



# Bareboat Necessities Projects

mgrouch

Version 2020-03-30, Bareboat Projects

<https://bareboat-necessities.github.io>

<https://github.com/bareboat-necessities/my-bareboat>

<https://github.com/bareboat-necessities/my-bareboat/issues>

<https://bareboat-necessities.wixsite.com/my-bareboat>

# Chapter 1. Boat Electronics Project

This document describes a DIY project of building a marine computer, a boat LTE/WiFi gateway, and a cockpit chartplotter display from easily obtainable and affordable components. This boat electronics project includes:

- Waterproof marine touch screen HDMI display
- GNSS (GPS, GLONASS, Beidou, Galileo) receiver
- Sensors for orientation (gyroscope, accelerometer, compass via IMU)
- AIS radar
- Environment temperature, barometric pressure, humidity sensors
- Connections to the boat instruments such as wind, depth, speed, AIS via NMEA 0183 serial ports
- Boat LTE / 4G Gateway, network storage
- Boat WiFi hotspot and a router with WiFi extender and a long range waterproof WiFi antenna
- Optional autopilot integration, rudder angle sensor
- Other NMEA devices, engine/battery status, bilge pump monitoring, etc
- Optional air mouse with a wireless keyboard and a touchpad
- Lightning EMI sensor and alarm
- RTL-SDR for weather fax, NavTex, satellite weather, AIS, RTL 433, morse code decoder, etc
- Boat IoT Integration via MQTT
- Music Player
- Can be used with Iridium Satellite Modems
- Can be used for processing transmissions received from SSB radio via audio interface
- Variety of options of using wireless handheld devices such as smart phones and tablets to connect to boat systems via WiFi and bluetooth. There are many marine applications available for smart phones and tablets.

The boat computer is connected to the waterproof HDMI touchscreen in the cockpit.

## Boat Computer



Figure 1. Boat Computer

## Boat Gateway



Figure 2. Boat Gateway

Keep in mind that by following this document you are building devices to be used in marine environment. All connections and wiring need to follow marine standards which are more strict than automotive. All nuts and bolts need to be properly tightened. I've run into issues in my sailboat experience on water just because of one missing washer (It was in mechanical system on gear switch wire). Heat shrink tubing, wire grades are different for marine standards. Corrosion in misty salt water air is much higher than on the ground. A boat is exposed to the elements more than house or automobile appliances. If you doubt you did something right you better of revisiting it or seeking peer review from other sailors. The same works the other way. If you see something wrong here with the design let us know :) There is issues reporting system in GitHub: <https://github.com/bareboat-necessities/my-bareboat/issues>

i

 Although this document describes mostly instructions on building hardware components, it is designed in the spirit of open source development. We hope this design is going to evolve and have numerous releases and corrections if it gains some community. Some software components might become part of this project too. Cost cutting is another sport and sub-hobby in recreational sailing and boating. So if same functionality can be built cheaper it probably should be, and here is the reason to change this document.

## 1.1. Boat Computer

The boat computer runs on Raspberry Pi (Raspbian Linux) with OpenPlotter 2.0 installed. The boat computer will reside below deck so it's not going to be waterproof. The touchscreen display runs OpenPlotter UI with OpenCPN chartplotter and dashboards as well as general Linux UI.

**The boat computer front panel interfaces:**

- 1 USB 3.0 data port
- 1 AUX audio port
- 1 USB 2.0 data port
- 1 HDMI port
- Computer Voltage Meter
- Amp and Voltage Meter Combined
- Status indicators via fiber-optic light pipes
- Fuse box panel mount
- On/Off power switch
- On/Off power switch for cockpit instruments



Figure 3. Boat Computer, Front Panel

#### The boat computer back panel interfaces:

- 1 Ethernet port 1Gbit (for the WiFi router)
- 1 USB 2.0 port for GPS (or something else)
- 1 NMEA-0183 port (More can be added in the same DIY fashion)
- DC power 2-wire input cord mounted inside a waterproof gland for 12v boat connection. SAE-type connector
- DC power 2-wire output cord mounted inside a waterproof gland for 12v cockpit connection. SAE-type connector (black male)
- HDMI and USB 3.0 connectors to the cockpit display and touchscreen
- RF connector for AIS antenna
- RF connector for RTL-SDR antenna
- SMA RF connector for a secondary GPS



Figure 4. Boat Computer, Back Panel

### Boat Computer Inside

Raspberry Pi lays on top of the middle divider made out of plastic sheet. The power supply (12v to 5v step-down converter) is mounted from the other side under the middle divider. The USB hub doesn't fit by height to simply lay on the divider, so there is a little shelf made out of the same plastic sheet and it is attached by 4 shortest standoffs. USB hub is mounted under a slight angle to give space to a screw which closes the enclosure.





Figure 5. Boat Computer, Inside

On the picture above 7-Port powered USB 3.0 hub, dAISy AIS, Raspberry Pi 4 with a cooling fan and heat sinks, serial-to-USB stick (with the chipset from FTDI), SSD, RTL-SDR RF stick. 12v to 5v step-down converter is located below this layer inside the housing box and is connected to the front panel via a fuse and a switch on the front panel.

You can customize the front and back panels for your needs.

### 1.1.1. Basic Schematics

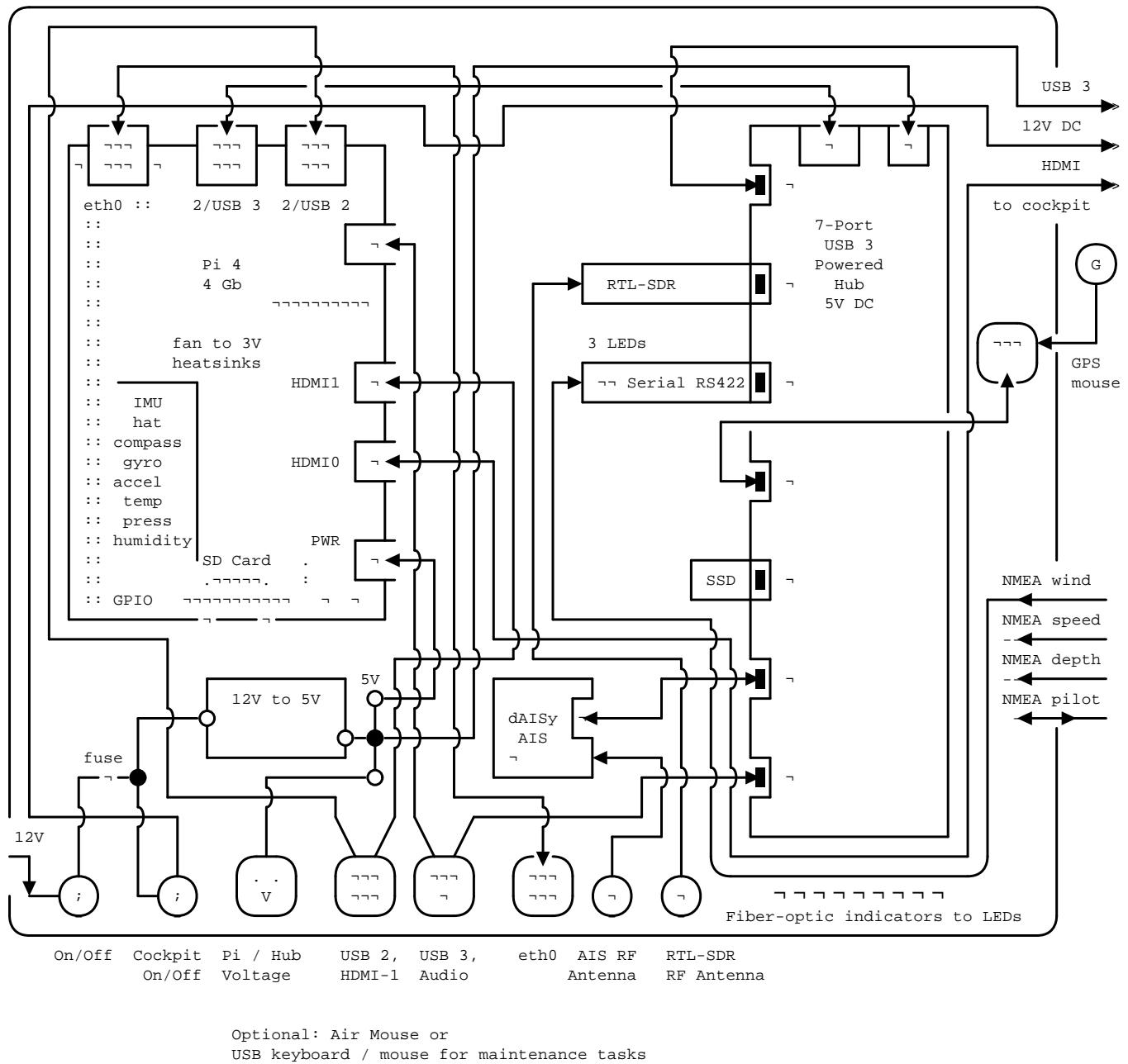


Figure 6. Boat Computer Basic Schematics Diagram

Raspberry Pi 4 has also WiFi and BlueTooth interfaces:

- 802.11ac/n
- Bluetooth 5.0

WiFi can be used to set up access to the boat computer from smart phones and tablets with additional software.

## 1.1.2. Tools and Supplies

Item	Description	Cost	Source
Standoffs	Hilitchi 120Pcs M3 Nylon Hex Spacers Screw Nut Standoff Plastic Accessories Assortment (Black) <ul style="list-style-type: none"> <li>• UNSPSC Code: 31161816</li> <li>• Thread Size: M3</li> <li>• Part Number: HNLM3</li> </ul> <a href="https://www.amazon.com/dp/B012G6E62I">https://www.amazon.com/dp/B012G6E62I</a>	\$6	Amazon
Screws, Nuts	Screws, nuts, etc for electronics	\$4.5	Microcenter
Cable ties	Cable ties	\$5	Homedepot
Soldering	Soldering Iron Kit - Soldering Iron 60 W Adjustable Temperature, Digital Multimeter, Wire Cutter, Stand, Soldering Iron Tip Set, Desoldering Pump, Solder Wick, Tweezers, Rosin, Wire - [110 V, US Plug] <ul style="list-style-type: none"> <li>• Heat Time: 60 seconds</li> <li>• Wattage: 60</li> <li>• UNSPSC Code: 41110000</li> </ul> <a href="https://www.amazon.com/dp/B07Q2B4ZY9">https://www.amazon.com/dp/B07Q2B4ZY9</a>	\$35	Amazon
Jumper Wires	120pcs Breadboard Jumper Wires 10cm 15cm 20cm 30cm 40cm 50cm 100cm Optional Arduino Wire Dupont Cable Assorted Kit Male to Female Male to Male Female to Female Multicolored Ribbon Cables  <a href="https://www.amazon.com/dp/B07GD2BWPY">https://www.amazon.com/dp/B07GD2BWPY</a>	\$5.80	Amazon
Waterproofing Spray for PCB, Conformal Coating (Optional)	422B-340G Silicone Conformal Coating, Clear, 12 oz Aerosol  <a href="https://www.amazon.com/dp/B008O9YGQI">https://www.amazon.com/dp/B008O9YGQI</a>	\$22.45	Amazon

Item	Description	Cost	Source
Heat Shrink Connections (Optional, You might have enough)	450pcs Heat Shrink Wire Connectors DIY Kit Heat Shrink Butt Connectors Crimping Tool Heat Shrink Tubing Heat Gun Waterproof Marine Automotive Terminals Set  <a href="https://www.amazon.com/dp/B07W41Y7CF">https://www.amazon.com/dp/B07W41Y7CF</a>	\$42	Amazon
Heat Shrink Tubing (Optional, You might have enough)	Heat Shrink Tubing	\$6	Local auto store
Fuses	Fuses  6x30mm	\$6	Local hardware store

### 1.1.3. Boat Computer Enclosure

#### Enclosure Parts

Item	Description	Cost	Source
Case	Brand: SZOMK, Model: AK-D-09, IP54 protection, plastic box for PCB design instrument. Black. Dimensions exterior: W 230mm, D 210mm, H 86mm  <ul style="list-style-type: none"> <li>• Brand (from inside markings): BAHAR</li> <li>• Model: BDH 20014-A2</li> </ul> <a href="https://a.aliexpress.com/_svVwOa">https://a.aliexpress.com/_svVwOa</a>	2 * \$19.80, Delivery: \$7	AliExpress
Plastic sheets	ABS Black Plastic Sheets Size 12" x 12", 0.118"-1/8" thick, 2-Pack, 1 Side Textured, Black  <a href="https://www.amazon.com/dp/B0007WTF02">https://www.amazon.com/dp/B0007WTF02</a>	\$10	Amazon

Item	Description	Cost	Source
12v to 5v step-down converter	TOBSUN EA50-5V DC 12V 24V to DC 5V 10A 50W Converter Regulator 5V 50W Power Supply Step Down Module Transformer <ul style="list-style-type: none"> <li>• Over-voltage, over-current, over-temperature, short-circuit auto protection</li> <li>• Input voltage: 12/24V, Output: 5V/10A</li> </ul> <a href="https://www.amazon.com/dp/B01M03288J">https://www.amazon.com/dp/B01M03288J</a>	\$9.60	Amazon

For those who like 3D printing and designing your own enclosures there is a nice project with [OpenScad](#) on ThingsVerse. See:

<https://www.thingiverse.com/thing:1264391> and

<https://www.thingiverse.com/thing:1355018>

It's called 'The Ultimate Box Maker'.

