14.2.3.1 Unzip the ***Gpredict*** file from the ThumbNet Software CD to your computer's desktop.

14.2.3.2 Move the entire Gpredict folder to the following path: ***C:\Program Files (x86)*** or another location you choose.

14.2.3.3 Open the ***Gpredict*** folder.

14.2.3.4 Open the ***BIN*** folder.

14.2.3.5 Right click on the file ***gpredict.exe*** and select ***CREATE SHORTCUT***.

14.2.3.6 Move the shortcut just created to your desktop or Start Menu.

14.2.3.7 Double click the shortcut to run the Gpredict program.

14.2.4 Gpredict Initial Setup

14.2.4.1 From the ***EDIT*** menu, select ***UPDATE TLE***, then select ***FROM NETWORK***.

14.2.4.2 When the update has completed, click ***CLOSE***.

14.2.4.3 From the ***EDIT*** menu, select ***PREFERENCES***.

14.2.4.4 Click the ***GENERAL*** button.

14.2.4.5 On the ***NUMBER FORMATS*** tab, check or as appropriate for your convenience.

14.2.4.6 On the ***GROUND STATIONS*** tab, click ***ADD NEW***, to add your station location.

14.2.4.7 Enter a name for your station and fill out the remaining fields as applicable.

> **NOTE -** It might be convenient for you to use the station ID number assigned by ThumbNet in the ***DESCRIPTION*** box, although this is not necessary.

14.2.4.8 Click on the original location named ***SAMPLE*** and then click the ***DELETE*** button.

14.2.4.9 Ensure that there is a check mark next to your station under the ***DEFAULT*** column.

14.2.4.10 On the ***TLE UPDATE*** tab, ensure that the age of the ***TLE*** data is set to ***WEEKLY*** and select your preferred action to update in the background, or notify you.

14.2.4.11 Click the ***MODULES*** button.

14.2.4.12 On the ***LAYOUT*** tab, select the screen layout that you are most comfortable with. Initially, ThumbNet recommends using the default "World Map, Polar and Single Sat" to familiarize yourself with the various screens.

14.2.4.13 Select any ***WINDOW PLACEMENT*** options you would like to use.

14.2.4.14 On the ***REFRESH RATES*** tab, set the value for ***REFRESH DATA EVERY*** to 500.

NOTE - This setting can be set higher or lower depending on processor speed, however, there is no practical advantage to updating the data on the screens any faster then every half second, but there might be impacts to the SDR# software or other running applications if you update the displays more frequently than required. If you notice a system performance issue while running multiple applications, this is one setting you can adjust to try to improve the overall system operation.

14.2.4.15 On the ***LIST VIEW*** tab, select which items you would like to see visible on the main display screens.

14.2.4.16 On the ***MAP VIEW*** tab, make any changes desired to the map screen, such as the background map that is being displayed.

NOTE - Gpredict comes with a number of existing background maps to choose from by clicking the **SELECT MAP** button and choosing one from the **MAPS** directory.

You can add your own map to the ***MAPS*** directory if you prefer, as long as it is roughly twice as wide as it is tall, (ie: 800x400 pixels or 2048x1024 pixels.) and is in jpg format. Copy your image to the folder:

C:\Program Files (x86)\gpredict\share\gpredict\pixmaps\maps
.

14.2.4.17 On the ***POLAR VIEW*** tab, select the options you would like to use.

14.2.4.18 On the ***SINGLE SAT VIEW*** tab, select the options you would like to use.

14.2.4.19 Click the ***PREDICT*** button and set options on the tabs as you like.

14.2.4.20 Click ***OK*** to exit the Preferences menus.

14.2.4.21 Click ***FILE*** > ***EXIT*** and restart Gpredict, to update all the settings that have been changed.

14.2.4.22 Select the satellites that you would like to see in the main window, click on the ***MODULE OPTIONS*** button in the top right of Gpredict, roll down and click ***CONFIGURE***.

