



# L-BAND RECEIVER

THE DIY PORTABLE [OUTERNET](https://outernet.is) RECEIVER MANUAL

For rxOS v2.02

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NOTE: L-Band is in Beta

The latest version of this manual can be found online at <https://outernet.is/docs> and in the root folder of the Librarian interface.

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# HOW OUTERNET WORKS

Outernet provides a unique service: filecasting. We send files over Inmarsat satellites, which transmit radio waves in the L-Band frequency range. These waves are received by the radio on the receiver, which turns them back into files, which are then stored on the receiver. In some cases, the receiver emits a WiFi hotspot, allowing access to the saved files through a web browser.



## COMPONENTS

There are 5 components required to build and operate a L-Band receiver:

- L-Band Antenna
- Amplifier
- Software-defined Radio (SDR)
- rxOS software on a Computer (C.H.I.P., Raspberry Pi 3, Linux, or Windows)
- Power source
- Optionally, a laptop running Windows 7/10 or Linux can be used to simply download files

All of the required components are included in **Outernet's** full DIY Receiver Kit with C.H.I.P. and a battery. To see the specifications of these Kit components, see Appendix 6 (page 21). We also sell components separately for those who wish to substitute our components with those that meet the proper specifications.

For hobbyists and tinkers, the L-Band hardware can also be used for Inmarsat reception, including SafetyNET, EGC, and AERO.

## HARDWARE SPECIFICATIONS FOR OUTERNET RECEPTION

### L-Band Air Gap Patch Antenna:

We strongly recommend purchasing from us.

- Center Frequency: 1542 MHz
- 8dbi
- SMA Male connector

### Software Defined Radio (SDR) Tuner Dongle:

- Ultra-low phase noise 0.5PPM TCXO
- RF-suitable voltage regulator custom heatsink
- SMA female connector
- SDR frequency range of approximately 25MHz-2200MHz
- Must have a bias tee enabled for use with the Outernet Amplifier

### Amplifier:

- Center Frequency: 1542 MHz
- Gain: 34 dB
- Voltage: 3.0V - 5.5V
- Current Draw: 25 mA

### Single-Board Computer:

rxOS demodulates and decodes the signal. If purchased with a kit, C.H.I.P. comes with rxOS pre-installed. Read more about rxOS on page 6. We have rxOS images that are compatible with:

- C.H.I.P.
- Raspberry Pi 3

For users without a Single-Board Computer, our software demodulator and decoder are available for simply tuning into the signal and downloading files on the following platforms:

- Windows 7 / 10
- Linux X86

### Power:

The receiver requires 2 Watts of power.

## HOW THE COMPONENTS WORK TOGETHER

Antenna	Tuned specifically for the L-band.
Amplifier	Reduces system noise, boosts gain, and amplifies the signal. The green light indicates the amplifier is receiving power.
SDR Tuner	Tunes into a particular frequency within the amplified signal and passes the signal to the computer running the demodulation software.
Computer	Runs software that demodulates and decodes the signal, and manages the received files.
Battery	An external battery or USB power is required to power the device.

# OUTERNET SOFTWARE: RXOS

Users with a C.H.I.P. with preinstalled software purchased from Outernet may skip this section.

For the full documentation for rxOS, visit <https://outernet.is/docs>. View the code on GitHub:

<https://github.com/Outernet-Project/rxOS/>.

## HOW RXOS WORKS

The files that are filecast by Outernet are encoded, modulated, and sent to several Inmarsat satellites. These satellites transmit the radio waves in the L band frequency range. The waves are received by the radio on the receiver and then passed on to the software demodulator. The demodulator turns the analog signal into bits and then passes them onto the decoder, which extracts the file information from the data and reconstructs the files on local storage.

The software components involved in this process are:

- the demodulator (sdr100)
- the decoder (ondd)
- file indexer (FSAL)
- web-based UI (Librarian)

## INSTALL RXOS ON YOUR DEVICE

rxOS for C.H.I.P.

Latest image for C.H.I.P.: <https://archive.outernet.is/images/rxOS-CHIP/>

How to Flash C.H.I.P.: [http://rxos.readthedocs.io/en/develop/getting\\_started/chip.html](http://rxos.readthedocs.io/en/develop/getting_started/chip.html)

rxOS for Raspberry Pi 3

In addition to the other components, a 8GB microSD card is required.