## Front Panel

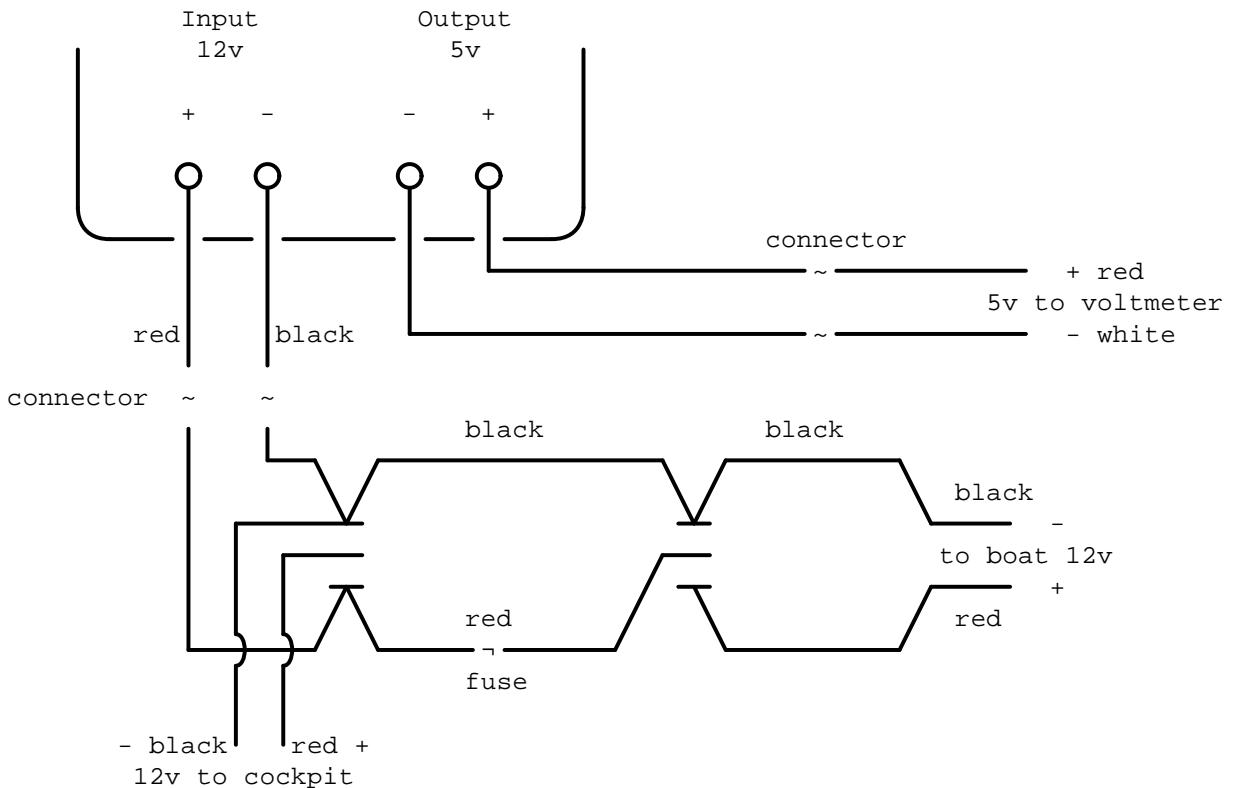


Figure 7. Front Panel Diagram

Item	Description	Cost	Source
2-Wire DC connectors SAE (Red, <b>Black</b> ) Pack of 2	DIY 1 to 2 SAE Power Extension Cable Adapter Connector 2 Pin Quick Connect Disconnect Plug SAE Power Extension Cable 18AWG 300mm (Pack of 2)  <a href="https://a.aliexpress.com/_seDmsO">https://a.aliexpress.com/_seDmsO</a>	\$10	AliExpress
2-Wire DC connector (Red, <b>White</b> )	SAE Connector DC Power Cable, 16 AWG Quick Disconnect (Pack of 2)   Used with 5v to distinguish from red/black for 12v  <a href="https://a.aliexpress.com/_sKPLty">https://a.aliexpress.com/_sKPLty</a>	\$2	AliExpress
USB 2.0 / HDMI	USB 2.0 HDMI Mount Cable – USB Extension Flush, Dash, Panel Mount Boat Cable (3.3FT/1m)  <a href="https://www.amazon.com/dp/B076DFRPLZ">https://www.amazon.com/dp/B076DFRPLZ</a>	\$10	Amazon
USB 3.0 / AUX	USB 3.0 & Flush Mount Cable + USB3.0 AUX Extension Dash Panel Waterproof Mount Cable for Boat, Car and Motorcycle - 3ft  <a href="https://www.amazon.com/dp/B072KGMJ5N">https://www.amazon.com/dp/B072KGMJ5N</a>	\$10	Amazon
Panel, etc	5 Gang 3 Pin Rocker Switch Panel Waterproof On-Off Toggle Switches with Pre-wired for Car Vehicle Trailer Truck SUV Marine Boat RV Ship  <a href="https://www.amazon.com/dp/B07Z1Q8Y3G">https://www.amazon.com/dp/B07Z1Q8Y3G</a>   Used for panel parts: Switches, 12v DC Wires	\$12	Amazon
Voltmeter	DC 12V-24V Digital Panel Voltmeter Voltage Meter Tester Led Display For Car Auto Motorcycle Boat ATV Truck Refit Accessories  <a href="https://a.aliexpress.com/_rw5xSI">https://a.aliexpress.com/_rw5xSI</a>	\$4	AliExpress

Item	Description	Cost	Source
Current (Ampere meter) and Voltmeter (2-pack)	Digital Ammeter Voltmeter DC 100V 10A 50A 100A Amp Meter Volt panel Voltage Current Meter Tester Gauge Dual LED Auto Car <a href="https://a.aliexpress.com/_sr9X34">https://a.aliexpress.com/_sr9X34</a>	\$6	AliExpress
Light Pipes (long)	<p>Fiber optic light pipes with lenses for panel mount for transfer of inside LED indicators light to the front panel</p> <ul style="list-style-type: none"> <li>• SMFLP12.0 492-1291-ND LIGHT PIPE CLEAR FLEXIBLE 12" (5 pack)</li> <li>• Brand: Bivar Inc</li> <li>• 4mm Board/Panel Mount</li> </ul> <p><a href="https://www.digikey.com/product-detail/en/bivar-inc/SMFLP12.0/492-1291-ND/2407239">https://www.digikey.com/product-detail/en/bivar-inc/SMFLP12.0/492-1291-ND/2407239</a></p>	\$15, Delivery: \$7	DigiKey
Light Pipes (short)	<p>Fiber optic light pipes with lenses for panel mount for transfer of inside LED indicators light to the front panel</p> <ul style="list-style-type: none"> <li>• Digi-Key Part Number 492-1293-ND (LIGHT PIPE CLEAR FLEXIBLE 6", SMFLP6.0)</li> <li>• Light Pipe Single Clear Flexible 6" (152.4mm) Round with Flat Top, 4mm Board/Panel Mount, Press Fit (5 pack)</li> <li>• Brand: Bivar Inc</li> <li>• 4mm Board/Panel Mount</li> </ul> <p><a href="https://www.digikey.com/product-detail/en/bivar-inc/SMFLP6.0/492-1293-ND/2407240">https://www.digikey.com/product-detail/en/bivar-inc/SMFLP6.0/492-1293-ND/2407240</a></p>	\$9	DigiKey
Fuse Box for Panel Mount	<p>Pack of 10 AC 15A 125V Black Electrical Panel Mounted Screw Cap Fuse Holder</p> <ul style="list-style-type: none"> <li>• Fit for: 6 x 30mm fuses</li> <li>• Rated: AC 125V 15A</li> </ul> <p><a href="https://www.amazon.com/dp/B012CTCWES">https://www.amazon.com/dp/B012CTCWES</a></p>	\$6	Amazon

## Back Panel

Item	Description	Cost	Source
SAE DC 2-pin connector	14AWG 100CM SAE TO SAE Quick Disconnect Extension Cable Sae Power Connector Heavy Duty With Dust Cap  <a href="https://a.aliexpress.com/_rQdwfe">https://a.aliexpress.com/_rQdwfe</a>	\$5	AliExpress
RF connector for RTL-SDR to panel	SMA Male to UHF PL-259 Male RG316 RF Coax Cable 1 ft <ul style="list-style-type: none"> <li>• Impedance: 50 ohm; Length: 1 ft</li> <li>• Ultra Low-loss Double Shielded RG316 Coaxial Cable</li> </ul> <a href="https://www.amazon.com/dp/B07TF6LZC7">https://www.amazon.com/dp/B07TF6LZC7</a>	\$11.30	Amazon
RF Connector to panel for GPS antenna	SMA Socket Connector Panel Chassis Mount SMA Female to Female Bulkhead Extendable Antenna Jack Adapter for Antennas Wireless LAN Devices Coaxial Cable, Pack of 2 <ul style="list-style-type: none"> <li>• Antenna cable connector SMA female to female bulkhead jack adapter</li> <li>• Surface treatment: Gold-plated, Impedance: 50ohm, Low-loss</li> </ul> <a href="https://www.amazon.com/dp/B07FKPJ4QQ">https://www.amazon.com/dp/B07FKPJ4QQ</a>	\$6	Amazon
AIS and RTL-SDR Antenna panel connectors	2pcs SO239 Adapter UHF Female to Female Jack Bulkhead RF Connector, Impedance:50 Ohm  <a href="https://www.amazon.com/dp/B01MR16V5X">https://www.amazon.com/dp/B01MR16V5X</a>	\$9.60	Amazon

Item	Description	Cost	Source
RF chord for dAISy AIS	BNC Male to PL259 RG58 Cable (8 Inches); UHF PL259 Jack to BNC Male Plug Adapter Jumper Pigtail Cable RG58 <ul style="list-style-type: none"> <li>• Connector: BNC Male to PL259</li> <li>• Impedance: 50 Ohm</li> <li>• Cable Type: RG58</li> </ul> <a href="https://www.amazon.com/dp/B07MK8FM94">https://www.amazon.com/dp/B07MK8FM94</a>	\$5.60	Amazon
RJ45	CAT6 RJ45 Shielded Industrial Panel Mount Bulkhead Female/Female Feed Thru Coupler - Network Connectors - IP67 Waterproof/Dust Cap (Single Pack, Black) <a href="https://www.amazon.com/dp/B01D0N7AI8">https://www.amazon.com/dp/B01D0N7AI8</a>	\$11.50	Amazon
Terminal Block for NMEA 0183	Brand Name: QSU Screw Terminal Block Kit <b>Long</b> Pins 5 mm Pitch 2, 3, 4 Pole (40 pcs) <a href="https://www.amazon.com/dp/B07RTHD45H">https://www.amazon.com/dp/B07RTHD45H</a>	\$9.50	Amazon
USB 2.0 Panel Mount	USB2.0 IP67 Waterproof Connector Industrial Standard Double Head Coupler Adapter Female to Female Socket Plug Panel Mount with Waterproof/Dust Cap, 2pcs <a href="https://www.amazon.com/dp/B07RPW5XGB">https://www.amazon.com/dp/B07RPW5XGB</a>	\$13 for 2	Amazon
Waterproof Cable Glands	35pcs Cable Gland Waterproof Cable Fixing Head Suitable for 3mm-14mm M12 M16 M18 M20 M22 Cable Gland Joints Assortment Set (M-Black) <a href="https://www.amazon.com/dp/B07TSC34D5">https://www.amazon.com/dp/B07TSC34D5</a>	\$11	Amazon
HDMI and USB 3.0 Panel Mount cord	USB 3.0 & HDMI to HDMI + USB3.0 AUX Extension Dash Panel Waterproof Car Flush Mount Cable For Car Boat and Motorcycle - 3ft <a href="https://a.aliexpress.com/_sGY9fK">https://a.aliexpress.com/_sGY9fK</a>	\$8.50	AliExpress

Item	Description	Cost	Source
GPS G-mouse (Optional)	<p>GlobalSat BU-353-S4 USB GPS Receiver (Black)</p> <ul style="list-style-type: none"> <li>• 48-Channel All-In-View Tracking</li> <li>• SiRF Star IV GPS Chipset</li> <li>• WAAS/ EGNOS Support</li> </ul> <p><a href="https://www.amazon.com/dp/B008200LHW">https://www.amazon.com/dp/B008200LHW</a></p>	\$26.10	Amazon
GPS Antenna (Optional)	<p>Waterproof Active GPS Antenna with Magnetic Base - 28dB - 3-5V - SMA Connector and Adapter Included</p> <ul style="list-style-type: none"> <li>• compatible with BerryGPS-IMU</li> <li>• Magnetic base for easy placement</li> <li>• Cable length is 3 meters[9.8 Feet]</li> <li>• Includes SMA to uFL connector</li> <li>• Active 28dB</li> </ul> <p><a href="https://www.amazon.com/dp/B0769FRT6X">https://www.amazon.com/dp/B0769FRT6X</a></p>	\$11.50	Amazon
GPS Antenna	<p>GPS Boat Antenna Compatible with Beidou 30dB SMA Male External Navigation Receiver 0.2 Meter Wire</p> <ul style="list-style-type: none"> <li>• Connector: SMA Male</li> <li>• Voltage: 3-5 Volt</li> <li>• LNA Gain (Without Cable): 30dB</li> <li>• Operating Temperature (Deg.C): -45~+85</li> <li>• Center Frequency: 1575.42 MHz(GPS); 1561 MHz(BD)</li> </ul> <p><a href="https://www.amazon.com/dp/B07ZBVG1PK">https://www.amazon.com/dp/B07ZBVG1PK</a></p>	\$16.25	Amazon
GPS Antenna Cable	<p>SMA Male to SMA Female Wifi Antenna Connector Extension RG174 Cable</p> <ul style="list-style-type: none"> <li>• 8 meter</li> </ul> <p><a href="https://a.aliexpress.com/_subQWM">https://a.aliexpress.com/_subQWM</a></p>	\$8.40	AliExpress

