Five Raspberry Pi Uses For Amateur Radio

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Before We Begin…

- Raise your hand if you've heard of Raspberry Pi
  - The computer - not the dessert
- Raise your hand if you own a Raspberry Pi
- Raise your hand if you own a Raspberry Pi but haven't used it

By The Time We're Done…

- You will understand what the Raspberry Pi is and the difference between models
- You will see how to install the operating system and load applications
- You will hear some ideas of how a Raspberry Pi can support your radio activities
- You will be exposed to other applications and embedded computers

About The Raspberry Pi

- Raspberry Pi is a family of low cost single board computers.
- It was originally developed in the UK to teach computer skills.
- It has become a very popular platform for robotics, Maker projects, and other IoT* applications.
- There is a large eco-systems of hardware peripherals, software support, and project plans.

*IoT stands for “Internet of Things” – houses, appliances, cars, and other devices with embedded processors and Internet connectivity.

The Original Grandparents

Model Name	Raspberry Pi Model A	Raspberry Pi Model B
Introduced	2013	2012
CPU	One 32bit ARM6 core @700 MHz	One 32bit ARM6 core @700 MHz
Memory	256 MB	256 MB
Flash Card	SD/MMC/SDIO	SD/MMC/SDIO
USB	1	2
Ethernet	No	Wired 10/100 Mbps
Initial Price	$25	$35

To distinguish from later models, they are also sometimes called “Raspberry Pi 1”. In 2014 the “plus” models were introduced supporting micro SD and the A was smaller, and in 2016 memory increased to 512 MB. You probably shouldn’t pay money for these today unless speed is not required or you need composite video output.

The Parents

Model Name	Raspberry Pi 2 Model B	Raspberry Pi 2 v1.2 Model B
Introduced	2015	2016
CPU	Four 32bit ARM7 @900 MHz	Four 64bit ARM8 @900 MHz
Memory	1 GB	1 GB
Flash Card	microSDHC	microSDHC
USB	4	4
Ethernet	Wired 10/100 Mbps	Wired 10/100 Mbps
Initial Price	$35	$35

The Pi 2 Model B's voltage regulator is sensitive to certain wavelengths; a flash can cause it to crash! These boards have considerably more resources than previous versions, but not as many as…

The Kids

Model Name	Raspberry Pi 3 Model B	Raspberry Pi 3+ Model B
Introduced	2016	2018
CPU	Four 64bit ARM8 @1.2 GHz	Four 64bit ARM8 @1.4 GHz
Memory	1 GB	1 GB
Flash Card	microSDHC or USB	microSDHC or USB
USB	4	4
Ethernet	Wired 10/100 Mbps Wireless 802.11n	Wired 10/100/1000 Mbps Wireless 802.11ac
Bluetooth	4.1	4.2 LS BLE
Initial Price	$35	$35

With the small antenna don’t expect great coverage from the WiFi.

Family Resemblances

- Fan-less, No Enclosure, 5V Power
  - Later models recommend 2-2.5A
- Require Flash Memory To Boot
  - Model 3's can boot from USB
- GPU and HDMI Video Output
  - Compatible with DVI-D with passive adaptor
- MIPI Camera And Display Interfaces
- Status LED's And Multiple GPIO Pins
  - Some variations among models

The Cousins

- Compute Modules
  - Stripped down for smaller size and lower cost
  - Based on Pi 1 and 3 hardware specs
  - $25-30
- Raspberry Pi Zero
  - Stripped down for smaller size and lower cost
  - Based on Pi 1 hardware
  - $5-10
  - On-board wireless Ethernet available

Necessities

2A Power Supply
$10-15

USB Mouse
$0-5

Flash Memory and Adapter
(Class 10 and 8 GB or Better)
$0-20

Video Cable
$0-10

USB Keyboard
$0-10

Case (Recommended)
$5-10

Many starter kit bundles are available,
but some are overpriced

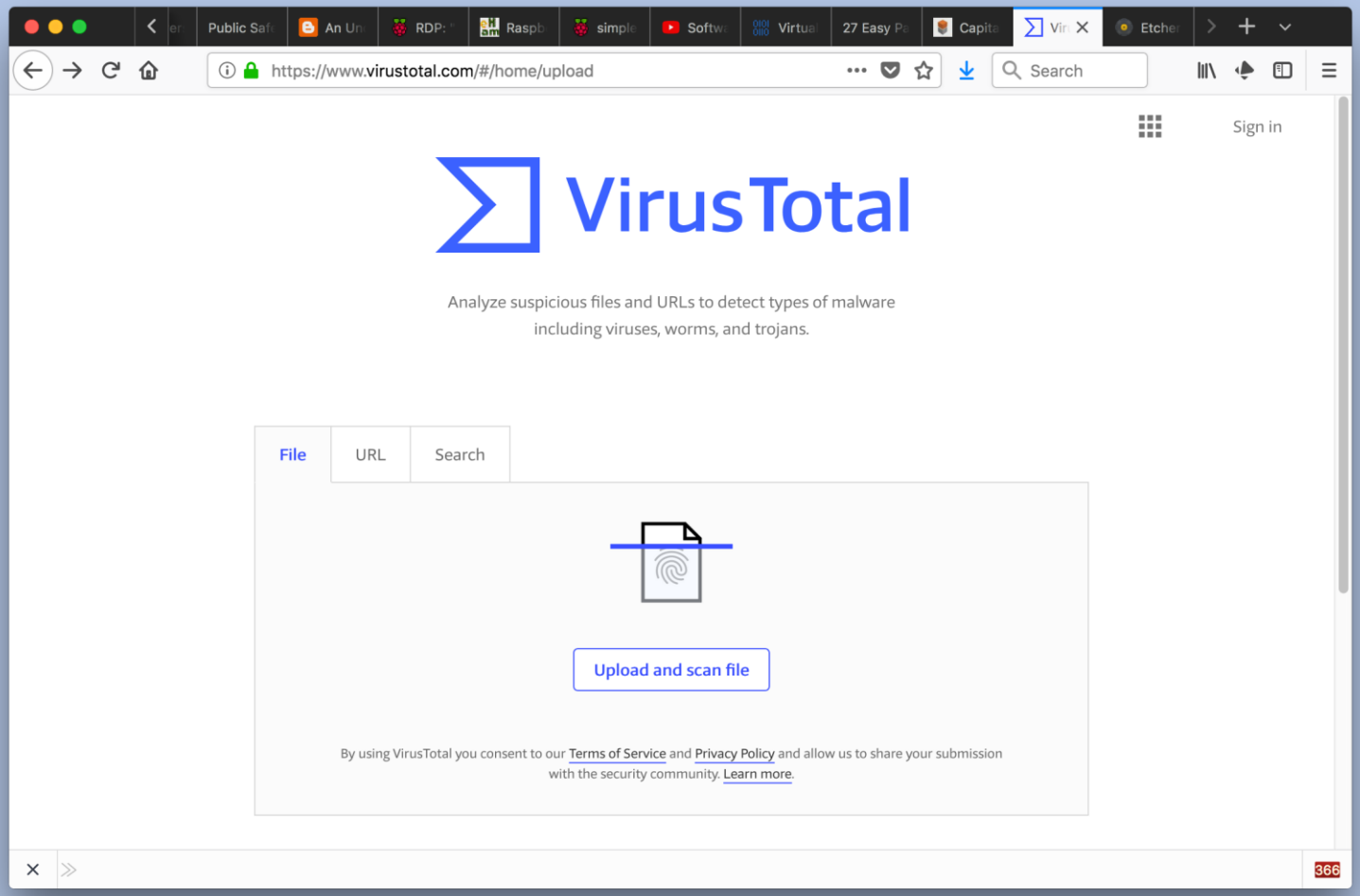
Choose An Operating System

- Raspberry Pi Can Run “Windows 10 IOT Core”
  - Good integration with Microsoft but not amateur radio
- Most Options Are Derived From Linux
  - Some are applications focused – like media center
  - Some are stripped-down or developer-focused
  - “NOOBS” makes it easy to experiment with many
- We Will Choose Raspbian Desktop
  - Best support and very “Windows-like”
  - Works on ALL Raspberry Pi models
  - Installs in four easy steps