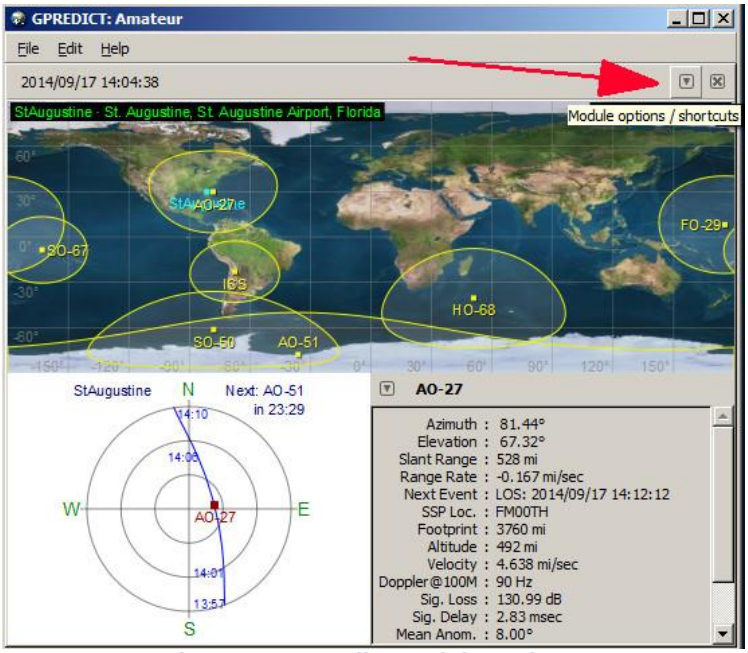


Figure 29 - Gpredict Module Options

14.2.4.23 Scroll through the list on the left or use the search box to find a particular satellite by name.

14.2.4.24 When you have identified a satellite that you want to track, double click the name, to move it to the right hand window. Additionally, you can single click the satellite's name, and click the right arrow between the panes, to move the satellite to the right.

15.0 Appendix F – Acknowledgements

15.1 SDR#

SDR# is the incredibly useful software defined radio application used by ThumbNet to monitor the ThumbSat constellation as well as other broadcast radio frequencies using the R820T hardware. The home page for the project can be found here: http://www.sdrsharp.com/ .

ThumbNet sincerely appreciates the work done by the author and the open source license the software has been given.

ThumbNet encourages all users to make a small contribution to the software's author, via the DONATE link on the page above.

15.2 Orbitron

Orbitron is a wonderfully useful software application written by Sebastian Stoff of Poland. Sebastian has made the software available to all users free of charge, with the request that the user sends a postcard to him, to let him know where in the world his software is being used.

ThumbNet highly encourages all of ThumbNet's participants to support Sebastian by sending him a postcard at:

Sebastian Stoff
Ul. Dziewulskiego 36a/52
87-100 Torun, Poland

At a minimum, please send Sebastian an email at Sebastian@stoff.pl and say thank you for this wonderful piece or free software.

Home - http://www.stoff.pl/

Download - http://www.stoff.pl/downloads.php

15.3 Virtual Audio Cable

15.4 DL-FLDIGI

Latest version can be found here: http://code.google.com/p/dl-fldigi/
https://fedorahosted.org/fldigi/

15.5 Gpredict

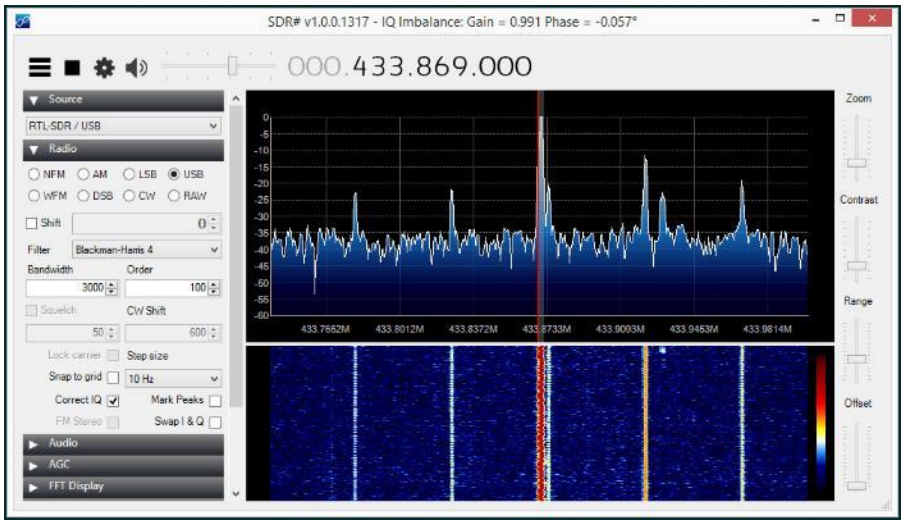
Gpredict is a very rich, full featured satellite tracking application that meets all of the needs of a ThumbNet station operator. There are versions for Windows, Mac OSX and Linux.

The home page for the project can be found here: http://gpredict.oz9aec.net/ .