Item	Description	Cost	Source
AIS Antenna	Tram VHF Marine Antenna <a href="https://www.amazon.com/dp/B01DUSBJ94">https://www.amazon.com/dp/B01DUSBJ94</a>	\$24.15	Amazon
AIS Antenna Cable	RG-58A/U Coaxial Cable w/Molded PL-259 Connectors (18 feet) <a href="https://www.amazon.com/dp/B001JT1IWU">https://www.amazon.com/dp/B001JT1IWU</a>	\$9	Amazon

### NMEA Pinout and Color Coding

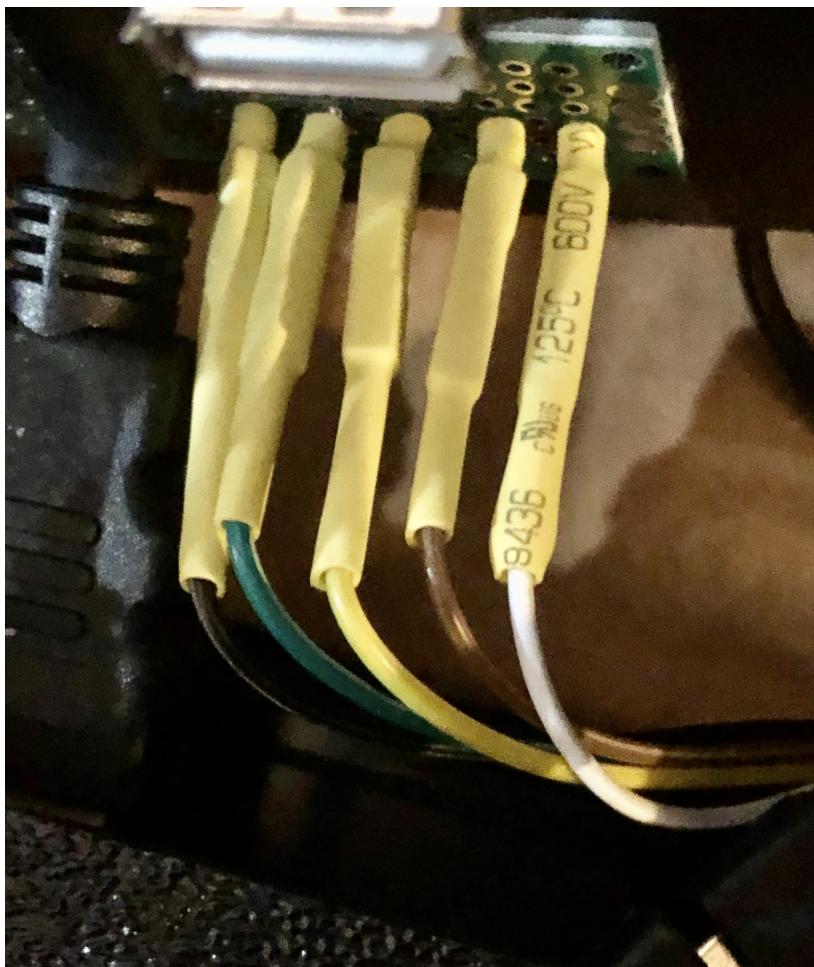


Figure 8. NMEA Wiring Colors

NMEA Pins:

1	White	Tx+
2	Brown	Tx-

3	Yellow	Rx+
4	Green	Rx-
5	Black	Gnd



Figure 9. NMEA Pins 1-2-3-4-5. 1 is left, 5 is right

When wiring NMEA 0183 devices:

Transmit (Tx) (+) should connect to a receive (Rx) (+)  
 Tx (-) should connect to a Rx (-)  
 Rx (+) should connect to a Tx (+)  
 Rx (-) should connect to a Tx (-)

1. In the event the sending device has a Tx (-), but there is not a corresponding Rx (-) on the receiving device, leave the sending device's Tx (-) disconnected. Failure to follow this guideline can damage the sending device.
2. In the event that the receiving device has a Rx (-), but there is no corresponding Tx (-) on the sending device, bring the Rx (-) to ground.

## Assembly Activities

Make sure you use correct tools for:

- Measuring
- Cutting
- Clamping
- Drilling
- Heat Shrinking

- Tying
- Crimping
- Screwing

## Tools

Drill, Screwdriver, Drill bits, Large hole drill bit, Cutting knife, Caliper, Soldering Kit, Rotary Tool (Like Dremel), Heat Gun, Crimper Tool

### 1.1.4. Computer and Sensors

Raspberry Pi 4

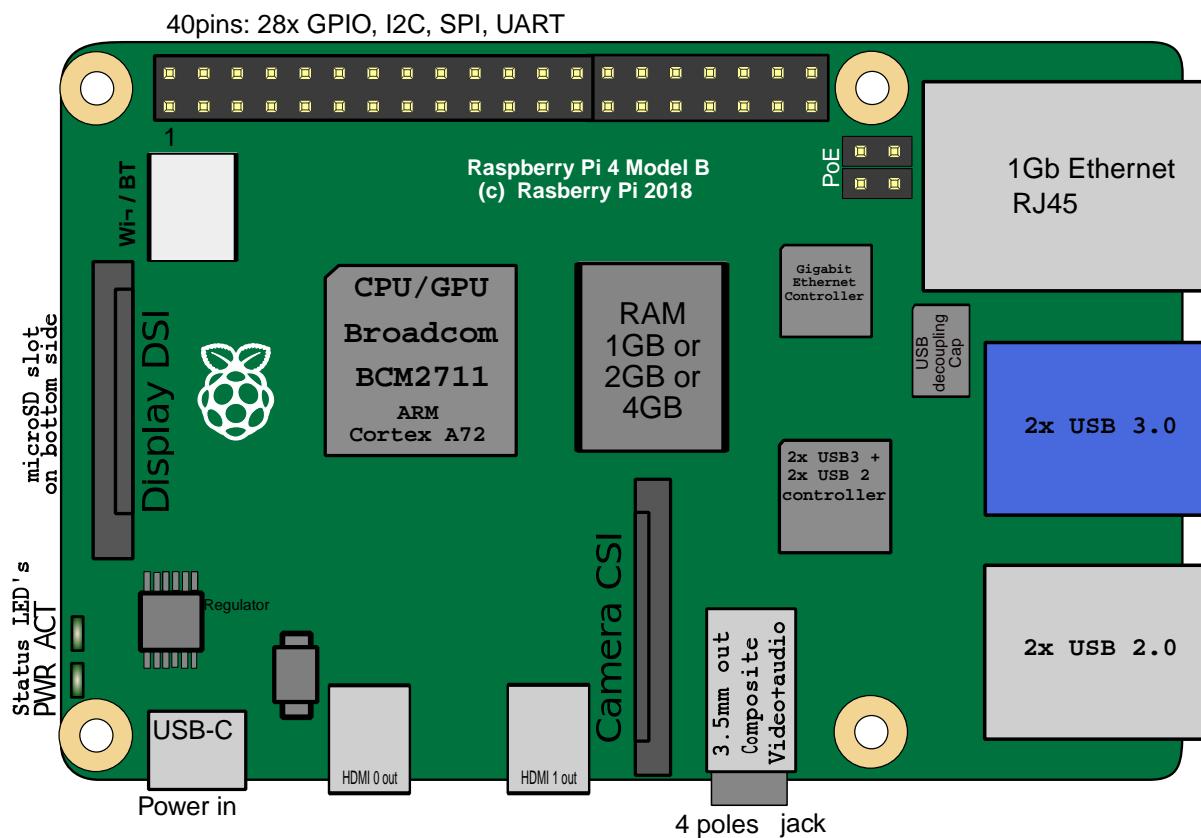


Figure 10. Raspberry Pi 4 Diagram

This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license

<https://creativecommons.org/licenses/by-sa/4.0/deed.en>

#### Sensors and Parts

Item	Description	Cost	Source
Pi 4	Raspberry Pi 4, 4Gb + Power Supply	\$65	Amazon
Heat sinks and Cooling fan, Case	Acrylic Case for Raspberry Pi 4 Model B & Raspberry Pi 3 Model B+, Raspberry Pi Case with Cooling Fan and 7PCS Heatsinks for Raspberry Pi 3/2 Model B/B+ (Brown)  <a href="https://www.amazon.com/dp/B07T3DRB1C">https://www.amazon.com/dp/B07T3DRB1C</a>	\$9	Amazon
USB Hub	USBGear 7-Port USB 3.0 Charging and SuperSpeed Mountable Data Hub  <a href="https://www.amazon.com/dp/B012DZ4RJY">https://www.amazon.com/dp/B012DZ4RJY</a>	\$35	Amazon
FTDI Serial to USB (2pcs)	DSD TECH SH-U11 USB to RS485 RS422 Converter with FTDI FT232 Chip Compatible with Windows 10, 8, 7, XP and Mac OS X  <a href="https://www.amazon.com/dp/B07B416CPK">https://www.amazon.com/dp/B07B416CPK</a>	\$34 (for 2)	Amazon
USB Isolator (Optional)	USB To USB Isolator Industrial Grade Digital Isolators With Shell 12Mbps Speed ADUM4160/ADUM316 USB Isolator Drop Ship  <a href="https://a.aliexpress.com/_sobQw2">https://a.aliexpress.com/_sobQw2</a>	11.20	AliExpress
USB Type-B short cable	USB 3.0 A Male AM to USB 3.0 B Type Male BM USB3.0 Cable 0.6m  <a href="https://a.aliexpress.com/_rv8IcU">https://a.aliexpress.com/_rv8IcU</a>	\$6	AliExpress
SSD Flash Drive	Samsung Fit Plus USB 3.1 Flash Drive 128GB  <a href="https://www.amazon.com/dp/B07D7PDLXC">https://www.amazon.com/dp/B07D7PDLXC</a>	\$30	Amazon

Item	Description	Cost	Source
SD Card	SanDisk Extreme Plus 32GB, 90MB/s	\$16	Office Depot
HDMI adapters	Cable Matters 2-Pack Micro HDMI to HDMI Adapter (HDMI to Micro HDMI Adapter) 6 Inches with 4K and HDR Support  <a href="https://www.amazon.com/dp/B00JDRHQ58">https://www.amazon.com/dp/B00JDRHQ58</a>	\$9	Amazon
dAISy AIS + BNC Adapter	<a href="https://shop.wegmatt.com/products/daisyais-receiver?variant=7104299008036">https://shop.wegmatt.com/products/daisyais-receiver?variant=7104299008036</a>	\$67.70	wegmatt.com
RTL-SDR	<p>RTL-SDR Blog V3 R820T2 RTL2832U 1PPM TCXO HF Bias Tee SMA Software Defined Radio with Dipole Antenna Kit</p> <ul style="list-style-type: none"> <li>• RTL-SDR blog software defined radio receiver with RTL2832U ADC chip, R820T2 tuner, 1PPM TCXO,</li> <li>• SMA F connector and aluminium case with passive cooling.</li> <li>• Tunes from 500 kHz to 1.7 GHz with up to 3.2 MHz (2.4 MHz stable) of bandwidth</li> </ul> <p><a href="https://www.amazon.com/dp/B011HVUEME">https://www.amazon.com/dp/B011HVUEME</a></p> <p> There might be a better suitable choice: "100KHz-1.7GHz Full Band UV HF RTL-SDR USB Tuner Receiver R820T+8232U Ham Radio" on AliExpress (\$22) and other stores. It has 2 antenna connectors one for HF 100KHz~30MHz band and another one for 25MHz~1.7GHz VHF/UHF bands. 100KHz~30MHz range is needed for NavTex messages and WeatherFax. <a href="https://a.aliexpress.com/_sfo9ho">https://a.aliexpress.com/_sfo9ho</a></p> <p> Or SdrPlay dongle (more expensive, about \$120)</p>	\$30	Amazon

Item	Description	Cost	Source
IMU + environmental sensors	BerryGPS-IMUv3 - GPS and 10DOF for The Raspberry Pi - Accelerometer, Gyroscope, Magnetometer and Barometric/Altitude Sensor   You can ask to pre-solder a header  <a href="https://www.amazon.com/dp/B072MNBC9M">https://www.amazon.com/dp/B072MNBC9M</a>	\$53.50	Amazon
RTC Clock (Optional)	2pcs DS3231 AT24C32 IIC RTC Clock Module Real Time Clock Module for Arduino Raspberry Pi  <a href="https://www.amazon.com/dp/B082G6MXVR">https://www.amazon.com/dp/B082G6MXVR</a>	\$7	Amazon

## Other Things to Consider (Add-ons)



What could I have done better? I think I could use one of the power boards like 'DockerPi power board' with momentary switch for safe shutdown. Or even couple Geekworm X828 SATA board (made by SupTronics Technologies) with their X710 power board. With those I wouldn't need internal USB hub and 12vDC to 5vDC internal step down converter.

See:

<https://geekworm.com/collections/raspberry-pi-4/products/raspberry-pi-x710-power-management-with-wide-voltage-input-6v-to-36v-safe-shutdown-expansion-board>

<https://geekworm.com/collections/raspberry-pi-4/products/raspberry-pi-x828-stackable-2-5-sata-hdd-ssd-shield>



(Update: Jan 2020) There is even better board came out. SupTronics X180. 7-Port USB 3.0 self powered hub shield for raspberry pi 4. So I'd use x710 and x180 combo.

<http://www.suptronics.com/miniPCkits/x180.html>



Another couple of interesting boards are discussed here <http://forum.openmarine.net/showthread.php?tid=1666&page=3> NMEA multiplexer, current, voltage and RPM sensors for engine/battery monitoring and fridge and thermostat control board.