Side Note: Avoiding Malware

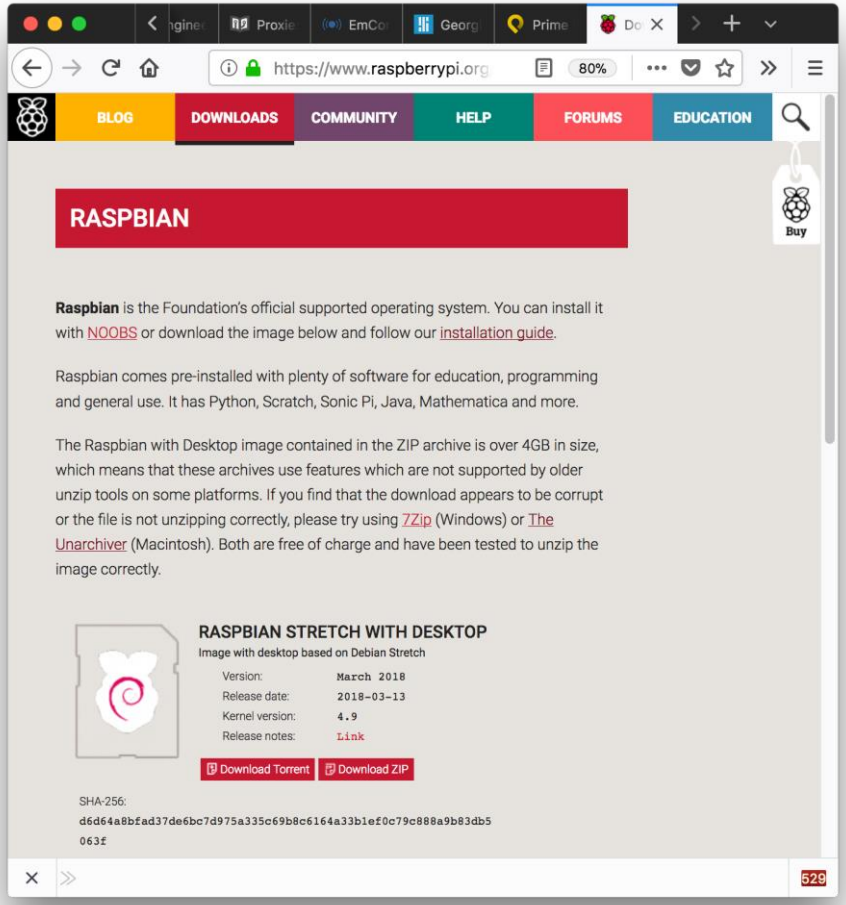
- Following Steps May Require Installing PC Software
  - Most open source is safe, but it takes only one malware to ruin your day
- Always Be Careful
  - Don’t follow links from suspicious email or URL’s
  - Ask yourself if you really need it
  - Use and update AntiVirus software
- Use VirusTotal As Extra Check
  - Upload PC software to https://www.virustotal.com/ *before* you run it on your PC

Side Note: Avoiding Malware



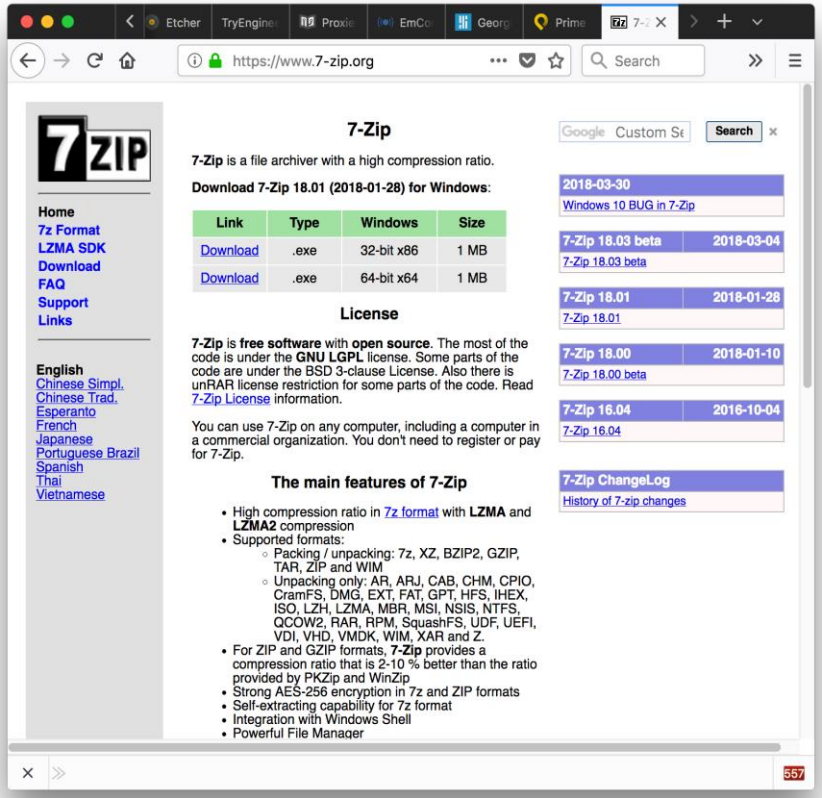
Step 1: Download Raspian Zip

- On PC Browse To https://www.raspberrypi.org/downloads/
- Download Zip For Raspbian With Desktop
  - Currently ~1.7 GB
  - Current version is called “Stretch”, but that will change when new version is published



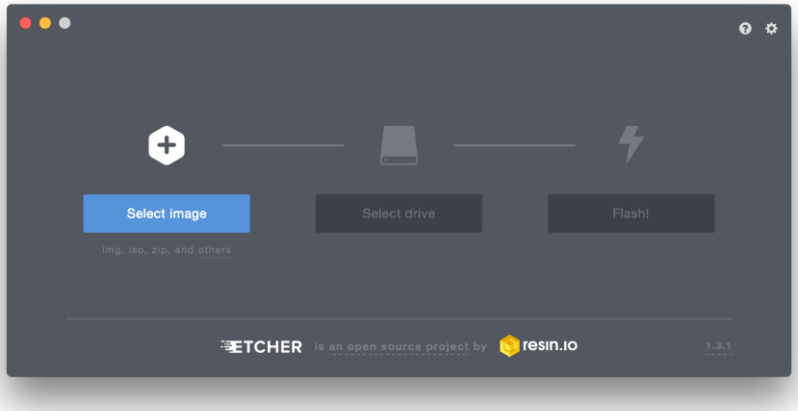
Step 2: Uncompress Zip

- Double Click Zip
  - Should extract the image file
  - If not go to https://www.7-zip.org/
  - Download and install the version for your PC
  - Use 7-Zip to expand Raspbian Zip file