Latest image for Raspberry Pi: <https://archive.outernet.is/images/rxOS-Raspberry-Pi/>

How to Flash RPi: [http://rxos.readthedocs.io/en/develop/getting\\_started/raspberry\\_pi.html](http://rxos.readthedocs.io/en/develop/getting_started/raspberry_pi.html)

## RXOS ALTERNATIVES

OuternetInABox for Windows and Linux

OuternetInABox is a portable virtual machine that offers the basic Outernet receiver software.

Latest Image: <https://archive.outernet.is/images/OuternetInABox/>

Raspbian: <http://outernet-l-band-on-raspberry-pi.readthedocs.io/en/latest/>

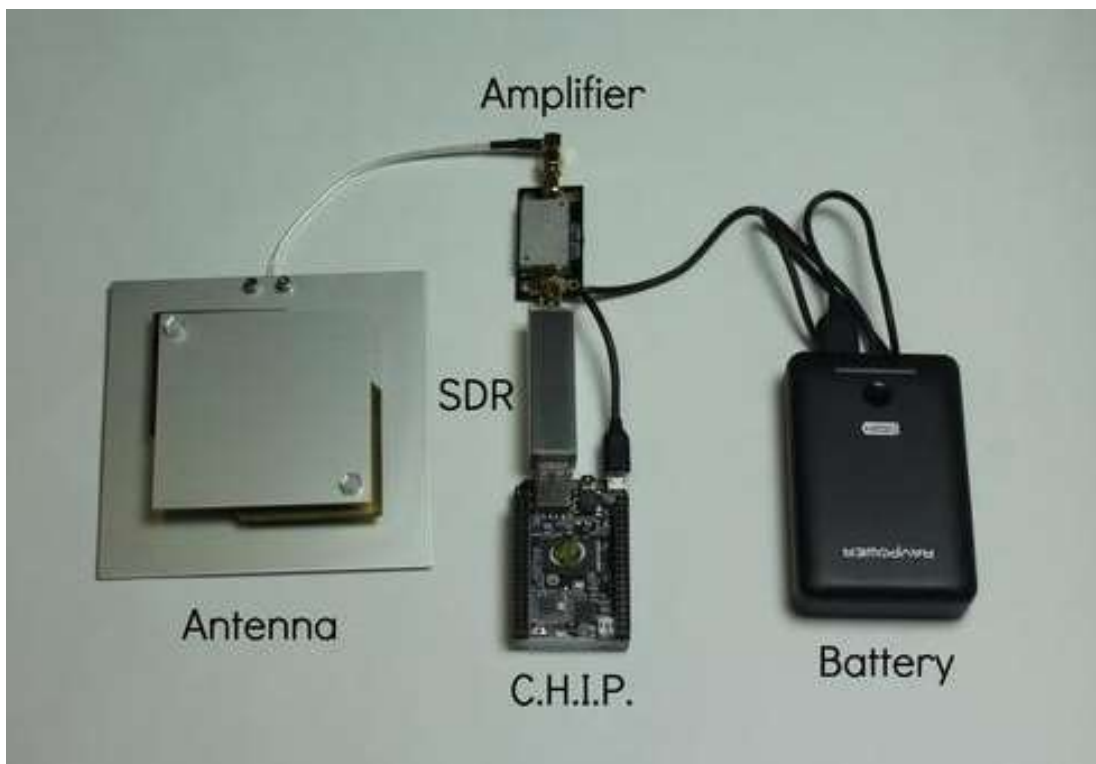
Linux: <http://outernet-l-band-on-linux.readthedocs.io/en/latest/>

This manual provides instructions for rxOS only. If using rxOS alternative, please use the linked reference documents as guides, rather than this manual.

# GETTING STARTED

## DIY RECEIVER ASSEMBLY

1. Install the rxOS or demodulation software on your chosen computer device (page 7).
2. Connect the male connector of the Antenna to the female connector of the Amplifier.
3. Connect the male connector of the Amplifier to the female connector of the SDR.
4. Insert the SDR USB into the USB port of your Computer with the correct version of rxOS installed (C.H.I.P. shown). For instructions for installing rxOS, see page 6.
5. Power the C.H.I.P. (RAV Battery shown).