<https://github.com/boatybits/boatymonpy>

[https://github.com/boatybits/ESP\\_Fridge](https://github.com/boatybits/ESP_Fridge)



One more board: <https://github.com/mairas/sailor-hat-hardware/blob/master/README.md>

- RTC Clock
- Opto couplers for NMEA interfaces
- Safe power down method
- Boot from USB SATA SSD
- Coaxial Lightning Arresters for RF cables
- Mount SD card reader to front panel to swap easier

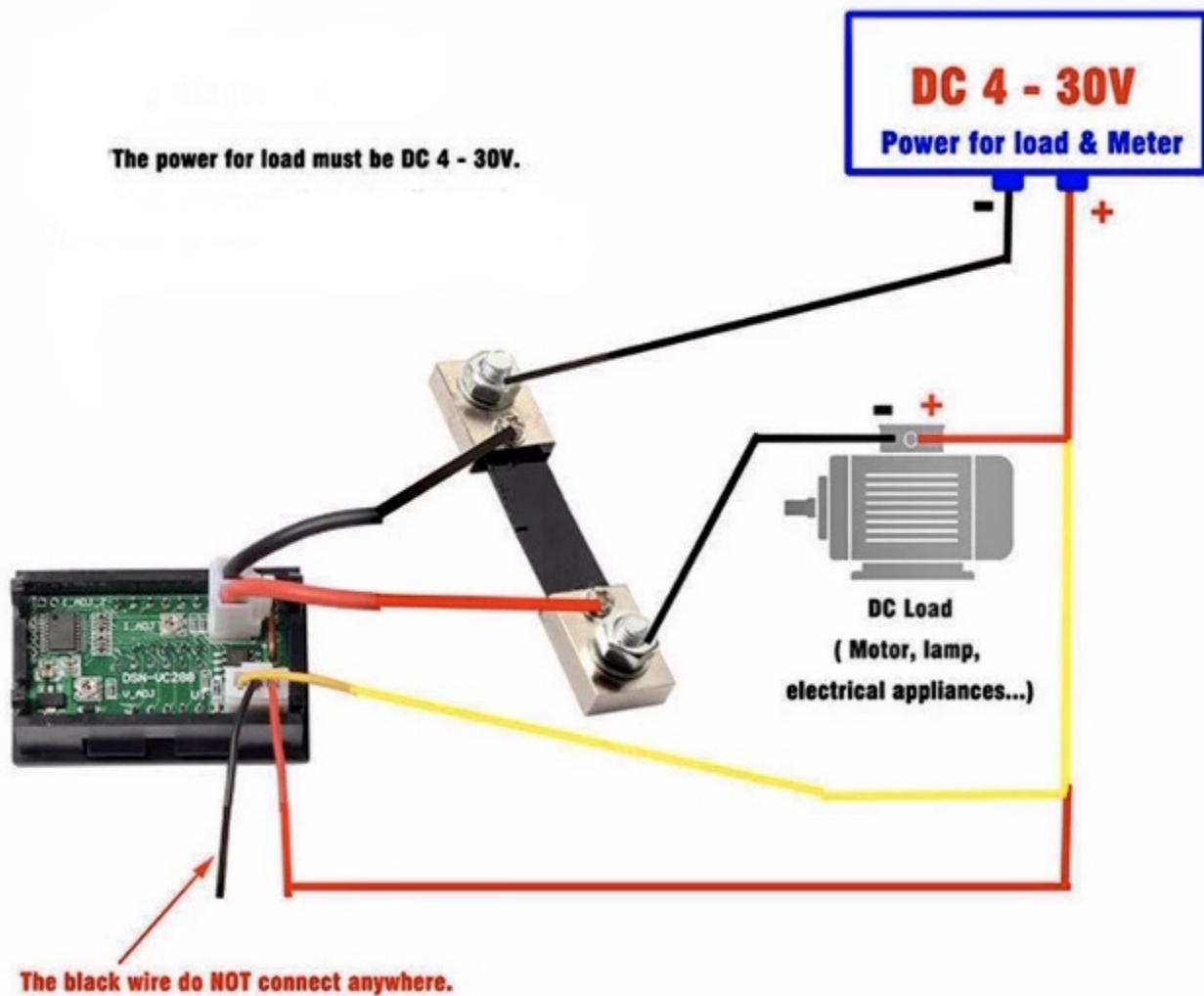


Figure 11. Amp Meter Wiring Diagram

### **Real blue water (off-shore) boat features (just brain storming)**

- GPS and chartplotter
- AutoPilot (PyPilot)
- AIS
- True Radar
- Automated WeatherFax via RTL-SDR, Satellite Weather, GRIBs via <https://sailmail.com/>
- Integration with Satellite Modems as Iridium
- Low power usage
- Weather Routing
- Better Integration with SSB radio via SDR stick, Morse decoding/encoding (?)
- Better Celestial Navigation
- Bilge Alarm, Better Alarms Overall (Deadman, Anchor Watch, Collision Avoidance, Jibe Warning, Landfall)
- Better monitoring of power usage of the boat
- Integration with Solar/Wind power generators
- Lightning strike front detection
- Wind/Speed/Drift (There are through hull transducers already which measure drift) NMEA sensors with True Wind calculation
- Comfort features: E-mail, Instagram, Spotify, Log Book, Blog Keeping better integration
- Integration with windlass and bow thrusters
- Active Captain, Squidd.io type of services integrated
- Security features, VPN, AdBlocking, Fire Alarms, Motion Sensors
- Better integration with engine sensors (temp, power, oil pressure, RPM, fuel usage, etc)
- FishFinder integration
- NightVision
- Sail Trim sensors and integration with powered winches
- More Maps and Charts
- Search and Rescue Patterns
- M5Stack deserves more attention