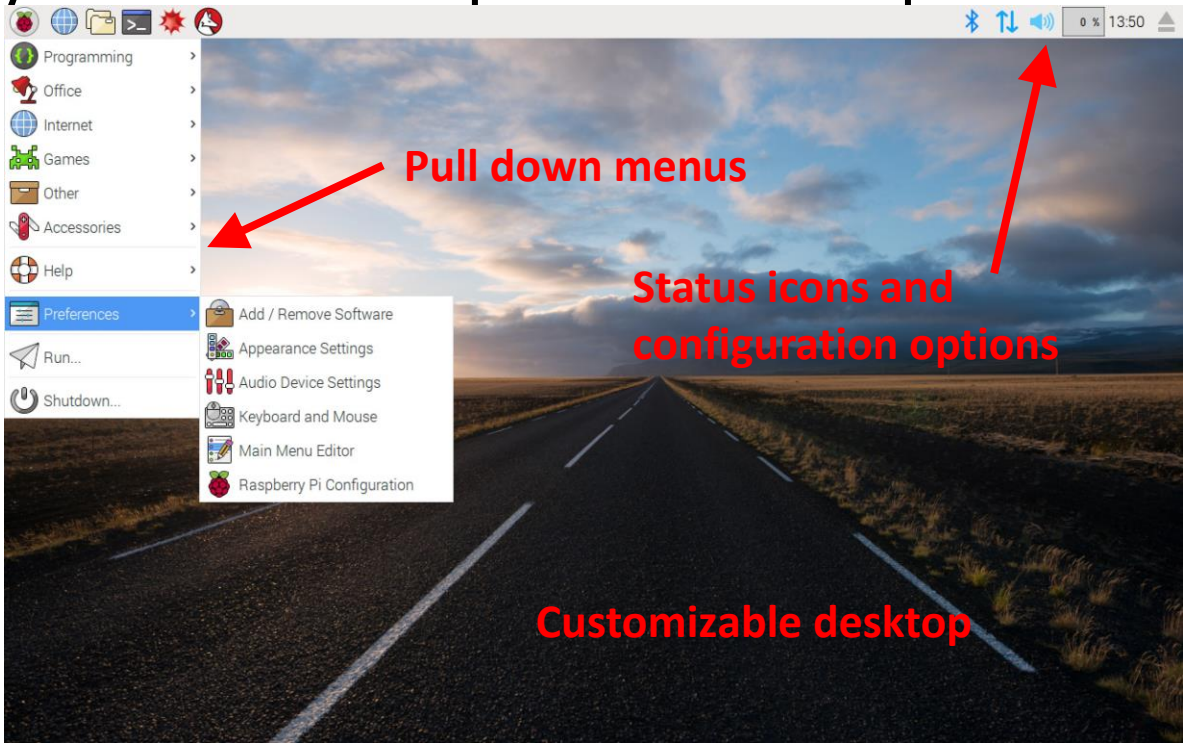
Step 3: Write Image To Flash

- Insert Boot Flash Into PC
  - Use microSD card to USB adapter if needed
- “Burn” Extracted File To Flash
  - Do not just copy file onto flash – must be written using a program that makes it able to boot Raspberry Pi
  - If you do not have a suitable program download and install Etcher from https://etcher.io/



Step 4: Boot The Pi

- Eject Flash From PC And Insert Into Raspberry Pi
- Connect Monitor, Keyboard, Mouse
- Apply Power And Explore Your Raspian Desktop!



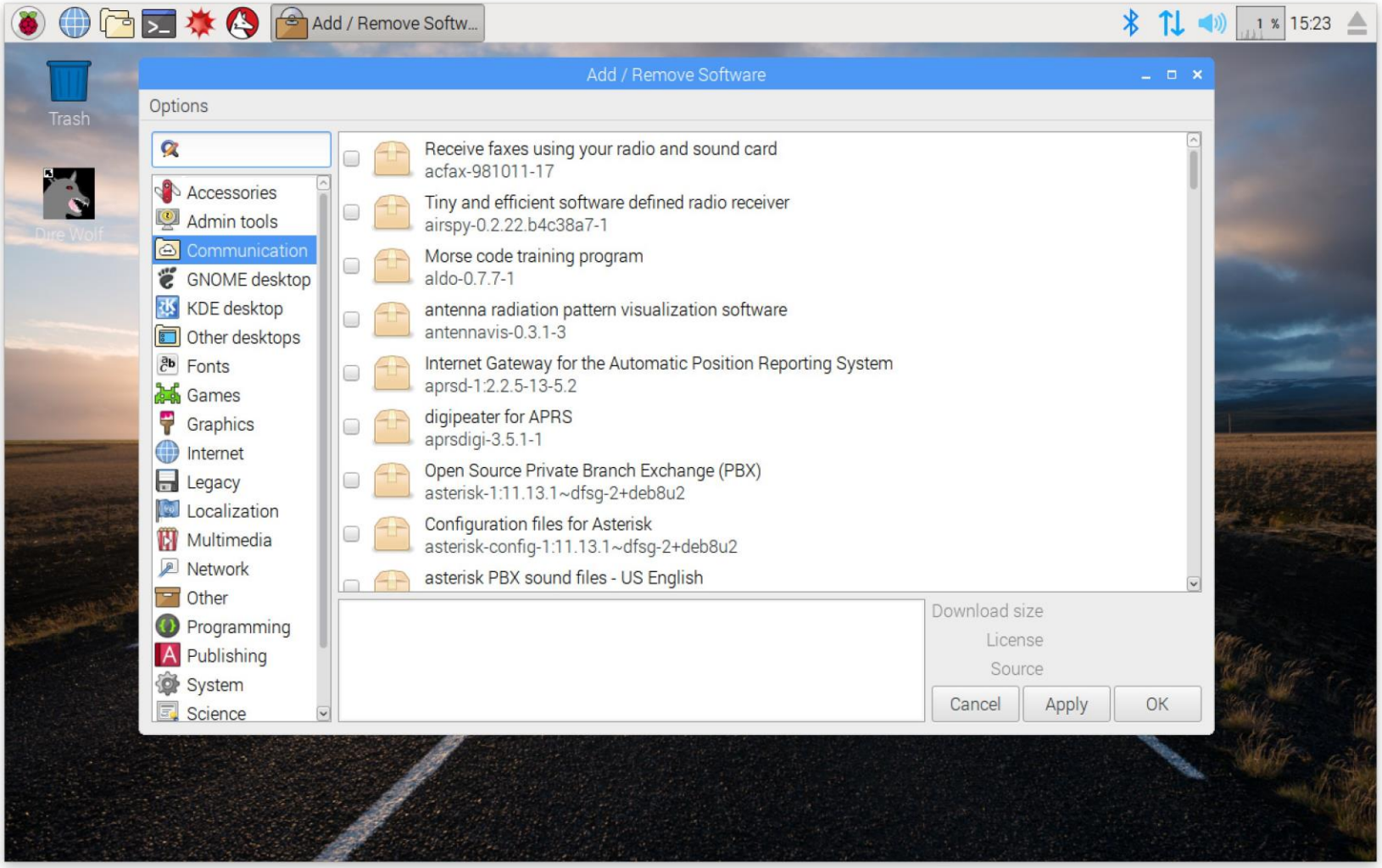
What You Should Do Next

- Update Software
  - If release is more than a few weeks old
- Change password
  - Default user “pi”, password “raspberry”
- Change Other Preferences
  - Keyboard, Timezone, etc

Install Software

- All Raspberry Pi's Are Based on ARM CPU's
  - EXE's, other compiled PC programs don't run natively
  - Many popular applications have been ported
- Raspian Desktop Includes Many Useful Programs
  - Browser, LibreOffice, Mathematica, Wolfram Alpha,…
- Many More Are Available
  - Easily loaded via GUI or command line
  - Automatically loads compatible version