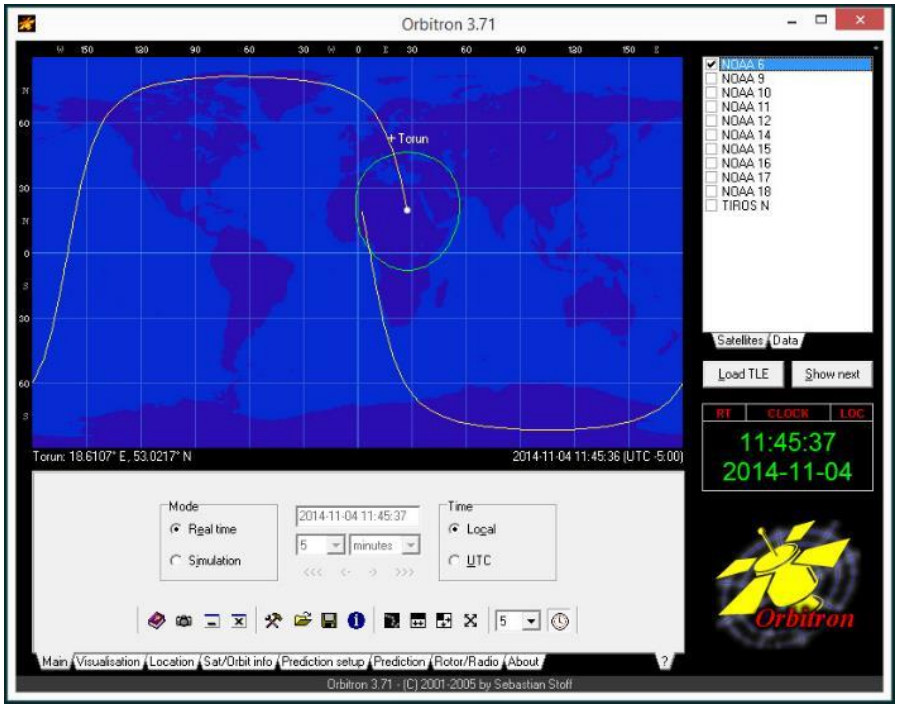
16.0 Appendix G - Screenshots

NOTE – The following screenshots give a representative look at what you should see in the various screens of all of the ThumbNet software as a ThumbSat signal is being processed. While not exact, your screens should look relatively similar.

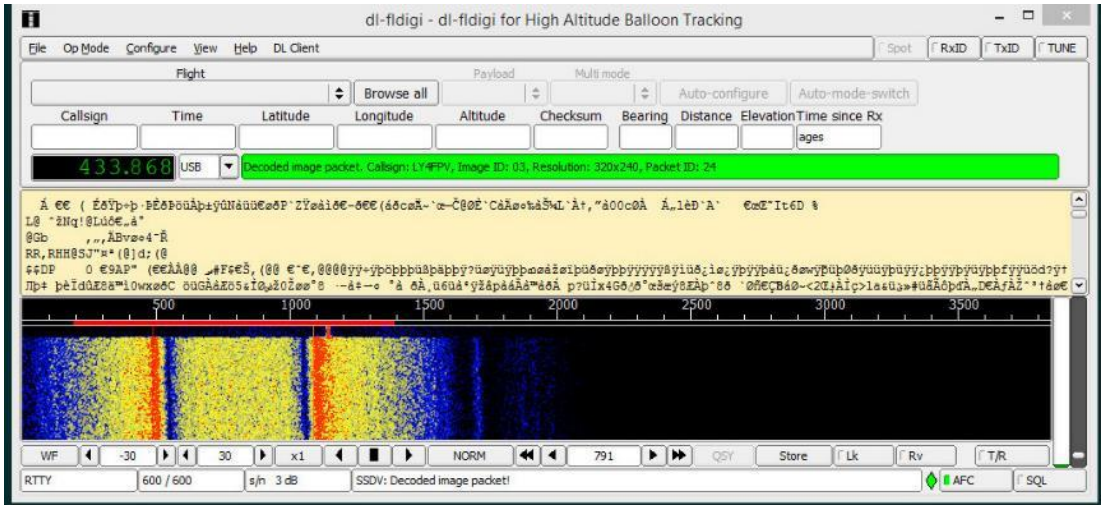
16.1 SDR#



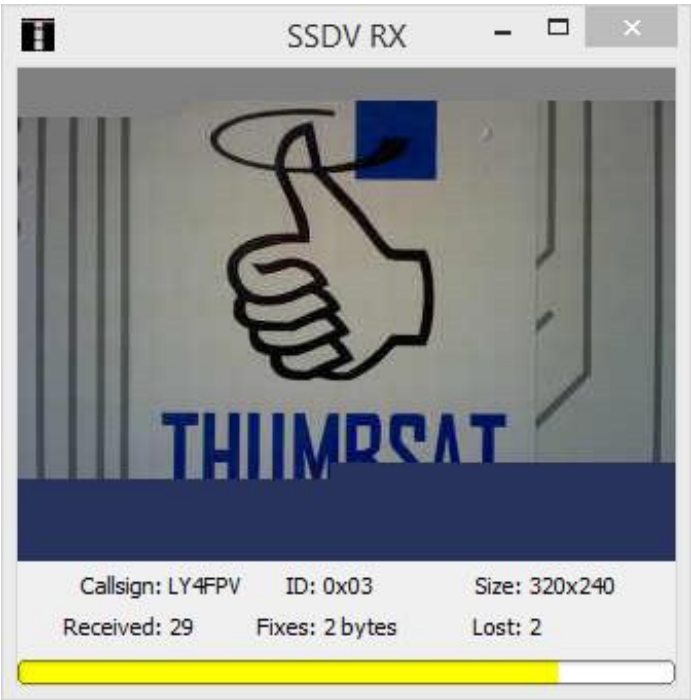
16.2 Orbitron



16.3 DL-FLDIGI



16.4 DL-FLDIGI SSDV RX


SSDV RX
Callsign: LY4FPV
ID: 0x03
Size: 320x240
Received: 29
Fixes: 2 bytes
Lost: 2

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