#### **1.1.5. Testing Boat Computer and Cockpit Display**

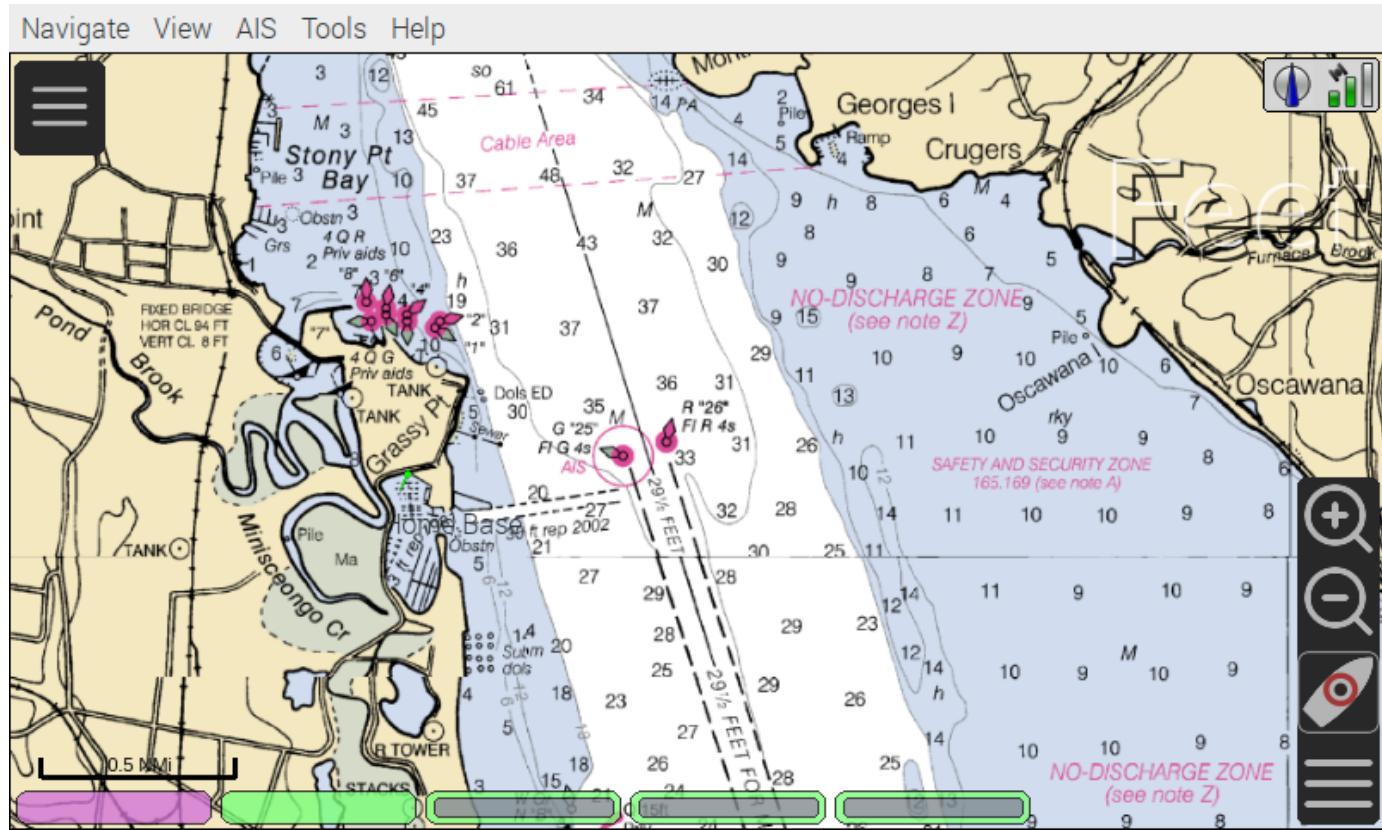


Figure 12. OpenCPN MBTiles

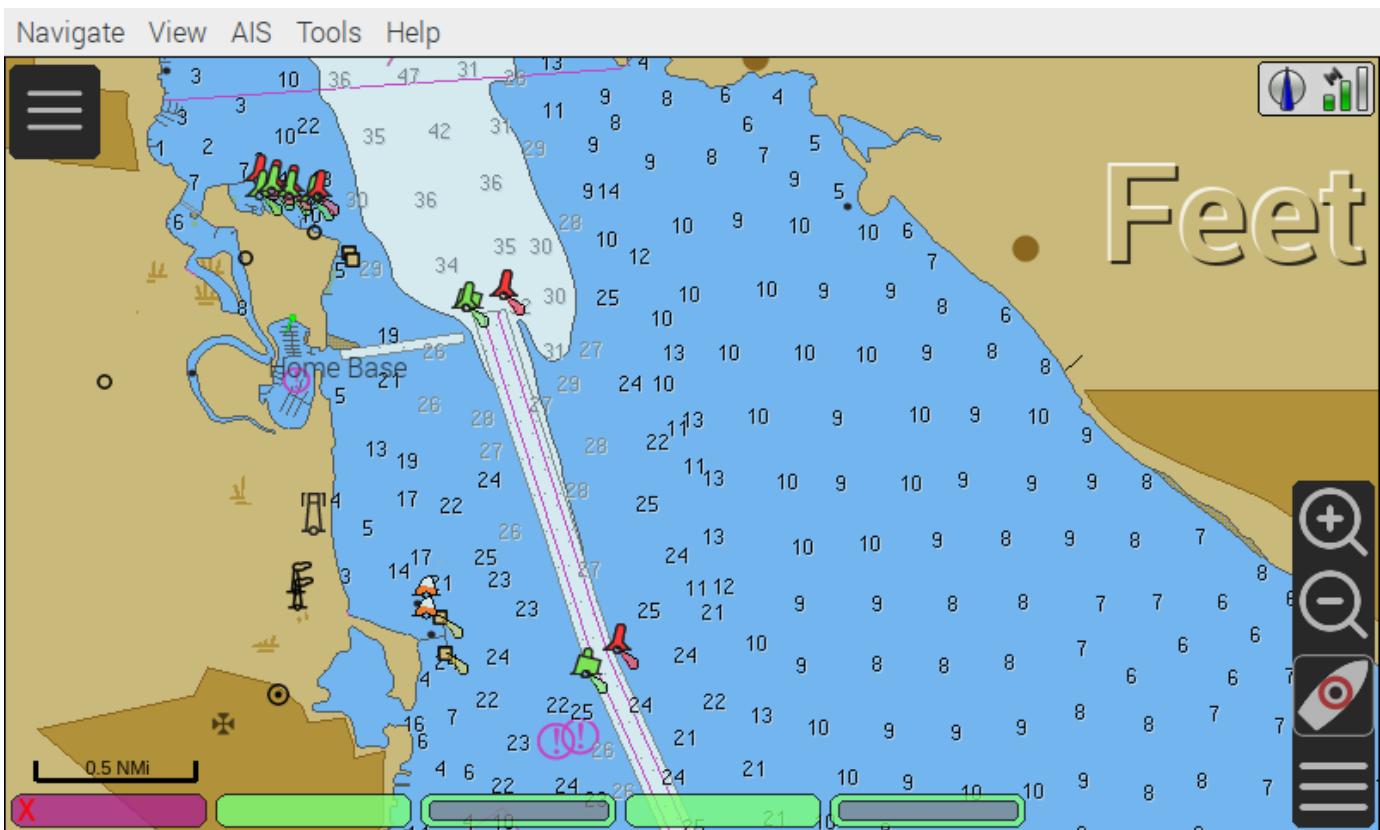


Figure 13. OpenCPN Vector

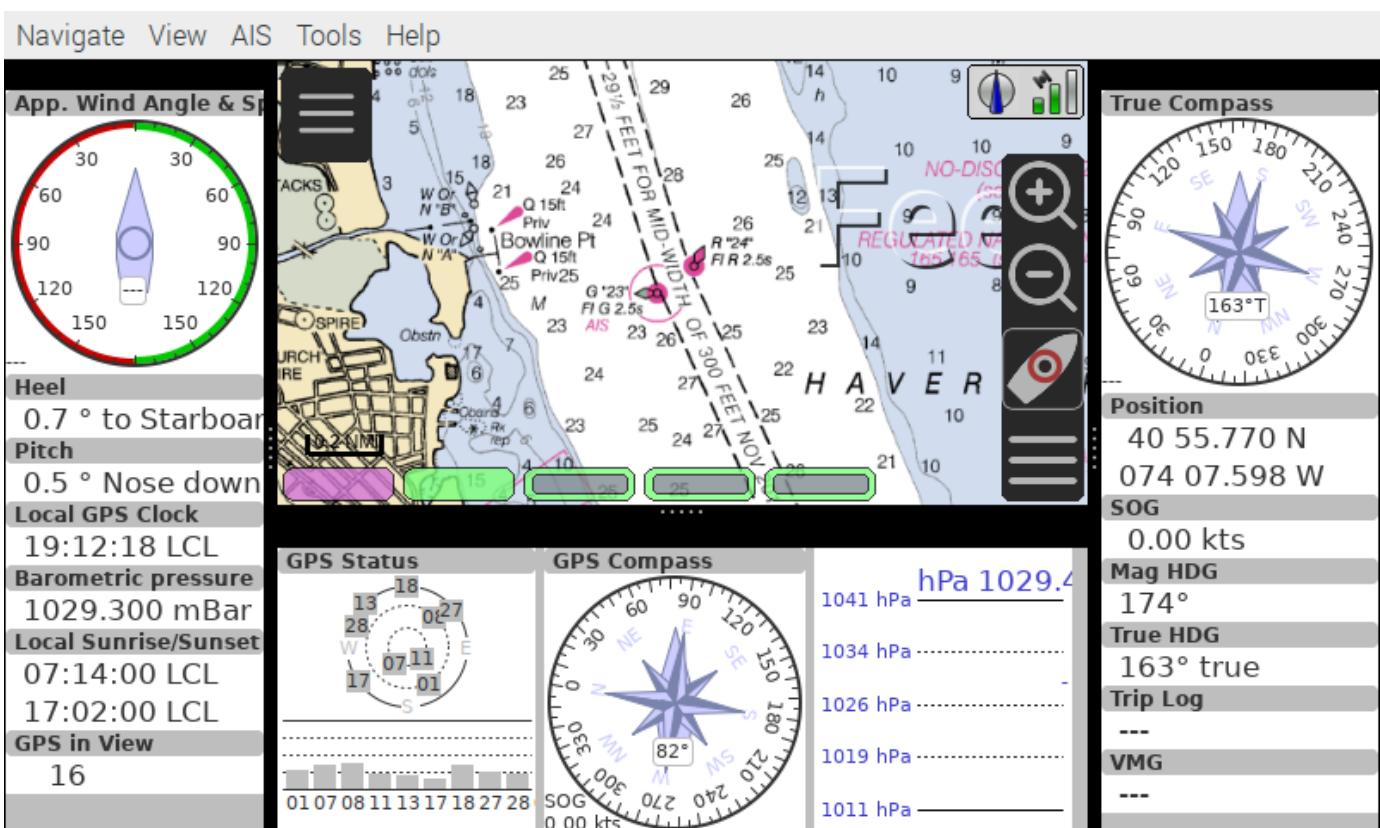


Figure 14. OpenCPN Dashboard

Saving it as a template in OpenCPN was a bit tricky on 7" screen as OpenCPN window is too big to see 'OK' button. I had to press Ctrl-Tab twice followed by Enter, doing it basically blindly.

## Power Usage

- Preliminary tests show that combined power consumption of Raspberry Pi 4 based boat computer and Argonaut M7 gen2 7-inch touch display stays under 10 watts. If I turn off the display then wattage drops to 4-4.5 watts. If I reduce the brightness on the display backlight it drops dramatically as well. So both display and Pi contribute about the same share in power consumption. On average I see their combined draw of 0.75 amps at 12v (about 9 watts). This is with 2 chained USB hubs and long wires (HDMI/USB/power) between a computer and cockpit display and hub, AIS (dAISy), RTL-SDR (plugged in but idling), Flashdrive SSD, FTDI (connected only into USB).
- 10 watts on 80 amp-hours 12v battery (in my understanding they are rated for that before drop below 10v, so it is all usable amps) will give you approximately  $80*12/10=96$  hours of chartplotting at max brightness. C'est la vie. That's why you need solar panels on your sailboat.
- While experimenting with power usage and connecting/disconnecting various USB devices and Argonaut M7 to different USB ports and hubs (USB2, USB3) Argonaut M7 became unresponsive. Even its own power on/off button didn't work. I had to perform a factory reset of it.
- The reset procedure as per manufacturer requires to hold power button on Argonaut M7 display immediately after full power off/on cycle. On my boat it's really a two-man job then. There is no power switch in cockpit because the M7 display has its own and the other switch to power it on is below deck. It seems they didn't think about single handed sailors when they came up with this reset procedure design.
- Turns out if I turn off 12v supply into cockpit it does turn-off the display but it's LED status light still stays on. So it still gets some power via USB (not much per amp meter). Apparently this is the default behavior of most self powered USB hubs to draw from the host when they lose own power supply. There are some hubs which have this behavior configured by a jumper on their PCB, but the default is to power itself from the host.
- I did test fiber-optic USB data cable leading to the cockpit as well. It does have regular wires for power as well, so it behaves exactly the same. The cable is much thinner so you can have a smaller hole in your boat in a cockpit deck.
- Reboot doesn't work. It just shuts down Pi. There are many reports that pi4 doesn't reboot with USB self powered hubs if they are not powered off before the reboot and backfeed power into Pi. So currently the reboot procedures are shutdown and then power cycle the boat computer.
- I've tried installing rpi-backlight but it seems Argonaut M7 monitor doesn't support software backlight control (at least it doesn't work under Linux) So the only way to control backlight is via Argonaut's own control on the side of the monitor.

After long testing and research I've found a solution for UBS hub power issues. There are two. The first one is that the hub in cockpit powers the cockpit via USB hub even if I turn the cockpit 12v switch off. The second one is that Pi doesn't reboot as it stays powered from the hubs. The simplest way to solve it was to tape USB +5v pin inside female part of USB type A plugs with the electrical tape (see pic). There are two places because there are 2 self powered hubs need to be isolated. The procedure is actually makes the whole set up even safer. You do not want extra circuits running from below deck into the cockpit when cockpit switch is 'off'. Power savings when you turn cockpit off are impressive. Pi takes less than 0.2 amps @ 12v with no HDMI video connected (only USB connected sensors and flash drive stick). For the cockpit USB 3.0 hub I got the shortest USB 3.0 type A male to female cable and put tape in it. And for the computer's hub I've just taped it inside USB 3.0 type-A male part connecting the hub. This is how it was done:

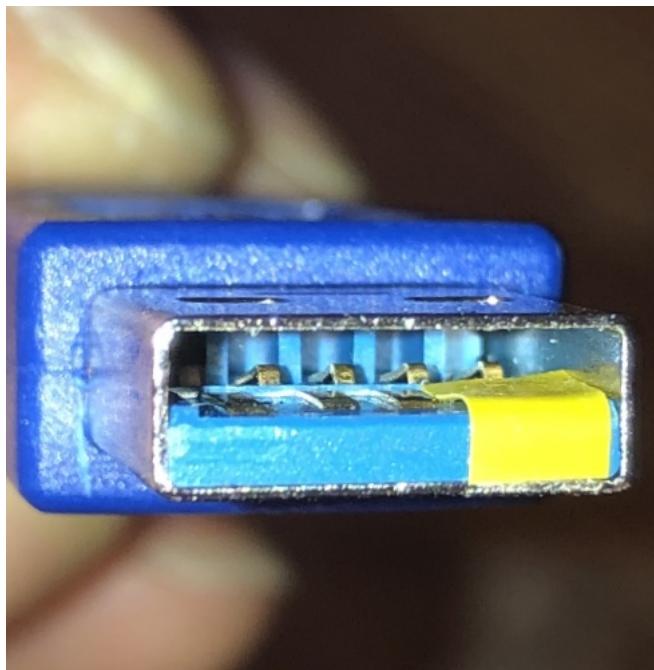


Figure 15. USB 3.0 self-powered hub backfeed and forward-feed power isolation male

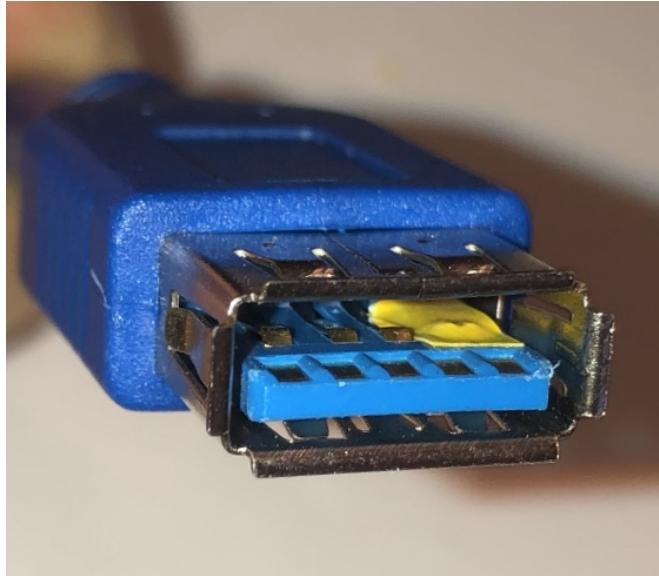


Figure 16. USB 3.0 self-powered hub backfeed and forward-feed power isolation female

Temperature readings stay under 56 C.

```
pi@raspberrypi:~ $ vcgencmd measure_temp  
temp=48.0'C
```

Check your USB set up

```

pi@openplotter:~ $ sudo apt install uhubctl
pi@openplotter:~ $ sudo uhubctl
Current status for hub 2-1.4 [05e3:0612 GenesysLogic USB3.0 Hub, USB 3.00, 4 ports]
  Port 1: 02a0 power 5gbps Rx.Detect
  Port 2: 02a0 power 5gbps Rx.Detect
  Port 3: 02f0 power 5gbps Polling reset
  Port 4: 02a0 power 5gbps Rx.Detect
Current status for hub 2-1 [05e3:0612 GenesysLogic USB3.0 Hub, USB 3.00, 4 ports]
  Port 1: 0203 power 5gbps U0 enable connect [090c:1000 Samsung Flash Drive FIT
0353019060002728]
  Port 2: 02a0 power 5gbps Rx.Detect
  Port 3: 02a0 power 5gbps Rx.Detect
  Port 4: 0263 power 5gbps U3 enable connect [05e3:0612 GenesysLogic USB3.0 Hub, USB
3.00, 4 ports]
Current status for hub 2 [1d6b:0003 Linux 4.19.97-v8+ xhci-hcd xHCI Host Controller
0000:01:00.0, USB 3.00, 4 ports]
  Port 1: 0203 power 5gbps U0 enable connect [05e3:0612 GenesysLogic USB3.0 Hub, USB
3.00, 4 ports]
  Port 2: 02a0 power 5gbps Rx.Detect
  Port 3: 02a0 power 5gbps Rx.Detect
  Port 4: 02a0 power 5gbps Rx.Detect
Current status for hub 1-1.1.4 [05e3:0610 GenesysLogic USB2.0 Hub, USB 2.10, 4 ports]
  Port 1: 0103 power enable connect [0403:6001 FTDI FT232R USB UART AK08UZHY]
  Port 2: 0100 power
  Port 3: 0503 power highspeed enable connect [05e3:0610 GenesysLogic USB2.0 Hub, USB
2.10, 4 ports]
  Port 4: 0103 power enable connect [067b:2303 Prolific Technology Inc. USB-Serial
Controller D]
Current status for hub 1-1.1 [05e3:0610 GenesysLogic USB2.0 Hub, USB 2.10, 4 ports]
  Port 1: 0100 power
  Port 2: 0503 power highspeed enable connect [0bda:2838 Realtek RTL2838UHIDIR 00000001]
  Port 3: 0103 power enable connect [16d0:0b03 Adrian Studer dAISy AIS Receiver
76443A5131002900]
  Port 4: 0503 power highspeed enable connect [05e3:0610 GenesysLogic USB2.0 Hub, USB
2.10, 4 ports]
Current status for hub 1 [1d6b:0002 Linux 4.19.97-v8+ xhci-hcd xHCI Host Controller
0000:01:00.0, USB 2.00, 1 ports]
  Port 1: 0503 power highspeed enable connect [2109:3431 USB2.0 Hub, USB 2.10, 4 ports]

```

Check SSD Drive transfer speed

```

pi@openplotter:~ $ sudo apt install hdparm
pi@openplotter:~ $ sudo hdparm -Tt /dev/sda

/dev/sda:
Timing cached reads: 1948 MB in 2.00 seconds = 974.71 MB/sec
Timing buffered disk reads: 628 MB in 3.00 seconds = 209.28 MB/sec

```

## Assembly Activities

Make sure you use correct tools for:

- Soldering
- Screwing

## 1.2. Cockpit Display and Chartplotter

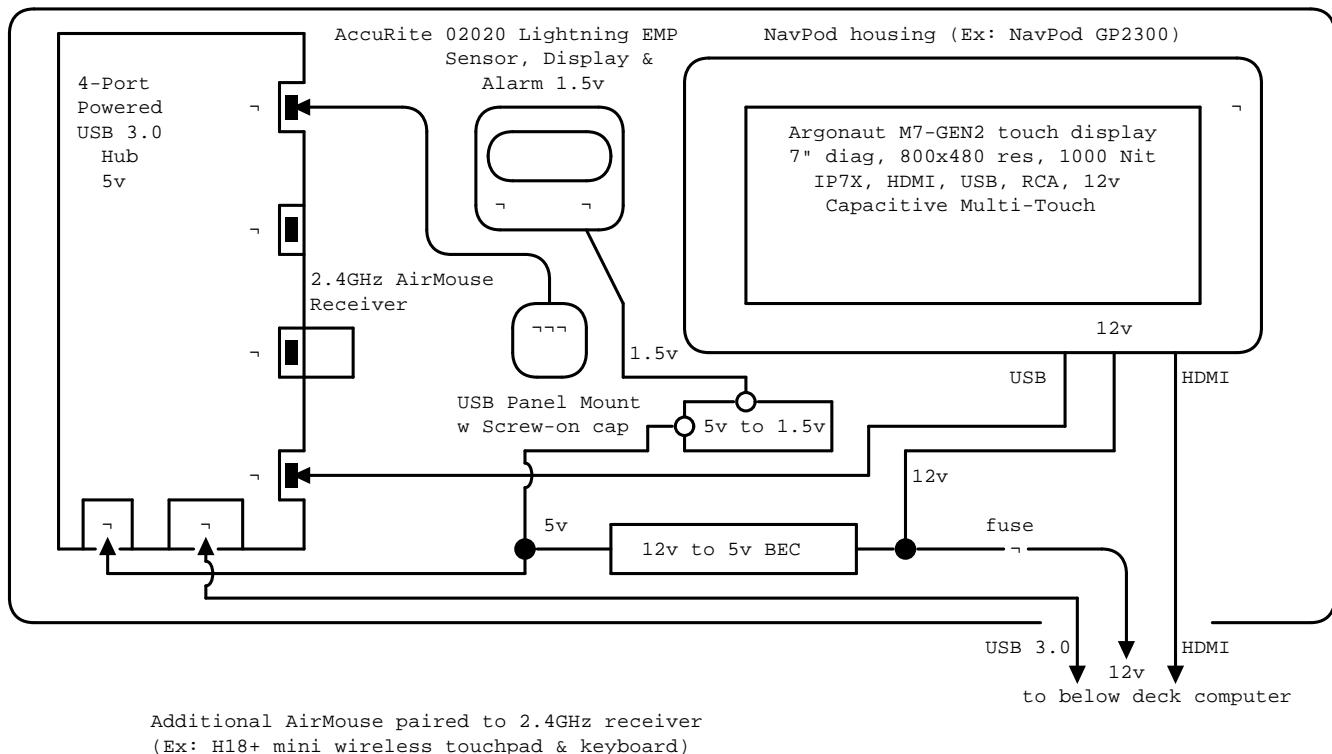


Figure 17. Cockpit Display Diagram

Item	Description	Cost	Source
NavPod	NavPod GP2300	\$225, Shipping: \$9	anchorexpress. com
5V/6V 3A Switch-mode UBEC, Max 5A Lowest RF	<a href="https://www.amazon.com/dp/B008ZNWOYY">https://www.amazon.com/dp/B008ZNWOYY</a>	\$3	Amazon
Waterproof touch screen	Argonaut M7-gen2 + Water Sealed back  <a href="https://www.argonautcomputer.com/products/m7-smart-touch-monitor">https://www.argonautcomputer.com/products/m7-smart-touch-monitor</a>	\$518	argonautcomputer.com
	<p> Here is another (DIY) option:  <a href="http://forum.openmarine.net/showthread.php?tid=1547&amp;page=2">http://forum.openmarine.net/ showthread.php?tid=1547&amp; page=2</a></p>		
DC Wire to cockpit	Marine Wire  <a href="https://www.amazon.com/dp/B01FRK09OY">https://www.amazon.com/dp/B01FRK09OY</a>	\$25.50	Amazon
Female to Female HDMI adapter	<ul style="list-style-type: none"> <li>• Compatible with HDMI standard (4K video at 60 Hz, 2160p, 48-bit/px color depth)</li> <li>• Supports bandwidth up to 18Gbps</li> <li>• backwards compatible with earlier versions</li> </ul> <a href="https://www.amazon.com/dp/B07K6HKD8S">https://www.amazon.com/dp/B07K6HKD8S</a>	\$4.75	Amazon
Standard Horizon MMB-97 Flush Mount Kit for Explorer GX1600/GX1700	<a href="https://www.amazon.com/dp/B004NZOV8A">https://www.amazon.com/dp/B004NZOV8A</a>	\$16.50	Amazon
USBGear 4-Port USB 3.0 Mountable Charging and 5Gbps Data Hub	<ul style="list-style-type: none"> <li>• Supports Super-Speed USB 3.0 over each port with transfer rates up to 5Gbps.</li> <li>• Power Adapter: 5V 2A output, 100-240V, 50/60Hz 0.40A</li> </ul> <a href="https://www.amazon.com/dp/B012DZ4NJ8">https://www.amazon.com/dp/B012DZ4NJ8</a>	\$29	Amazon

Item	Description	Cost	Source
USB 3.0 Extension Cable 20ft, Hftywy USB Type A Male to Female Extension Cord 5Gbps Data Transfer, Red	<p><a href="https://www.amazon.com/dp/B07XF3GM1W">https://www.amazon.com/dp/B07XF3GM1W</a></p>  <p>Consider also fiber optic USB 3.0 active extension cables</p>	\$13	Amazon
Long HDMI Cable	<p>Postta HDMI Cable(25 Feet) Ultra HDMI 2.0V Cable with 2 Piece Cable Ties+2 Piece HDMI Adapters Support 4K 2160P,1080P,3D,Audio Return and Ethernet, Blue</p> <p><a href="https://www.amazon.com/dp/B075YPT2F1">https://www.amazon.com/dp/B075YPT2F1</a></p>  <p>Consider also fiber optic HDMI cables</p>	\$14	Amazon
Air Mouse and wireless keyboard and touchpad	<p>H18+ 2.4Ghz Mini Wireless Keyboard Touchpad Combo with 3 Level Backlit Rechargeable Full Screen Mouse Remote Control for Android TV Box, Projector, IPTV, HTPC, PC, Laptop</p> <p><a href="https://www.amazon.com/dp/B0776T8QDC">https://www.amazon.com/dp/B0776T8QDC</a></p>	\$20	Amazon
AcuRite 02020 Portable Lightning Detector (Optional)	<ul style="list-style-type: none"> <li>• Detects lightning bolts and storms within 25 miles</li> <li>• Warning light, audible alarm and text alerts</li> </ul> <p><a href="https://www.amazon.com/dp/B00EO1H3X8">https://www.amazon.com/dp/B00EO1H3X8</a></p>	\$30	Amazon
12v to 1.5v DC Converter (Optional - For AcuRite Lightning Detector)	<p>AMS1117 1.5V (4.75-12V) output 1.5V Step Down Power Supply Module AMS1117-1.5V</p> <p><a href="https://a.aliexpress.com/_sXL1Bu">https://a.aliexpress.com/_sXL1Bu</a></p>	\$1	AliExpress
In-Line Marine Fuse Holder	In-Line Marine Fuse Holder 6x30 mm	\$7	Amazon
SSD Flash Drive	<p>Samsung Fit Plus USB 3.1 Flash Drive 128GB</p> <p><a href="https://www.amazon.com/dp/B07D7PDLXC">https://www.amazon.com/dp/B07D7PDLXC</a></p>	\$30	Amazon

Item	Description	Cost	Source
Wireless Phone Charger and Holder (Optional: I think I can DIY much cheaper)	ScanStrut ROKK Wireless - Active (SC-CW-04E) 12v / 24v Waterproof Wireless Phone Charging Mount <a href="https://scanstrut.com/products/waterproof-wireless-charge/rokk-sc-wc-04-detail">https://scanstrut.com/products/waterproof-wireless-charge/rokk-sc-wc-04-detail</a>	\$97.60	hodgesmarine.com

## 1.3. Boat Gateway Box

The second box is a boat LTE/WiFi/IoT gateway device and it is an extension to the boat computer. In case if you do not need HDMI display you might need only the boat gateway because the boat gateway runs its own Kplex server under OpenWrt Linux. The boat gateway has M5Stack ESP32 micro-controller and is capable to connect to NMEA (if you customize it a bit further). The boat gateway is connected to the boat computer via Ethernet. The boat gateway uses the same type of an enclosure as the boat computer.

Features of the boat gateway box:

- WiFi Gateway (connecting to marina's WiFi and on-shore WiFi hot-spots via a long range WiFi antenna)
- LTE / 4G Gateway (providing a boat with Internet and voice access within the zone of reception of a cellular network)
- VPN gateway
- Ethernet Hub
- Network Access Storage, Network back-up
- M5Stack ESP32 Controller and 3-Buttons LCD display (panel mounted, numerous optional M2Stack add-ons)
- Kplex server running on router's OpenWrt Linux
- GPS NMEA 0183 talker via Kplex
- IoT gateway with MQTT
- Voltage and Amperage Display to monitor power consumption
- Any other additional sensors and devices can be added via M5Stack. M5Stack is programmable micro-controller without an operating system but very capable of running complex programs

### 1.3.1. Boat Gateway Front Panel

- Power On/Off Switch

- Router Power On/Off Switch
- Panel Mounted Fuse Box
- Panel Mounted M5Stack LCD Display with 3 Buttons
- USB 2.0 Port connected to M5Stack
- Amp and Volt Meter



Figure 18. Boat Router Front Panel View

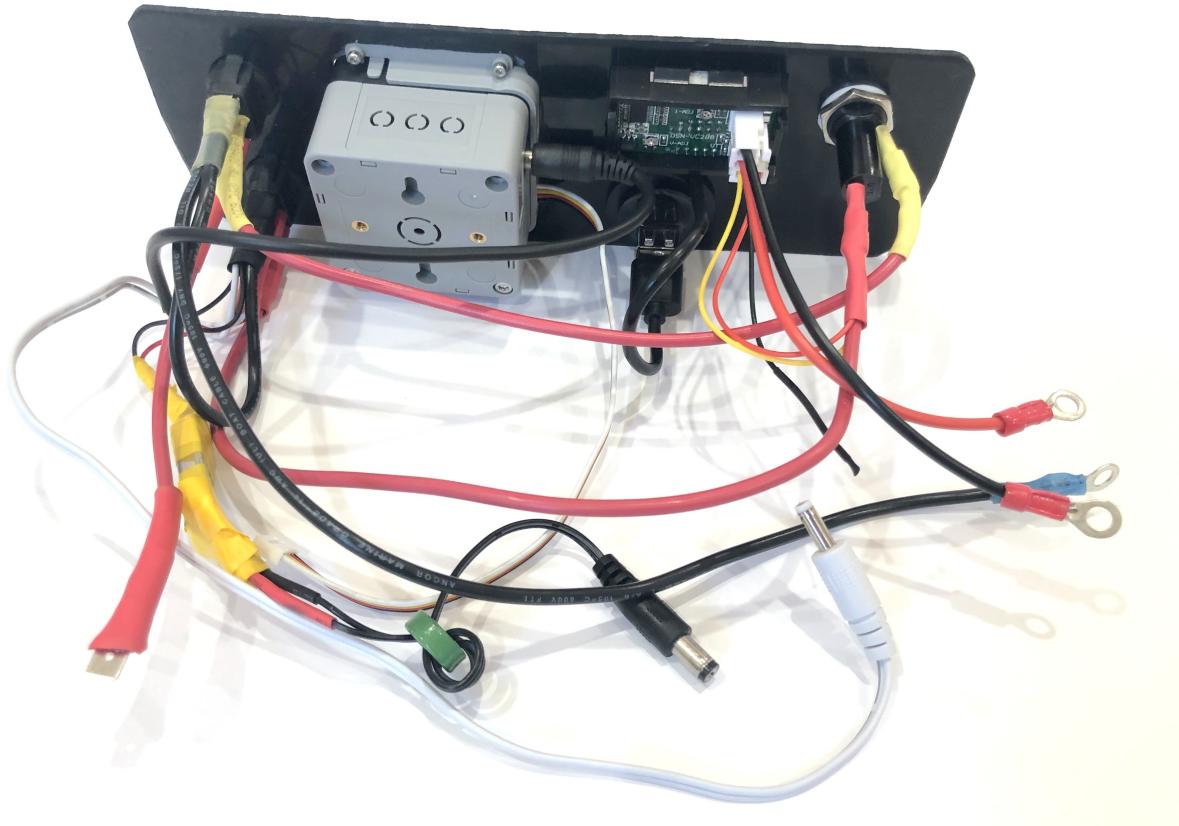


Figure 19. Boat Router Front Panel Wiring

### 1.3.2. Boat Gateway Back Panel

- SAE power (red/black, red male) 12V connector with waterproof gland to boat 12v
- Two SMA coax connectors to external cellular LTE antennas
- SMA RP coax connector for external long range WiFi antenna
- SMA coax connector to external active GPS antenna
- Three Ethernet Ports with water tight caps for LAN
- Ethernet port with water tight cap for WAN