Add/Remove Software Screen



Software Command Line

- Many Instructions Use Command Line
  - Very easy to install new packages

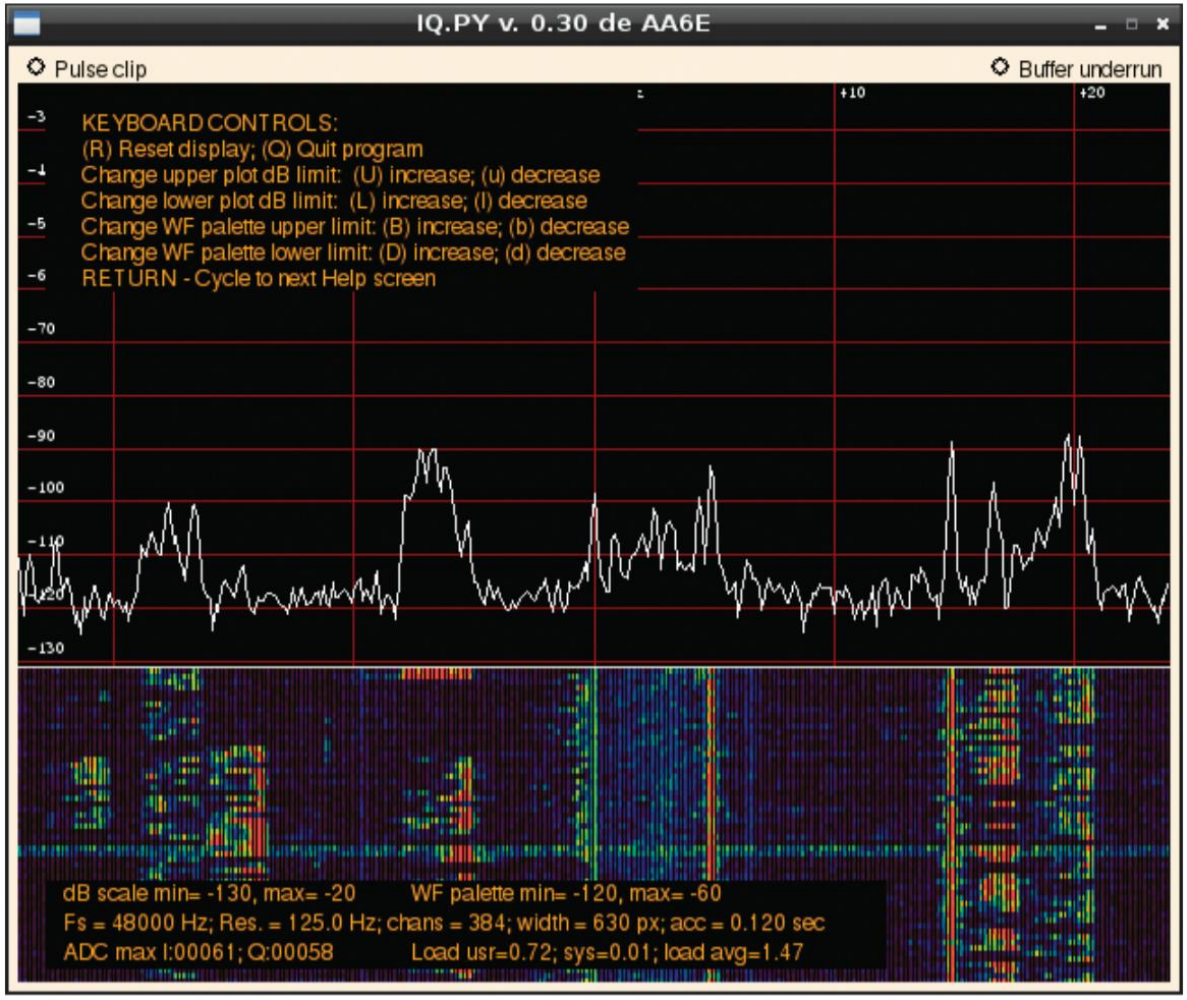
```
sudo apt-get install <package> [<package>…]
```

- Let's Look At Five Amateur Radio Applications
  - There isn't time to go into each in great detail
  - Some of the references detail the installation process using the command line
  - These are personal favorites that take advantage of Raspberry Pi's low cost, low power, or other attributes

#1: Panadapter

- Real-Time Spectrum Waterfalls Are Very Useful
  - Find stations when activity is low
  - Find open frequencies when activity is high
- Raspberry Pi Implementation
  - Does not require computer for SSB, CW
  - Works with older Raspberry Pi's using stereo USB audio dongle
- Detailed Article Available From ARRL
  - "A Tiny *Python* Panadapter", Martin Ewing, AA6E, QST Magazine, April 2014, pp 33-38

#1: Panadapter



#1: Panadapter

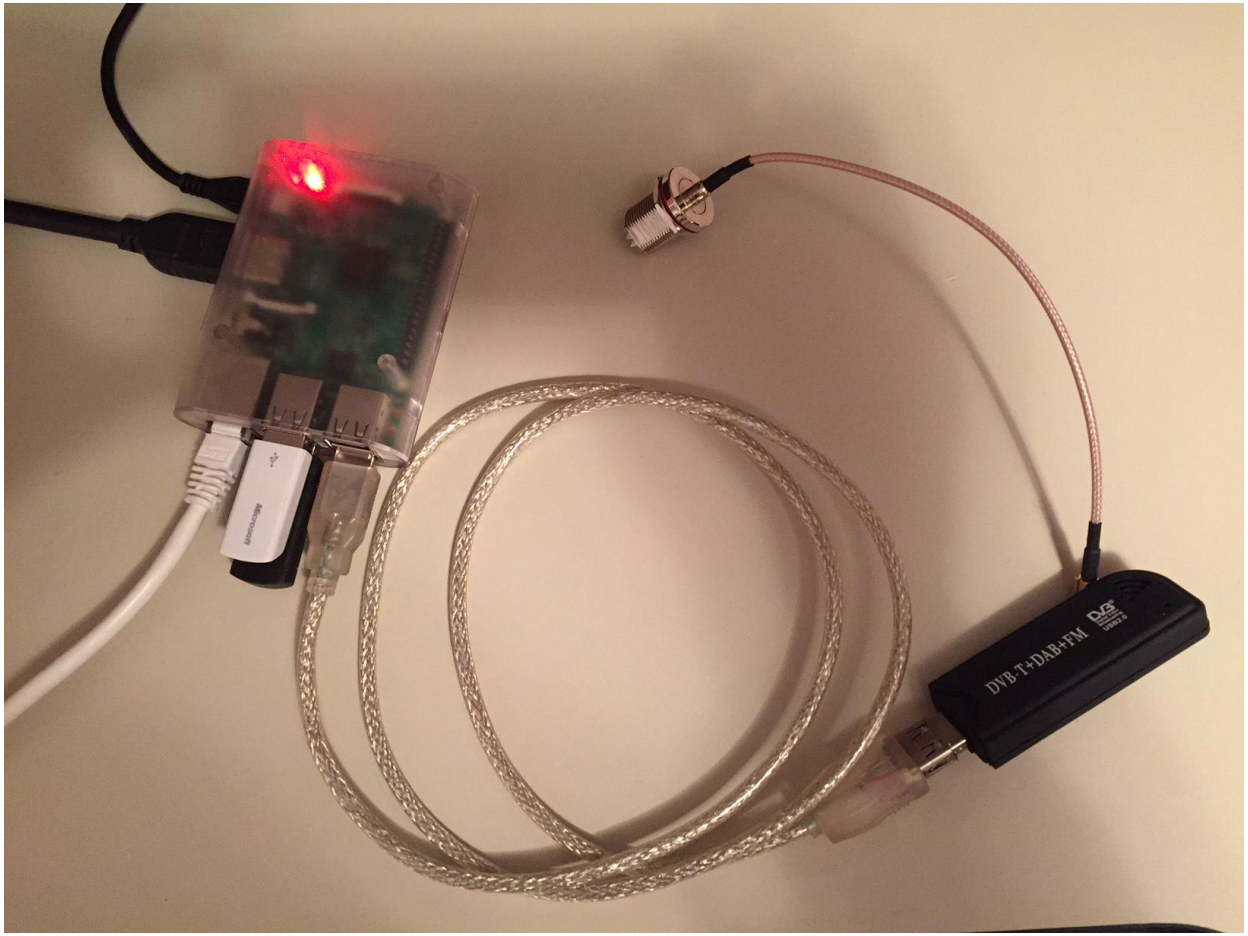
- Limitations
  - Article tailored for Elecraft KX3 with I/Q audio out
  - Bandwidth 48 KHz
- Alternatives
  - There are many other SDR applications available for Raspberry Pi that provide a waterfall, i.e.: http://gqrx.dk/download/gqrx-sdr-for-the-raspberry-pi
  - Some will use RTL-SDR dongle or similar but require faster Raspberry Pi