## SET UP THE RECEIVER

After assembly, use a Wi-Fi enabled device to complete the receiver set up:

1. Open the list of WiFi networks on a Wi-Fi enabled device and connect to the wireless access point named *Outernet*.
2. Open any browser and type <http://outernet.is> in the address bar.
3. Complete the Librarian Setup Wizard (next page).



## LIBRARIAN SETUP WIZARD

The Librarian setup wizard will configure the receiver.

- Language                      This is the interface language that will be used by default when users connect to the device. Users can switch to another language later. If you want to contribute to our translations, please post on our forum.
- Superuser                      Superuser account is used to administer the receiver. Superuser will have access to receiver settings, and ability to manage the content library. Write down the *password reset token* (6-digit number), as it is required to reset credentials if they are forgotten: \_\_\_\_\_.
- Tuner settings                Choose the correct satellite (page 17) to have the device automatically set the correct settings for the tuner and click “Finish”.

Once the setup wizard steps are completed, click the **“Start Using Outernet”** button.

# SATELLITE RECEPTION GUIDE

To receive files, two things are required:

1. A lock on the satellite signal. A lock is required to receive data packets.
2. Receiving data packets. A weak signal or high error rate can prevent receipt of packets.

In Librarian, check the Signal Meter icon in the header bar:



Arrow pointing down above the bars. The device has a signal lock and is receiving data. Wait to see files in Librarian. More solid bars mean better quality signal.



An **'X'** and a dotted line through the bars. No signal lock and packets are not being received. Adjust how the antenna is pointed.



An **'X'** and a straight line through the bars. The device has a signal lock, but **it's not** receiving packets. The signal may be weak or there may be interference. Adjust how the antenna is pointed.

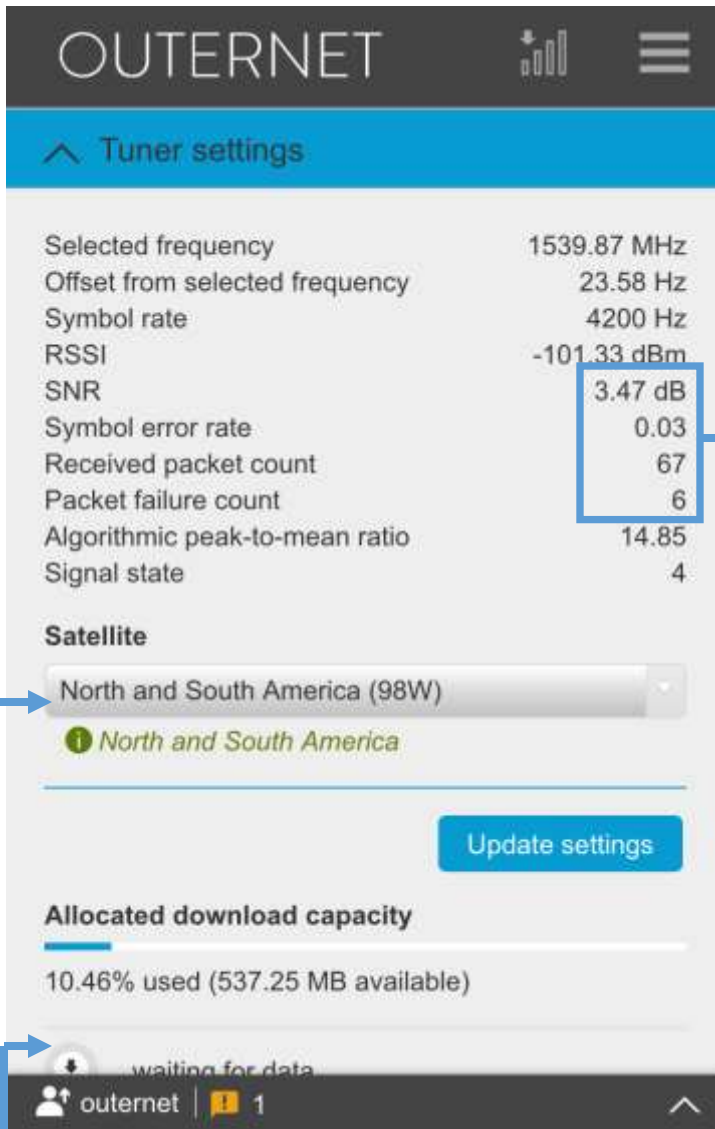
## POINT THE ANTENNA

To achieve a signal lock, the antenna needs to have a clear view of the satellite:

1. Determine which satellite you will be getting service from, and which direction it is relative to **the device's** current location (page 17).
2. Find a location for the receiver with a clear view of the sky.
3. Point and angle the antenna in the direction of the satellite.
4. Roughly **speaking, an antenna's angle relative to the ground** corresponds to its latitude. At the equator ( $0^\circ$ ), the antenna would be flat on the ground. At  $30^\circ\text{N}$ , the angle of the antenna facing south would be  $30^\circ$  relative to the ground. At  $65^\circ\text{N}$ , the angle of the antenna facing south would be  $65^\circ$ .
5. Move any objects in the periphery of the antenna that may create interference.
6. Connect to the device via WiFi, and check the Signal Meter at the top menu bar.
7. If you do not have a signal lock and receive packets immediately, adjust the direction and angle of the antenna.
8. Use Tuner Settings to help make the proper adjustments (next page).

## TUNER SETTINGS

Go to the Dropdown Menu and Log in as Superuser, using the credentials from the Librarian Setup Wizard. Then go to Settings > Tuner Settings. The page has a list of changing values.



Pay attention to:

SNR: needs to be over 3.0 dB. Watch this value and make fine adjustments to the **antenna's position** to increase the value.

Symbol error rate: should be as low as possible. A high rate is means lost packets.

Received packet count: the number of data packets successfully received.

Packet failure count: packets that were lost due to interference or poor signal.

The other settings:

Selected Frequency: Preset value.

Offset from the selected frequency: the difference between the preset frequency and the actual received frequency.

Symbol rate: Preset value.

RSSI: signal strength.

Algorithmic peak-to-mean ratio is how much the signal stands out from the noise.

Signal State is the quality of the signal, displayed in the number of solid bars in the Signal Meter Icon. Lower numbers usually mean a higher error rate, and greater number of lost packets.

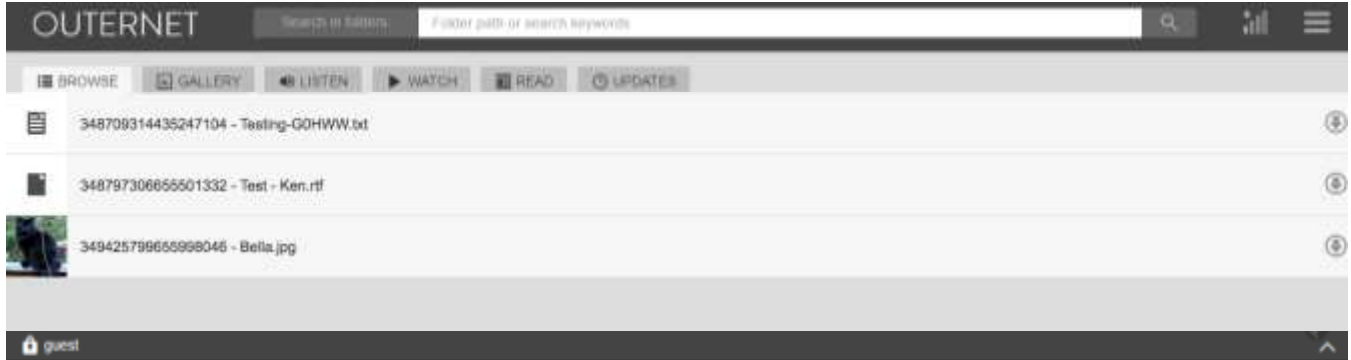
Satellite the drop-down menu options pre-set the values specific to that satellite. To change, choose a different satellite from the **dropdown and click "Update settings"**.