Figure 20. Boat Router Back Panel View



Figure 21. Boat Router Back Panel Wiring

### 1.3.3. Inside Boat Gateway

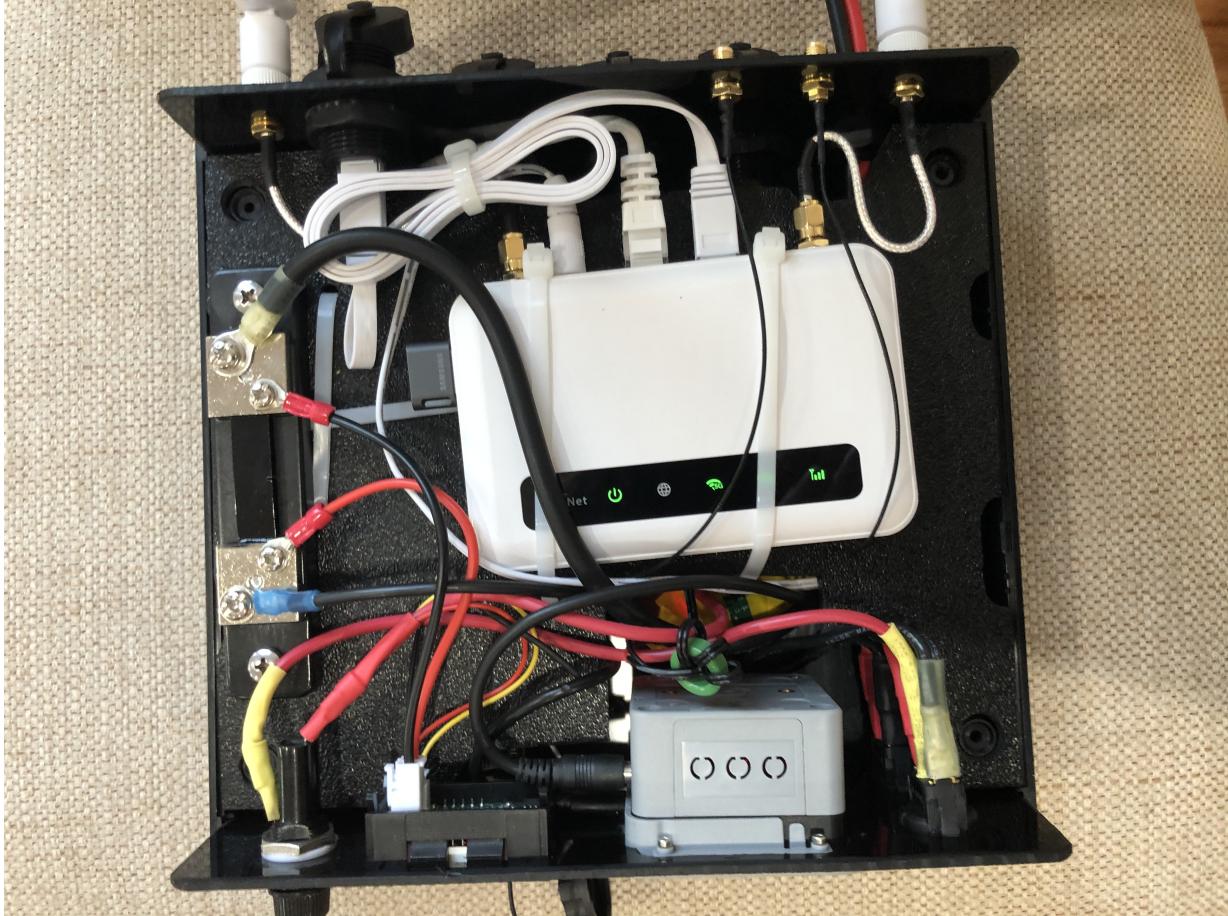


Figure 22. Boat Router Inside

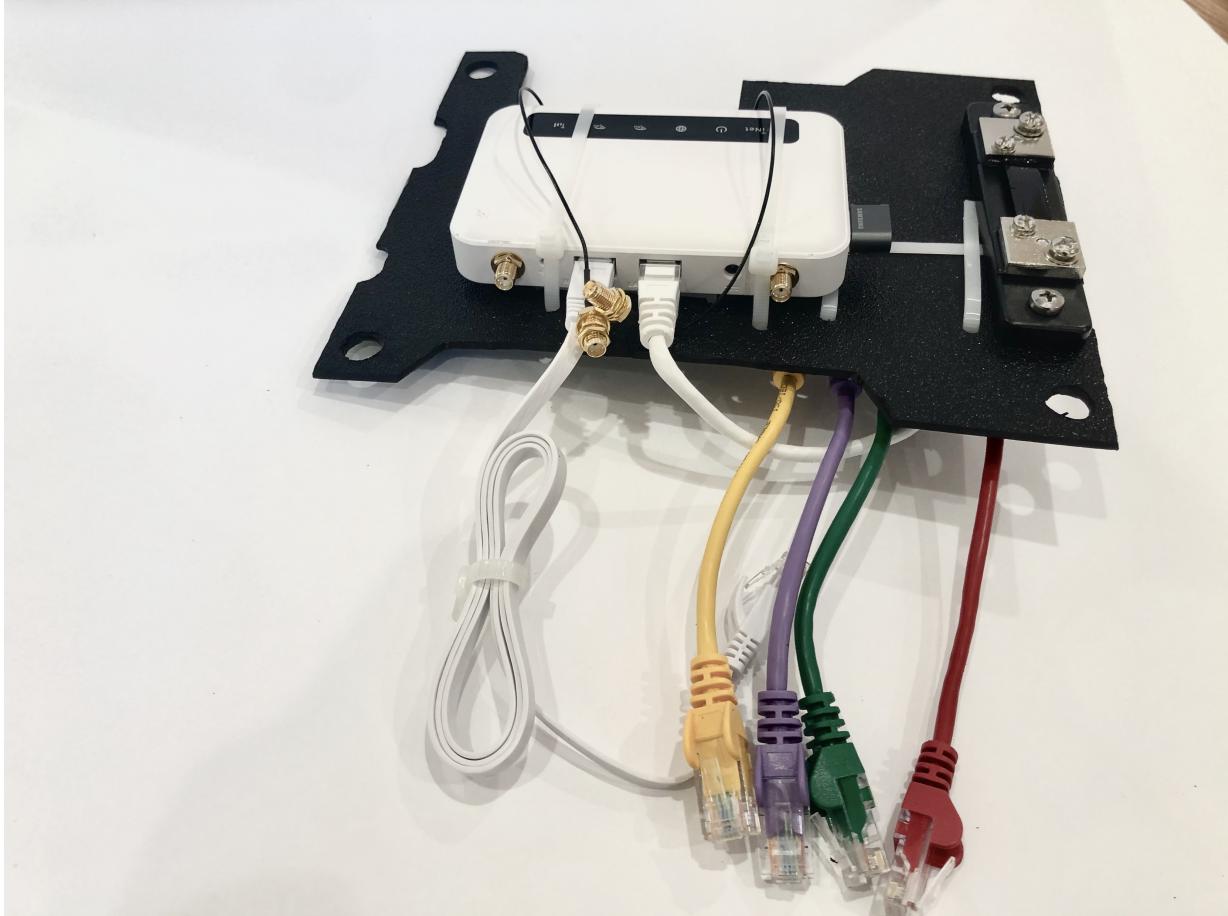
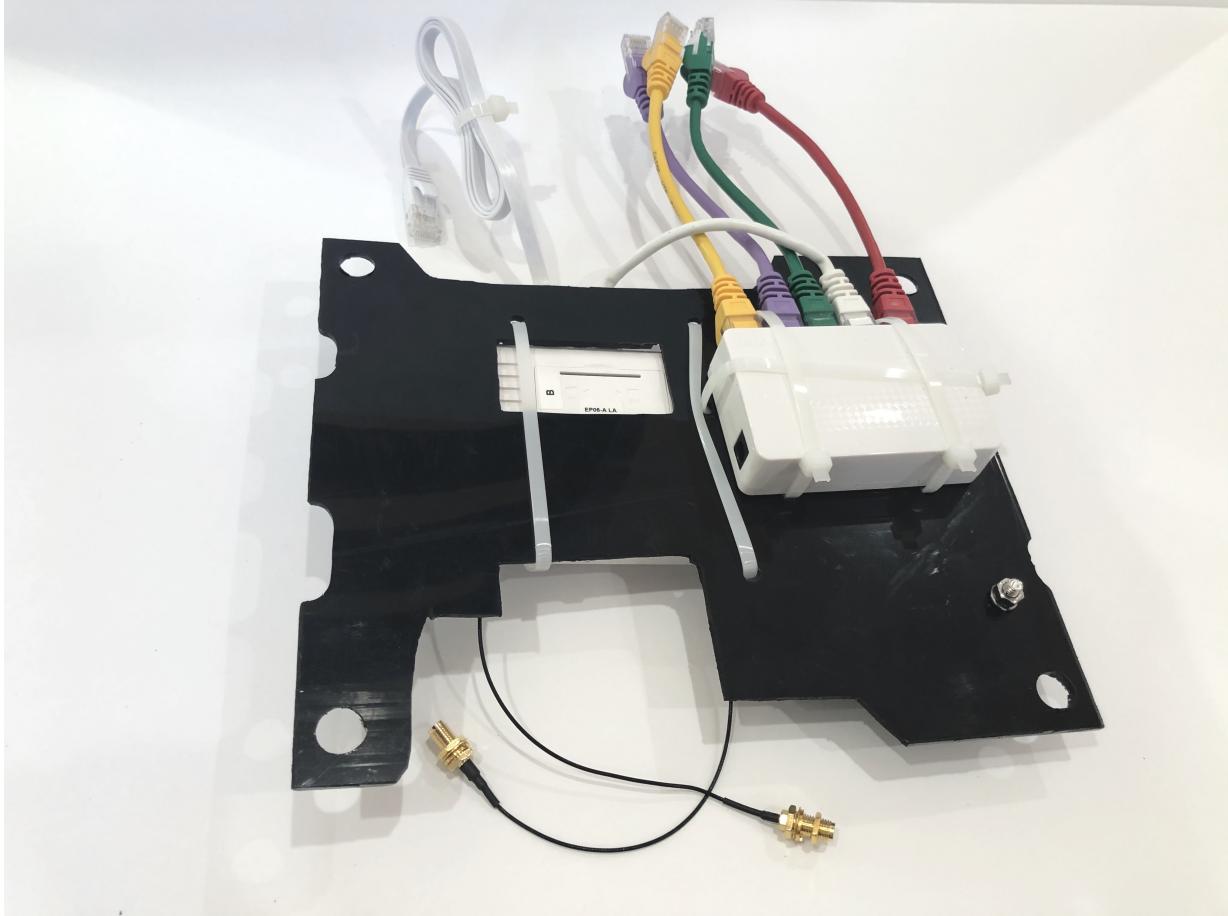


Figure 23. Boat Router Inside Top



*Figure 24. Boat Router Inside Bottom*

I've made an opening for easier access to SIM card and SD card slots. A better idea probably would be to have SD and SIM card extension cords and panel mounted slots.

Item	Description	Cost	Source
GL-X750 LTE 4G/3G and Wifi Router (It's the best choice, GL-AR750 is not needed if you pick this)	<p>GL.iNet Spitz (GL-X750) 4G Router &amp; 4G Modem (with Sim card slot) for your area and cellular provider</p> <ul style="list-style-type: none"> <li>Transfer 4G LTE signal to Wi-Fi, 5G (433Mbps), 2.4G(300Mbps) Wi-Fi, 4G (EC25, EP06) PCIe modules</li> <li>Powered by Atheros AR9531, @650Mhz</li> <li>2 x 4G LTE external antennas, 2dBi 5G &amp; 2.4G internal antennas</li> <li>Interface: 1WAN, 1LAN, 1USB2.0, 1 MicroSIM slot, 1 MicroSD slot</li> <li>OPEN SOURCE &amp; PROGRAMMABLE: OpenWrt/LEDE, OpenVPN pre-installed</li> <li>12v input power</li> </ul> <p><a href="https://www.gl-inet.com/products/gl-x750/">https://www.gl-inet.com/products/gl-x750/</a></p>	\$119 + Modem: \$20 + (Optional not really needed bluetooth module and wall mount: \$16)	gl-inet.com
WiFi Router (not needed if you go with GL-X750 option)	<p>GL.iNet GL-AR750 Travel AC Router, 300Mbps(2.4G)+433Mbps(5G) Wi-Fi, 128MB RAM, MicroSD Storage Support, OpenWrt/LEDE</p> <ul style="list-style-type: none"> <li>OpenWrt/LEDE (open source)</li> <li>OpenVPN client pre-installed</li> <li>128MB RAM, up to 128GB MicroSD slot, USB 2.0 port, three Ethernet ports, and optional PoE module</li> </ul> <p><a href="https://www.amazon.com/dp/B07712LKJM">https://www.amazon.com/dp/B07712LKJM</a></p>	\$45	Amazon
WiFi RF Connector Cable ( <b>RP</b> )	<p>U.FL Mini PCI to <b>Reverse Polarity</b> SMA Pigtail Antenna WiFi Cable Pack of 2</p> <ul style="list-style-type: none"> <li>Reverse Polarity SMA Female ( <b>Pin in center</b> ) to IPX ufl Female Coaxial Connector</li> </ul> <p><a href="https://www.amazon.com/dp/B005UWD0EG">https://www.amazon.com/dp/B005UWD0EG</a></p>	\$5.30	Amazon