#2: APRS IGate

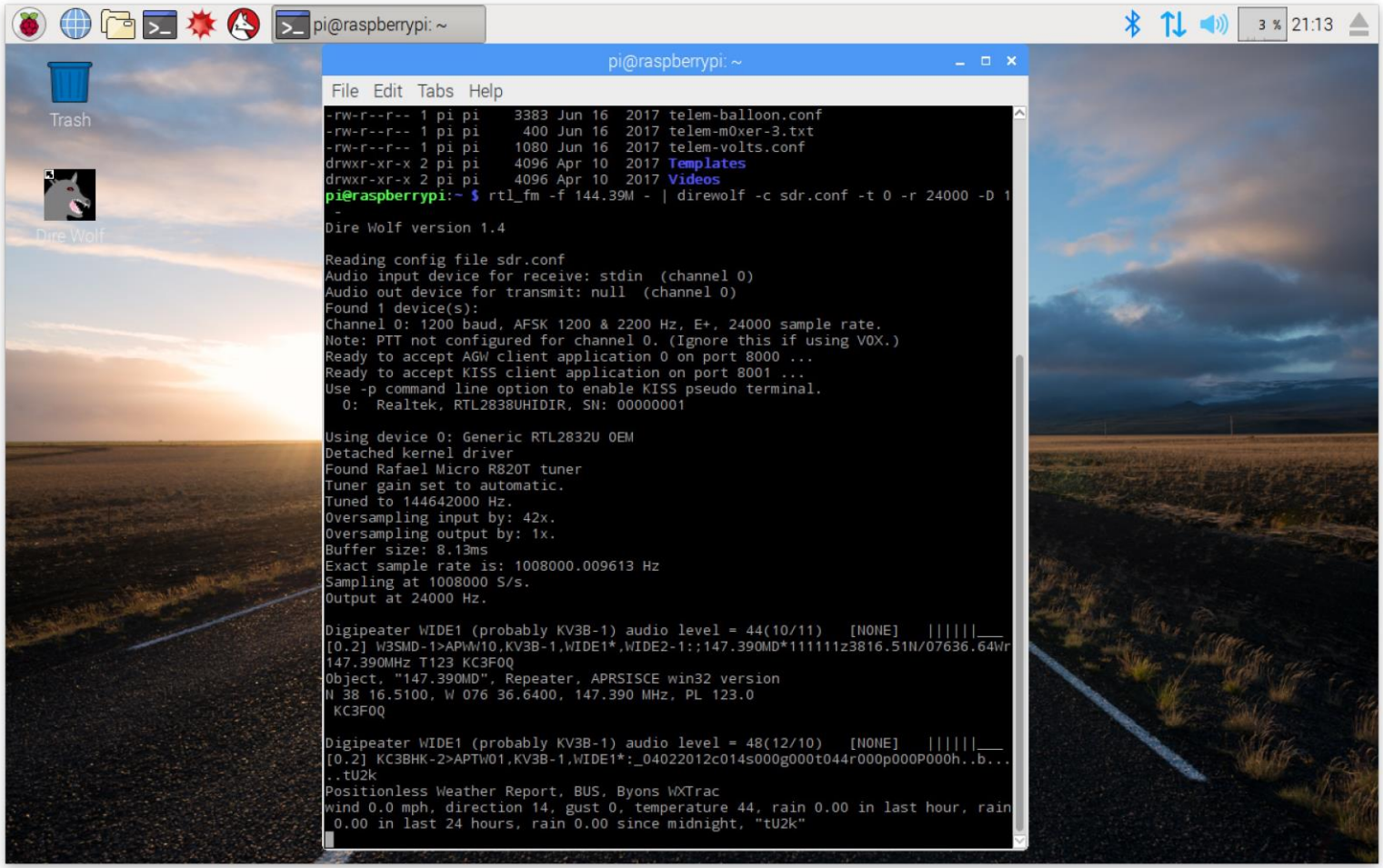
- Automatic Packet Reporting System IGate
  - Scale APRS by separating Digipeater collision domains
  - Extend APRS by sending traffic to APRS Internet Service (APRS-IS)
- Raspberry Pi 3 Implementation
  - RTL-SDR dongle receiver and antenna
  - Dire Wolf decoding software: https://www.rtl-sdr.com/setting-up-a-raspberry-pi-based-aprs-rx-igate-with-an-rtl-sdr/
  - Small, quiet, inexpensive
  - Low power – leave it on all the time

#2: APRS IGate

Raspberry Pi 3 configured to decode APRS using attic antenna



#2: APRS IGate


pi@raspberrypi: ~
3 %
21:13
Trash
Dire Wolf
pi@raspberrypi: ~
File Edit Tabs Help
-rw-r--r-- 1 pi pi 3383 Jun 16 2017 telem-balloon.conf
-rw-r--r-- 1 pi pi 400 Jun 16 2017 telem-m0xer-3.txt
-rw-r--r-- 1 pi pi 1080 Jun 16 2017 telem-volts.conf
drwxr-xr-x 2 pi pi 4096 Apr 10 2017 Templates
drwxr-xr-x 2 pi pi 4096 Apr 10 2017 Videos
pi@raspberrypi:~ $ rtl_fm -f 144.39M - | direwolf -c sdr.conf -t 0 -r 24000 -D 1 -
Dire Wolf version 1.4
Reading config file sdr.conf
Audio input device for receive: stdin (channel 0)
Audio out device for transmit: null (channel 0)
Found 1 device(s):
Channel 0: 1200 baud, AFSK 1200 & 2200 Hz, E+, 24000 sample rate.
Note: PTT not configured for channel 0. (Ignore this if using VOX.)
Ready to accept AGW client application 0 on port 8000 ...
Ready to accept KISS client application on port 8001 ...
Use -p command line option to enable KISS pseudo terminal.
0: Realtek, RTL2838UHIDIR, SN: 00000001
Using device 0: Generic RTL2832U OEM
Detached kernel driver
Found Rafael Micro R820T tuner
Tuner gain set to automatic.
Tuned to 144642000 Hz.
Oversampling input by: 42x.
Oversampling output by: 1x.
Buffer size: 8.13ms
Exact sample rate is: 1008000.009613 Hz
Sampling at 1008000 S/s.
Output at 24000 Hz.
Digipeater WIDE1 (probably KV3B-1) audio level = 44(10/11) [NONE] |||||___
[0.2] W3SMD-1>APWW10,KV3B-1,WIDE1*,WIDE2-1:;147.390MD*111111z3816.51N/07636.64Wr
147.390MHz T123 KC3FOQ
Object, "147.390MD", Repeater, APRSISCE win32 version
N 38 16.5100, W 076 36.6400, 147.390 MHz, PL 123.0
KC3FOQ
Digipeater WIDE1 (probably KV3B-1) audio level = 48(12/10) [NONE] |||||___
[0.2] KC3BHK-2>APTW01,KV3B-1,WIDE1*:_04022012c014s000g000t044r000p000P000h..b...
..tU2k
Positionless Weather Report, BUS, Byons WXTrac
wind 0.0 mph, direction 14, gust 0, temperature 44, rain 0.00 in last hour, rain
0.00 in last 24 hours, rain 0.00 since midnight, "tU2k"

#3: Digital Mode Terminal

- Use PSK31, JT-65,… Without PC
- Detailed Article Available From ARRL
  - “The Raspberry Pi Alternative for WSJT-X”, Thomas Kocourek, N4FWD, QST Magazine, July 2017, pp 34-37
- Multiple Interface Options
  - USB sound interface and GPIO for keying
  - USB interface to RIGblaster/similar
  - USB direct to radio