Allocated download capacity is the amount of storage on the receiver allocated to storing the data of files that are in the process of being downloaded.

List of files at the bottom shows which files are currently being downloaded. Once files are downloaded, they are available in Librarian.

# LIBRARIAN GUIDE

Librarian is the content management software of the receiver. Outernet continuously sends content over its filecast stream. Once received, the content is displayed in Librarian.



## HEADER BAR

Outernet Logo is like a home button, which will bring the user back to the top level of content.

Search Bar allows users to search for folder paths or words in a file name.

Signal Meter shows the reception status. See Satellite Reception Guide (page 10).

Dropdown Menu Bar click to reveal options to change interface Language, Log in as a Superuser, or access Settings (Settings option is visible only to the logged-in Superuser).



## FOOTER BAR

Displays name of the user (guest or Superuser username) and notification alerts when minimized. Click the bar to expand the menu.



The top tab displays the current version of Librarian and rxOS firmware



The bottom tab expands to list notifications. Common notifications include: Imported content, firmware upgrades, and Low storage space. To dismiss, click “Mark all as read”.

## CONTENT SECTION

Librarian organizes content in a file structure format, the way a computer organizes files. Click through the folders to find content. To delete a file or folder, a Superuser may click the X on the right. Users may either interact with files while connected to the receiver, or click to the download arrow to download the file onto their WiFi device<sup>1</sup> for later use.

Tabs display content by their specific file formats in specialized viewing environments:

Browse shows all of the content available at that particular folder level.

Updates shows files received in the last 365 days.

Gallery displays image files in a gallery view. The section to the right of the file being viewed displays a list of the content, and provides information about the file being displayed, and allows the user to download it to the viewing device.

Listen displays audio files in an audio player, with a playlist.

Watch displays all videos in a video player view, similar to that of the Listen view.

Read displays all PDF files in a reader format.



## SETTINGS DASHBOARD

To access the Settings, use the Dropdown Menu to Log In and then return to the Dropdown menu and select Settings. From there, a Superuser can access:

Tuner Settings – Check the signal strength, quality, and bit rate, or watch the progress of files in the process of downloading. Use the Satellite Reception Guide for more information (page 10).

FTP Settings – This setting is for app developers who wish to push data from the receiver to a device application via WiFi. Outernet does not have any apps developed for this use.

Software Version Management – This will allow users to change specific parts of the software stack in the future.

Remote Access Setup – Enter Key, Hostname, Host, and Port information to allow for remote access to the receiver.

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<sup>1</sup> iPhone devices do not allow users to download files outside of the App Store.

Application Logs - Download receiver logs to help troubleshoot issues. Helpful for sharing and troubleshooting issues on the Outernet forum.

Storage Devices - Shows available storage on the receiver, both internal and attached external storage. To move content from internal to external storage, or vice versa, use the “Move files here” **button** below the listed storage device.

Settings – **Set the device’s** Default Language. Users may change the language for their session using the option in the Dropdown Menu.

Update Firmware – Updated firmware files are delivered over the filecast. If an update is missed, upload the firmware file here. The firmware update file-type will always be .pkg. See page 18 for instructions.

Network Interfaces – Provides information and settings for the built-in WiFi.

- Access Point name - rename the Outernet WiFi. **Check** “Do not show in scan lists” to keep it from appearing in the available WiFi networks on devices.
- Country – Set the WiFi to regional standards.
- Channel – Set WiFi Channel.
- Security – **Enable to require users to provide a password to connect to the device’s WiFi.**
- Device Type – Standard or Realtek-Based devices.

## LIBRARIAN HOW-TO QUESTIONS

Change the interface language of a session

Any user may go to the Dropdown Menu Bar and select Language to choose the language. This **changes the Language of that user’s session, not the default language of the device.**

Log in as a Superuser

Go to the Dropdown Menu Bar and go to Log in, and use the credentials chosen during the set-up of the device.

Manage Settings

To access the Settings dashboard, a Superuser needs to login. Then, go to the Dropdown Menu Bar and select Settings (option is only available to logged-in Superuser).