#3: Digital Mode Terminal

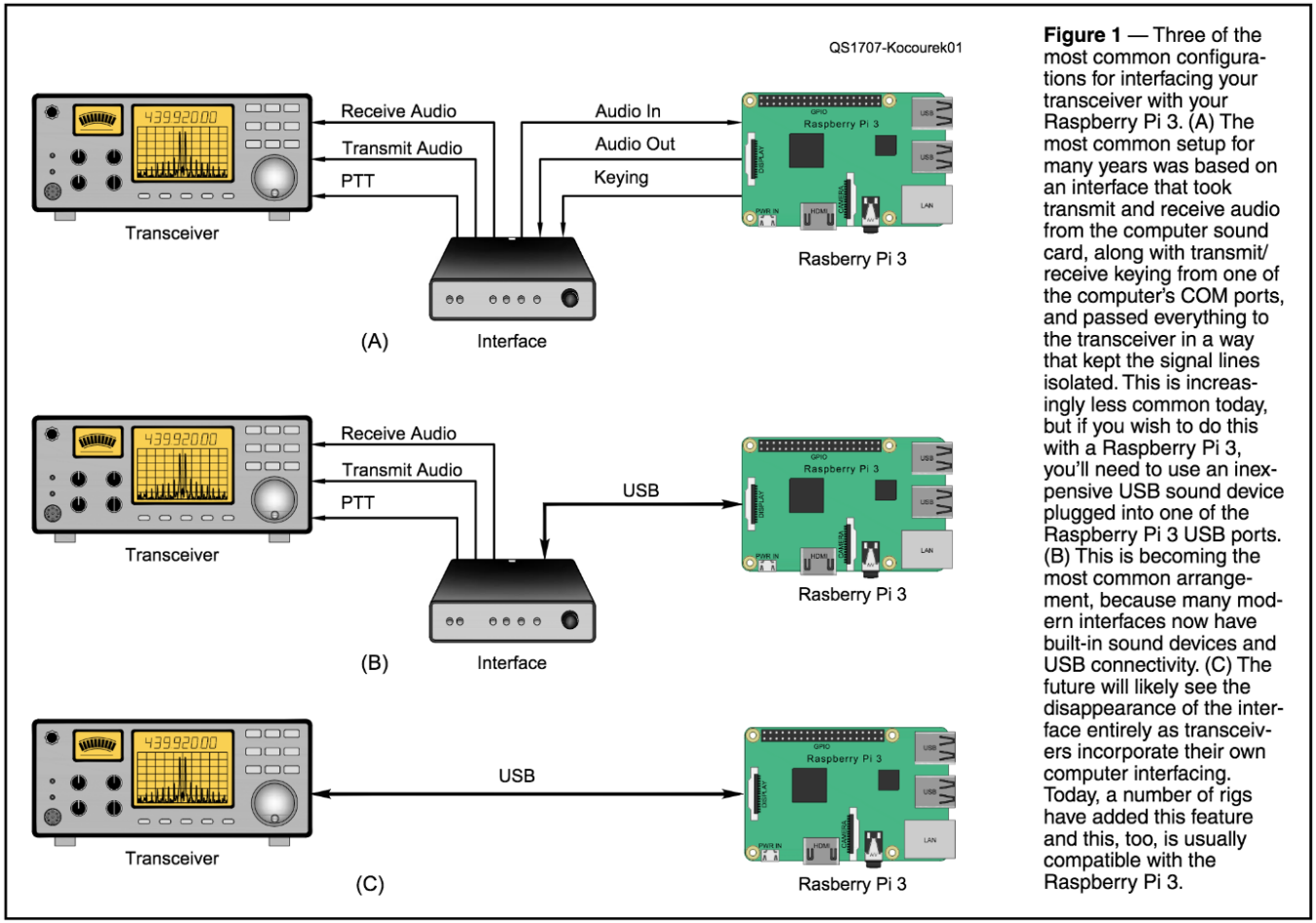


Figure 1 — Three of the most common configurations for interfacing your transceiver with your Raspberry Pi 3. (A) The most common setup for many years was based on an interface that took transmit and receive audio from the computer sound card, along with transmit/receive keying from one of the computer's COM ports, and passed everything to the transceiver in a way that kept the signal lines isolated. This is increasingly less common today, but if you wish to do this with a Raspberry Pi 3, you'll need to use an inexpensive USB sound device plugged into one of the Raspberry Pi 3 USB ports. (B) This is becoming the most common arrangement, because many modern interfaces now have built-in sound devices and USB connectivity. (C) The future will likely see the disappearance of the interface entirely as transceivers incorporate their own computer interfacing. Today, a number of rigs have added this feature and this, too, is usually compatible with the Raspberry Pi 3.

#3: Digital Mode Terminal

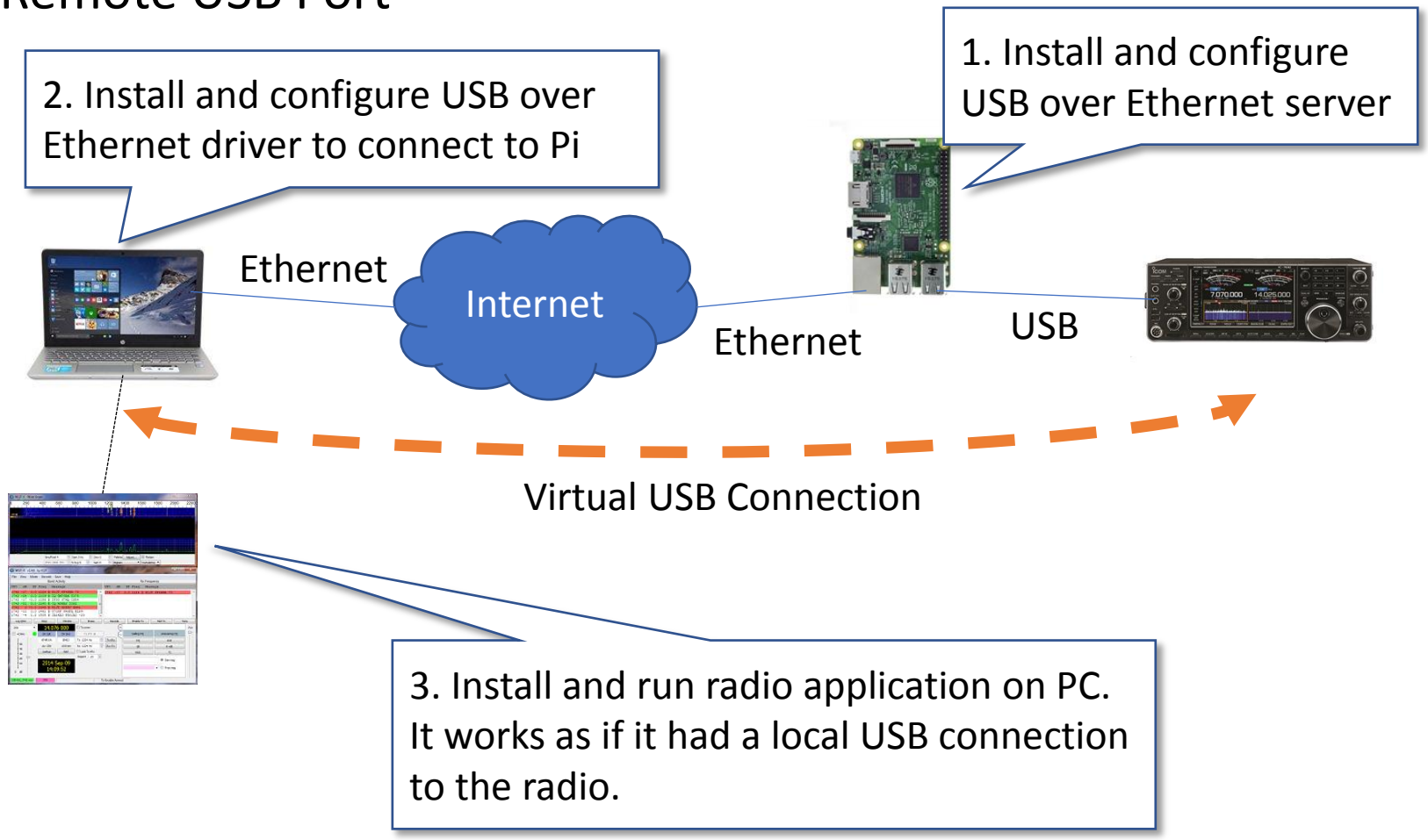
- Benefits Of Using x86 Computers
  - Newer x86 systems will be much faster than Raspberry Pi and laptops include monitors
  - Laptops include monitors for portable operation
- Benefits of Raspberry Pi 3
  - Silent - no moving parts
  - Bigger screen than laptop and some radios
  - Lower power for battery operation
  - Possibly lower EMI or easier to shield

#4: Do-It-Yourself Rig Remote

- Remote Rig Control Benefits
  - Avoid HoA antenna restrictions
  - Use different radios
  - Operate while traveling
- Drawbacks Of Typical Solutions
  - Dedicating a PC adds cost and takes up space, time
  - Commercial solutions are somewhat expensive
- Raspberry Pi Can Serve As Remote Interface
  - At least two ways to do it

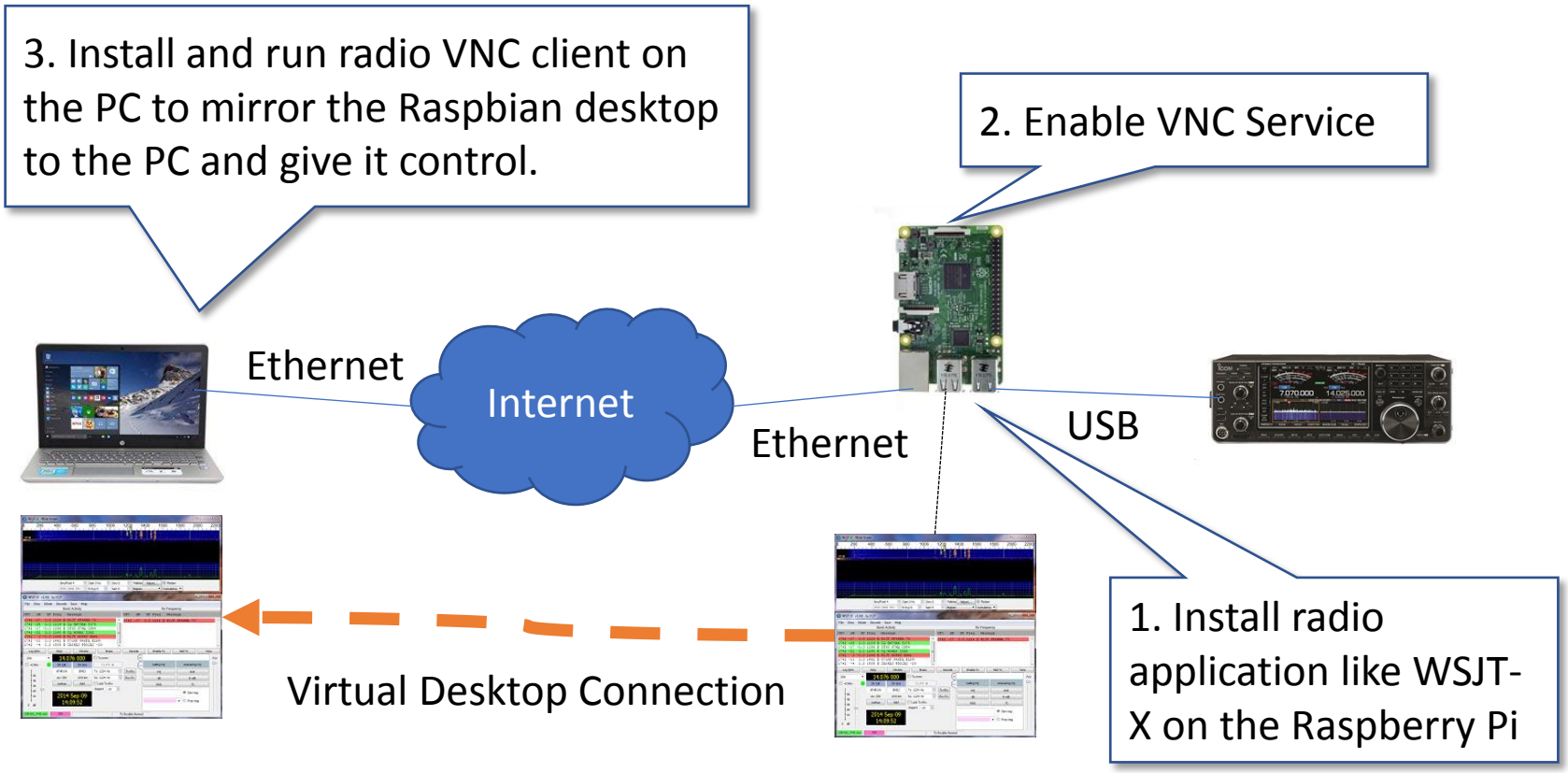
#4: Do-It-Yourself Rig Remote

Remote USB Port



#4: Do-It-Yourself Rig Remote

Remote Virtual Desktop



#4: Do-It-Yourself Rig Remote

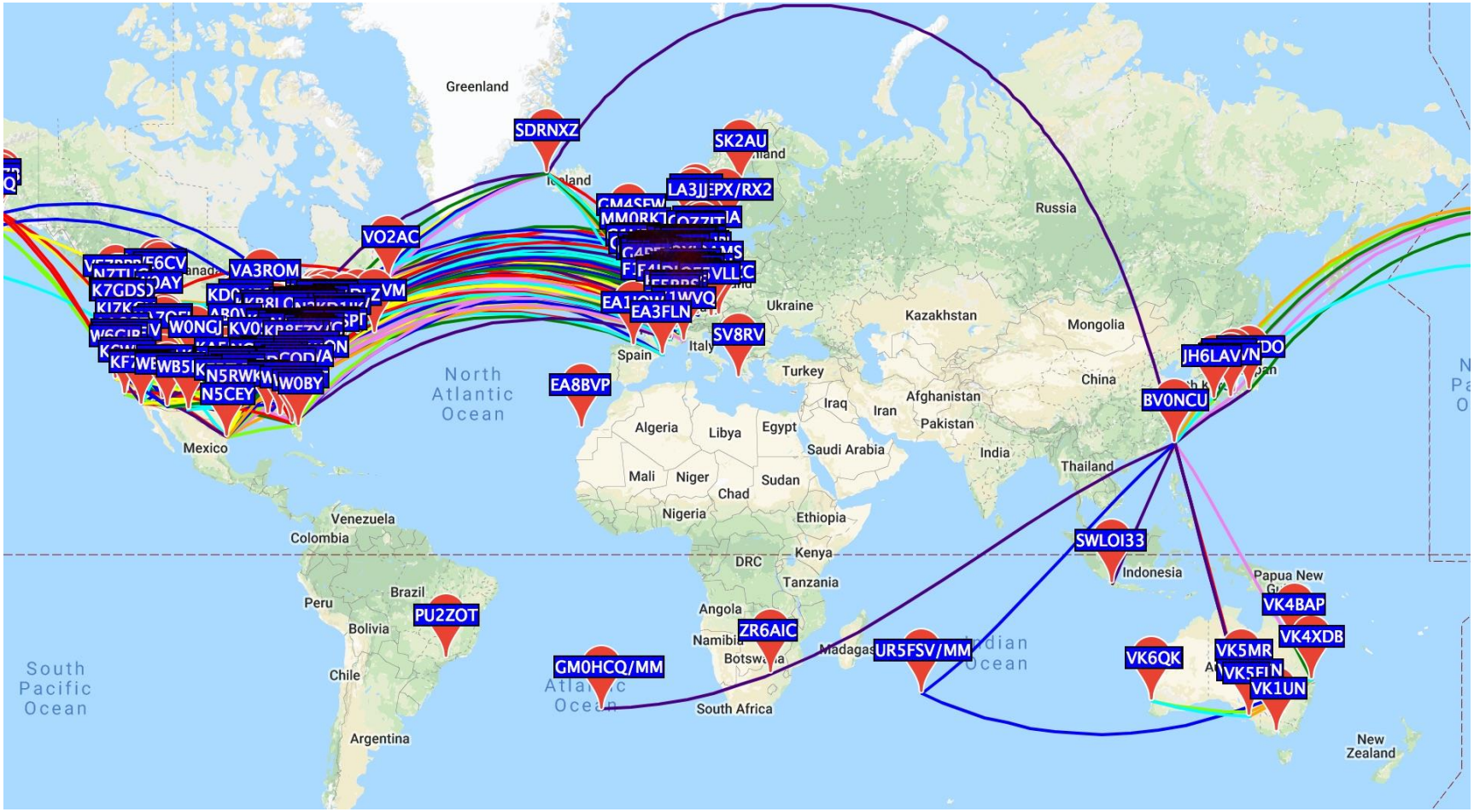
- More Opportunities
  - The Raspberry Pi can also monitor power, temperature, a remote camera, etc.
- Some Considerations
  - Internet connection must have sufficient speed
  - CAT and audio may not tolerate high latency or loss
  - Some USB over Ethernet solutions have a license cost
  - Change the default Raspberry Pi password
  - Configuring home router for remote access and using VPN* are topics for another presentation