# TROUBLESHOOTING

## No signal or not receiving any data

- Use a compass or a Satellite Finder application to ensure the antenna is pointed in the correct direction.
- Try restarting the receiver (disconnect and reconnect power).
- Check the connectors between the components.
- Adjust the antenna to increase SNR (page 11).
- Make sure correct satellite preset is selected in Tuner settings.
- If you are seeing that data packets are being received the Tuner settings section, but the files say "**waiting for data...**", please wait for at least 5 minutes. File names are not visible until signaling data is received, which may take up to 5 minutes.
- Check that you have enough storage space under Storage Devices and plug in an external storage device as needed (page 19).

## Library section is empty

- Check that there is a signal lock and packets are being received (page 10).
- Wait and give the receiver time to finish downloading content.
- Try restarting the receiver.
- Check that you have enough storage space under Storage Devices and plug in an external storage device as needed (page 19).

# PRODUCT SUPPORT

The quickest way to find answers or get support is to visit our forum or read our documentation.

## FORUM

Our team is active on the forums, and often users have already found resolutions to common questions. If a question has not already been addressed in a previous posting, our developers will quickly respond to new posts: <http://forums.outernet.is/c/outernet-hardware/>

## DOCUMENTATION

Documentation of our software is available on our website: <https://outernet.is/docs>

## GITHUB

Most of our code is open-source. View our code on GitHub:

<http://github.com/Outernet-Project/>

rxOS: <https://github.com/Outernet-Project/rxOS/>

Librarian: <https://github.com/Outernet-Project/librarian>

StarSDR: <https://github.com/Outernet-Project/StarSDR/>

## CONTACT US

For questions related to an order, contact us using the form on our website:

<https://outernet.is/about/>

## SOCIAL MEDIA

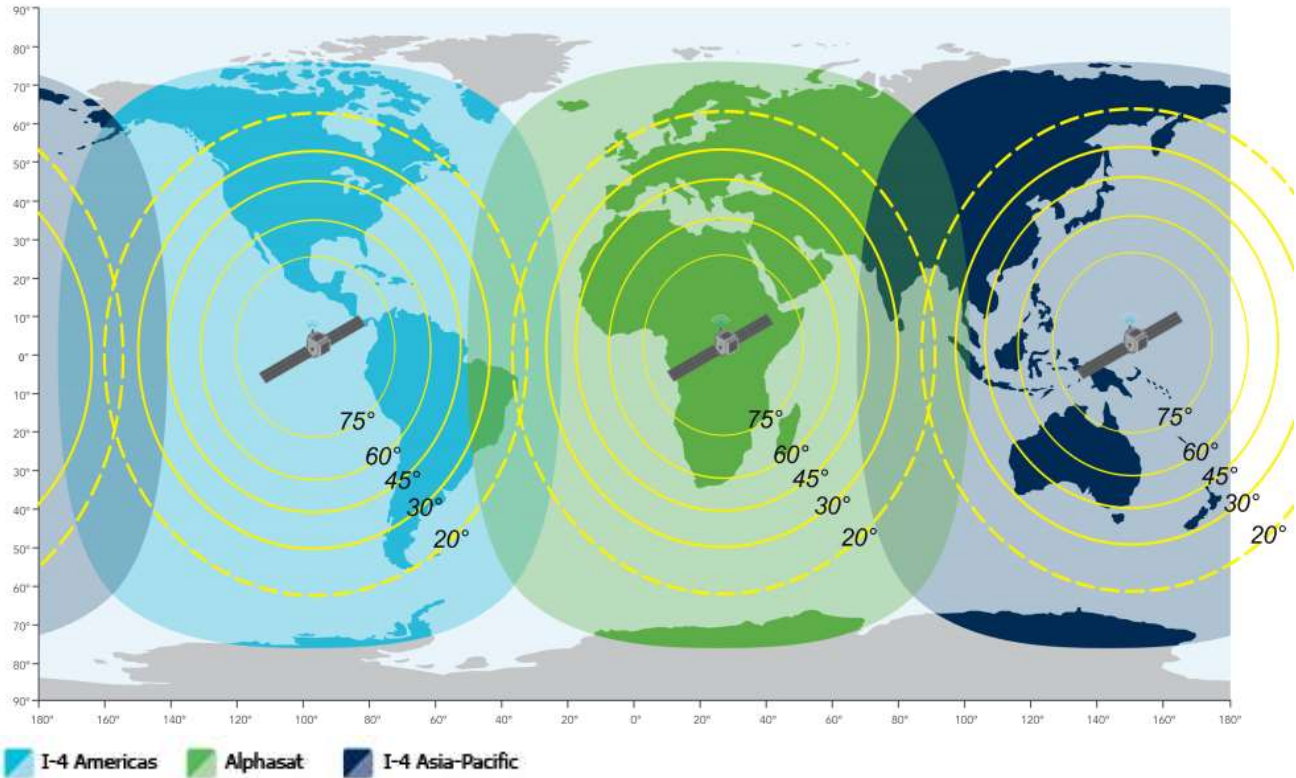
Facebook: <https://www.facebook.com/OuternetForAll/>