*A Virtual Private Network uses encryption to prevent unauthorized access.

#5: WSPR Beacon

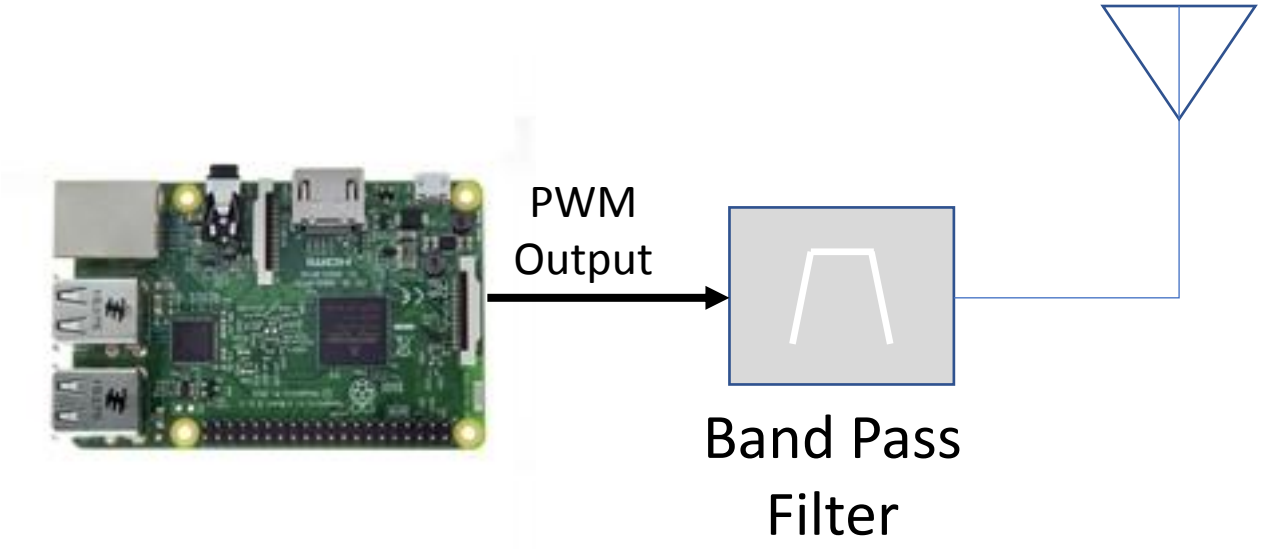
- Radio Propagation Varies Widely
  - Measure current propagation to know what bands/countries to work
- Weak Signal Propagation Reporter (WSPR) Network
  - Transmitting stations broadcast call and location with low power, redundant coding
  - Listening stations apply advanced decoding and submit received messages to Internet servers
  - Propagation map updated at http://wsprnet.org/drupal/

#5: WSPR Beacon



#5: WSPR Beacon

It is very simple to create a beacon using a Raspberry Pi



#5: WSPR Beacon

- Benefits Of Using A Raspberry Pi
  - Frequency agility – LF to VHF
  - Frequency accuracy using NTP
  - Modulation agility – Digital, SSB, CW,…
  - Very low power – ~10 mW
  - Does not tie up a radio!
- Multiple Implementations – i.e.:
  - http://rockingdlabs.dunmire.org/exercises-experiments/bpf-analysis
  - http://www.vk3bq.com/2014/08/12/raspberrypi-wspr-beacon-wsprrypi/
  - https://www.arvos.org/wspir/, http://www.tapr.org/

Other Applications

- Many More For Amateur Radio
  - Use your favorite search engine
  - For some applications microSD cards are on Amazon or eBay with the application already installed
- Plenty Of Other Uses!
  - Motion sensing camera
  - Home automation
  - Build Your Own Amazon Echo
  - Media Center
  - Weather Station
  - Dedicated secure computer

Sample Accessories

LCD Screen

Stepper Motor Hat

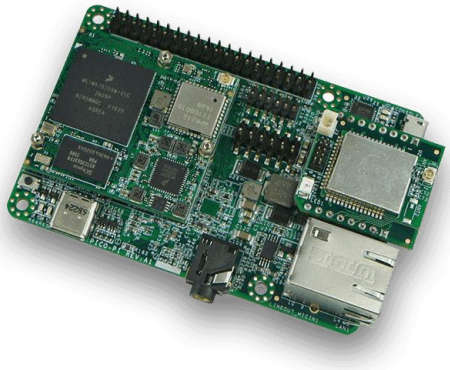
Camera

GPS

Buffered I/O

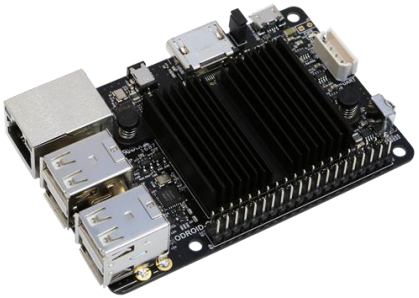
Unbuffered I/O

Similar Computers

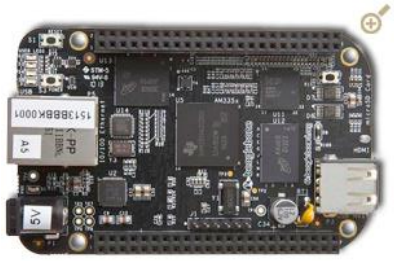


Wandboard
(Multiple Versions)

Banana Pi
(There is also an
“Orange Pi”)



ODROID
(Multiple Versions)



BeagleBone
(Multiple Versions)

Minnowboard
(Multiple Versions)

Summary

- Raspberry Pi's Have Many Uses In The Shack
  - These five are my favorites – there are more
  - They have many other uses beyond radio
  - If you're allergic to raspberry's there are other options
- They Have Advantages Over PC's
  - Lower SWAP (Size, Weight, and Power)
  - Easy to use – lots of online help
  - No BSoD! (Blue Screen of Death)
  - Very inexpensive
- Now Is A Great Time To Experiment With Them!