Twitter: @OuternetForAll



# APPENDIX 1: CHOOSING A SATELLITE

Outernet filecasts over three Inmarsat satellites offering coverage on every continent and on open waters. All satellites use L-Band and have a bitrate of 2kbps, or 20MB of content per day.



I-4 F3 Americas

Position: 98°W

Coverage: North, South, and Central America, Pacific and Atlantic Oceans

Outernet Frequency: 1539.8725 MHz

Alphasat

Position: 25°E

Coverage: Europe, Africa, Middle East, East Asia, Atlantic and Indian Oceans

Outernet Frequency: 1545.525 MHz

I-4 F1 APAC (Asia-Pacific)

Position: 144.0°E

Coverage: Asia, Australia, Pacific and Indian Oceans

Outernet Frequency: 1545.9525 MHz

## APPENDIX 2: UPDATING FIRMWARE MANUALLY

Firmware images are updated over the air, so as long as the device is tuned in, it will automatically update by receiving **the new firmware package**. A device's current firmware version can be found by clicking the Footer Menu of the interface to expand the information bar. If an update is missed, a user can update the firmware manually.

**WARNING:** Do not update a device with an earlier firmware version (for example, update a v1.2 device with a v1.1 firmware). This could brick a device.

1. Download the latest firmware package for the device from <https://archive.outernet.is/images/>.
2. Log in as the Superuser.
3. Go to Settings under the Dropdown Menu.
4. Under Settings, go to the Update Firmware section.
5. Click "Choose File", and select the newly downloaded .pkg file.
6. Click the "Update Firmware" button.
7. Wait for the update to complete.

## APPENDIX 3: STORAGE

### AVAILABLE STORAGE

rxOS uses two types of storage:

- NAND flash on C.H.I.P. (about 1GB available for received content)
- SD Card on Raspberry Pi (recommend 8GB or more)

Check available storage under Settings > Storage Devices.

More about storage is available in our online guide:

[http://rxos.readthedocs.io/en/develop/how\\_it\\_works/storage\\_layout.html](http://rxos.readthedocs.io/en/develop/how_it_works/storage_layout.html)

### ATTACHING EXTERNAL STORAGE

rxOS-based receivers support external storage devices to expand the storage available on the SD card (Raspberry Pi) or built-in NAND flash storage (C.H.I.P.). This is recommended for experienced users and those who are comfortable experimenting.

For full documentation, visit our online guide:

[http://rxos.readthedocs.io/en/develop/how\\_it\\_works/external\\_storage.htm](http://rxos.readthedocs.io/en/develop/how_it_works/external_storage.htm)

To expand the storage of C.H.I.P., use a USB hub to attach an external storage device. For Raspberry Pi, use an available USB port to add storage.

Only one external storage device can be used at a time:

- A USB external hard disk
- A USB flash disk (also known as a USB stick, or thumb drive)

The device may be formatted using one of the filesystem formats: NTFS, FAT32, and Ext2, Ext3, and Ext4 on Linux).

Once the external drive is added, Librarian will need to re-index any content already saved on Internal Storage, which may take a few minutes. To move content between internal and external storage, visit Settings > Storage Devices.

## APPENDIX 4: MANUALLY ADD CONTENT TO DEVICE

It's possible to load content directly to a device so it is available in Librarian over the WiFi access point. To add content to a device, use external storage (page 19). Any files and folders copied to the external storage device a computer will be available in the Librarian interface.

Please note that the receiver needs a few minutes to index the content before it can display it in the interface. If the content from the external storage device does not appear after a long wait, restart device.

Use the "Move Content" feature under Settings > Storage Devices to move content from the external drive to the internal drive, as long as space allows.

## APPENDIX 5: SUPPORTING MORE CONNECTED DEVICES

The number of devices that can simultaneously connect to a receiver depends on the WiFi of the C.H.I.P. or Raspberry Pi being used. For the C.H.I.P., the number is 6 devices. Increase this capacity by connecting a WiFi dongle. For C.H.I.P., this requires a USB hub, as the board does not have available USB ports.

Connect a WiFi Dongle:

Note: the only officially supported wireless dongle is the Tenda W311mi

1. While the device is turned off, insert the WiFi dongle into one of the USB ports of the Raspberry Pi, or a USB hub connected to C.H.I.P..
2. Power on the device.
3. Open the browser list on a WiFi-enabled device.
4. Connect to the *Outernet* WiFi access point, open a browser, and navigate to Librarian (<http://outernet.is/>) as usual.
5. Invite more users to connect.

## APPENDIX 6: DIY KIT COMPONENT SPECIFICATIONS

Internal storage	4 GB (1 GB available for Content)
External storage (optional)	Up to one storage device
Wi-Fi range	50 ft. / 15.2 m
Wi-Fi maximum clients	6
Power Requirements	2 Watts Battery or USB Power

Outernet L-Band Air Gap Patch Antenna RHCP Specifications:

- Center frequency: 1542 MHz
- 8dbi
- 4 in SMA Male connector
- Dimensions: 12cm x 12 cm x 1.5 cm, Weight: 3.5 oz

Outernet/Inmarsat Amplifier Specifications:

- Center Frequency: 1542 MHz
- Gain: 34 dB
- Voltage: 3.0V - 5.5V
- Current Draw: 25 mA
- Dimensions: 6.5 x 1.5 x 2.5 cm, Weight: 0.3 oz

#### Outernet Elonics RTL-SDR Tuner Specifications:

- Ultra-low phase noise 0.5PPM TCXO
- RF-suitable voltage regulator custom heatsink
- SMA female connector
- SDR frequency range of approximately 25MHz-2200MHz
- Bias tee enabled
- Dimensions: 8.5 x 1.3 x 1.7 cm, Weight: 0.8 oz

#### C.H.I.P. Single Board Computer by [The Next Thing](#) Specifications:

- Comes with rxOS pre-installed
- WiFi built in
- 1GHz Processor
- 4GB storage
- 512 MB RAM
- Bluetooth 4.0

#### RAVPower External Battery Pack Specifications:

- Detects the optimal charging current a device needs
- Output: 5V/2.4A max
- Input: DC 5V/2A (Standard Micro USB Port)
- Capacity: 10050mAh
- 4 status LEDs keep you informed of remaining battery capacity
- iSmart Port Charging
- Dimensions: 3.8 x 2.4 x 0.9 inches, Weight: 7.2 oz

DISCLAIMER OF WARRANTY: TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, OUTERNET HARDWARE WITH THE ACCOMPANYING DOCUMENTATION IS PROVIDED "AS IS" WITHOUT WARRANTIES, CONDITIONS, REPRESENTATIONS OR GUARANTIES OF ANY KIND, EITHER EXPRESSED, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OR CONDITIONS OF MERCHANTABILITY, SATISFACTORY QUALITY, TITLE, NONINFRINGEMENT OR FITNESS FOR A PARTICULAR PURPOSE. OUTERNET INC DOES NOT WARRANT THE OPERATION OF ITS OFFERINGS WILL BE UNINTERRUPTED OR ERROR FREE. YOU BEAR THE ENTIRE RISK AS TO THE RESULTS, QUALITY AND PERFORMANCE OF THE SERVICE SHOULD THE SERVICE PROVE DEFECTIVE. NO ORAL OR WRITTEN INFORMATION OR ADVICE GIVEN BY AN OUTERNET INC AUTHORIZED REPRESENTATIVE SHALL CREATE A WARRANTY.

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