Item	Description	Cost	Source
GPS RF Connectors	Pack of 4 RF U.FL(IPEX/IPX) Mini PCI to SMA Female Pigtail Antenna Wi-Fi Coaxial RG-178 Low Loss Cable (7 inches (17.8 cm))  <a href="https://www.amazon.com/dp/B06Y6CB2SX">https://www.amazon.com/dp/B06Y6CB2SX</a>	\$14.30	Amazon
LTE RF Connectors	SMA Extension Cable Pigtail Male to Female WiFi Antenna Cable RF RG316 Coaxial Coax Jumper FPV SMA Antenna Wire (4 inch (4 Pcs))  <a href="https://www.amazon.com/dp/B0813RPPTX">https://www.amazon.com/dp/B0813RPPTX</a>	\$12	Amazon
Ethernet Switch	Tenda S105 V2.0 Slim 5-Port Fast Ethernet Switch  <a href="https://www.microcenter.com/product/486440/tenda-s105-v20-slim-5-port-fast-ethernet-switch">https://www.microcenter.com/product/486440/tenda-s105-v20-slim-5-port-fast-ethernet-switch</a>	\$9	Microcenter
Ethernet short patch cables 5-pack	Ethernet short patch cables 5-pack  QVS CAT 5e Snagless Network Cable 6 in. 5 Pack – Multi-Colored	\$12.50	Microcenter
4 Panel Mount RJ45 Sockets	RJ45 Extension Female Cable Connector CAT5/6 Network Cable Socket Connector IP67 Waterproof  <a href="https://a.aliexpress.com/_sfaqAI">https://a.aliexpress.com/_sfaqAI</a>	\$13.80	AliExpress
USB 2.0 Panel Mount	IP67 USB 2.0 4pin female to Female Waterproof data Connector plug socket Adapter IP 67 Water Proof Connectors  <a href="https://a.aliexpress.com/_sC6Vb8">https://a.aliexpress.com/_sC6Vb8</a>	\$9	AliExpress
5V/6V 3A Switch-mode UBEC, Max 5A Lowest RF	<a href="https://www.amazon.com/dp/B008ZNWOYY">https://www.amazon.com/dp/B008ZNWOYY</a>	\$3	Amazon
Micro Sim Adapter	Sim Card Adapter Kit Includes Nano Sim Adapter / Micro Sim Adapter / Needle / Storage Sheet( Sim Card Holder )  <a href="https://www.amazon.com/dp/B00HSOUQXM">https://www.amazon.com/dp/B00HSOUQXM</a>	\$4.30	Amazon

Item	Description	Cost	Source
WiFi Antenna Cable	<p>Low Loss RG58 WiFi Cable N Male to RP SMA Male Connector Hole in Center Pigtail SMA Cable 10M for 3G/4G/LTE/Ham/GPS/RF Radio to Antenna or Surge Arrester Use</p> <ul style="list-style-type: none"> <li>• Connector Gender N male , RP SMA Male</li> <li>• Model Number Lii-03695</li> <li>• Cable Length 32.8 feet</li> </ul> <p><a href="https://www.amazon.com/dp/B075MBXBY2">https://www.amazon.com/dp/B075MBXBY2</a></p>	\$16	Amazon
Long Range WiFi Antenna	<p>Lysignal Outdoor Omni Directional Antenna Fiberglass 2.4GHz 8dBi N Female Connector for Cell Phone Signal Booster, WiFi Router</p> <ul style="list-style-type: none"> <li>• Complies with all 802.11n/b/g (2.4GHz) products</li> <li>• High power, high gain outdoor wifi antenna. Extend coverage of a wireless network in all directions</li> <li>• Waterproof, striking resistant, anti-corrosion</li> <li>• RP (reverse polarity) SMA connector</li> </ul> <p><a href="https://www.amazon.com/dp/B07PG8RPSL">https://www.amazon.com/dp/B07PG8RPSL</a></p> <p> This has RP SMA connector, so corresponding panel mount part will need to be RP SMA.</p>	\$36	Amazon
IPEX U.FL Solder Sockets	<p>10pcs IPEX U.FL SMD SMT Solder for PCB Mount Socket Jack Female RF Coaxial Connector</p> <p><a href="https://www.amazon.com/dp/B07V3BV15W">https://www.amazon.com/dp/B07V3BV15W</a></p>	\$7	Amazon

Item	Description	Cost	Source
LTE/4G/3G Antenna	<p>700~2600mhz 88dbi 3g 4g Lte Antenna Mobile Antenna 2 * SMA Male Connectors Booster Mimo Panel Antenna, 5 Meters</p> <ul style="list-style-type: none"> <li>• Indoor</li> <li>• Wall mount</li> </ul> <p><a href="https://a.aliexpress.com/2iIG1Kc0">https://a.aliexpress.com/2iIG1Kc0</a></p>	\$15.10	AliExpress
M5Stack Core	<p>ESP32 Basic Core IoT Development Kit</p> <ul style="list-style-type: none"> <li>• ESP32 micro controller</li> <li>• Integrated 802.11b/g/n HT40 Wi-Fi transceiver, baseband, stack and LWIP</li> <li>• Bluetooth, BLE</li> <li>• 4 MByte flash + 520K RAM</li> <li>• Speaker, 3 Buttons, LCD(320*240), 1 Reset</li> <li>• 10x capacitive touch interface</li> </ul> <p><a href="https://m5stack.com/collections/m5-core/products/basic-core-iot-development-kit">https://m5stack.com/collections/m5-core/products/basic-core-iot-development-kit</a></p>	\$28	m5stack.com

Item	Description	Cost	Source
M5Stack LAN Module Base	<p>LAN is a M5 Base that having a W5500 chip, which is a Hardwired TCP/IP embedded Ethernet controller that provides easier Internet connection to embedded systems. This Base is specifically designed for industrial application scenarios, comes with couple of HT3.96 connectors</p> <ul style="list-style-type: none"> <li>• Input Supply Voltage: 9-24V</li> <li>• HT3.96 port for supporting RS485</li> <li>• TTL-to-RS485 adapter board</li> </ul> <p><a href="https://m5stack.com/products/lan-module">https://m5stack.com/products/lan-module</a></p> <p><a href="https://m5stack.com/collections/m5-base/products/lan-module">https://m5stack.com/collections/m5-base/products/lan-module</a></p> <p> You can use Base26 module instead <a href="https://m5stack.com/collections/m5-base/products/base-26proto-industrial-board-module">https://m5stack.com/collections/m5-base/products/base-26proto-industrial-board-module</a> you will have only WiFi connectivity</p>	\$14	m5stack.com
M5Stack Panel Mount Accessory	<p>FRAME Panel Extended Install Components (2 Sets)</p> <p><a href="https://m5stack.com/collections/m5-accessory/products/frame-panel-extended-install-components">https://m5stack.com/collections/m5-accessory/products/frame-panel-extended-install-components</a></p>	\$3.40	m5stack.com



Figure 25. M5Stack ESP32 Controller Board

"M5Stack" stands for "Modular 5cm Stackable".

Looks like waterproof version is already in works.

See: <https://twitter.com/m5stack/status/1164091308895457280?lang=en>



Figure 26. M5Stack LCD and Communication Module

### GL-AR750 Router Modifications

The AR-750 router needs to be modified to add external 2.4GHz antenna. Test U.FL connectors need to be removed and real ones should be soldered. The existing U.FL connector is used by internal 5G band antenna. See here:

<https://www.arednmesh.org/comment/12706#comment-12706>

### GL-X750 (Spitz) Router Modifications

You get this router with the modem you selected for your region. My modem is Quectel EP06-A. EP06-A has 3 antenna connectors. One is connected to external LTE antenna connector, another one is Rx Diversity antenna to external connector and middle one is GPS antenna not connected. You can open up router by unscrewing two screws under serial number sticker (it's easy to remove and put back after). I've just put another coax cable to GPS antenna connector and cut a bit of plastic in the case just enough to put that cable through (SMA side on outside).

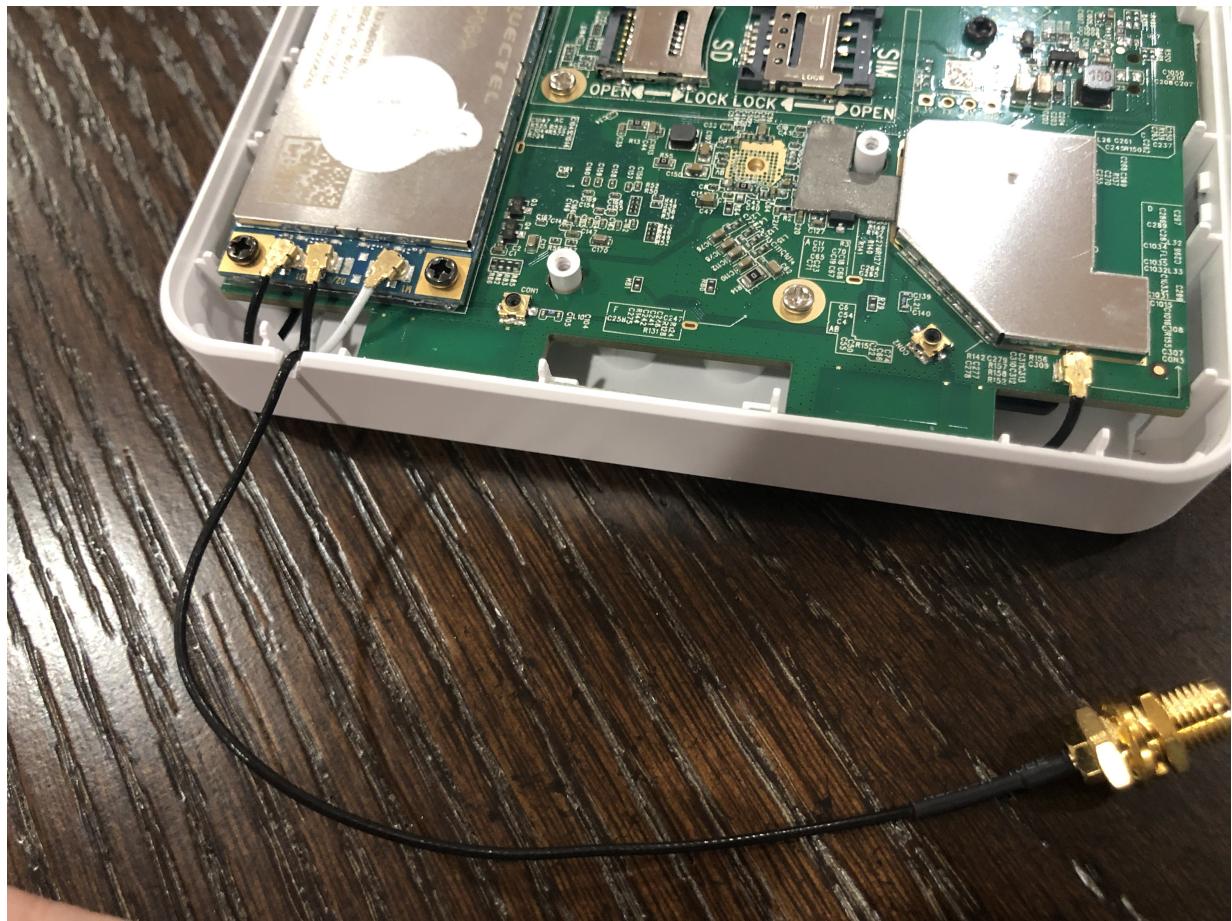


Figure 27. GL-X750 Antenna Mod



Figure 28. GL-X750 Case Mod

The modem is controlled via 'AT' commands.

Make sure you connect antennas first before activating SIM card in the network or you might get error like:

SIM card not registered

APN for AT&T has to be set to "broadband". Device: /dev/ttyUSB2 Service: LTE/UMTS/GPRS

To enable the GPS you have to use

AT+QGPS=1

command on /dev/ttyUSB2 and then one can read the nmea sentences on /dev/ttyUSB1. There are additional commands to configure the GNSS functions, but they're very limited compared to "regular GNSS chips". The details can be found in the Quectel EP06&EG06&EM06 GNSS AT Commands Manual. (Registration required to download)

The command to reset the modem to factory defaults is

```
AT+QPRTPARA=3
```

The router is running linux. While setting it up you can login into it like this:

```
ssh root@192.168.8.1
```

The password would be the one you set in web UI.

Hmm: There is even Kplex for OpenWrt. I think this GPS can be fed into OpenPlotter from the router!

<https://github.com/caesar/kplex-openwrt>

And you can install Kplex on a router (precompiled) from the router itself!

The screenshot shows the GL-X750 OpenWrt web interface. At the top, there's a navigation bar with links for Status, System, Network, and Logout. Below that is a header titled "Software". Under the "Software" header, there are two tabs: "Actions" and "Configuration", with "Configuration" being the active tab. A message "Displaying only packages containing \"kplex\" " is shown above a "Reset" button. A progress bar indicates "Free space: 78% (3.06 MB)" with a red segment on the left and a green segment on the right. Below the progress bar, there's a "Download and install package:" input field with an "OK" button next to it. A "Filter:" input field contains the text "kplex" and has a "Find package" button next to it. At the bottom, there's a "Status" section with tabs for "Available packages (kplex)" and "Installed packages (kplex)", with "Installed packages (kplex)" being the active tab. This section lists a single package: "kplex" version 1.3.4-1, size 28499. The description for "kplex" states: "Kplex is a program for combining and routing NMEA-0183 data to and from multiple sources and destinations. kplex inputs and outputs may be any of Serial lines, Pseudo Terminals (ptys), Network Interfaces and Files." To the right of this description is a blue "Install" button. At the very bottom of the page, there's a footer note: "Powered by LuCI openwrt-18.06 branch (git-18.196.56128-9112198) / OpenWrt 18.06.1 r7258-5eb055306f".

Figure 29. Kplex on OpenWrt Router

AT command for the GPS needs to be run every time on boot. This needs to be scripted. Install the

program called 'socat'. With it you can send commands to the modem from command line.

```
echo "AT+QGPS=1" | socat - /dev/ttyUSB2,crnl
```

```
vi /etc/kpex.conf
```

Put these lines

```
[serial]
name=gps
filename=/dev/ttyUSB1
direction=in
baud=9600
strict=no

[tcp]
name=router
mode=server
port=10110
direction=out
```

Add startup script

```
cat > /etc/init.d/modem-gps-init
#!/bin/sh  /etc/rc.common

START=98

start()
{
    echo "AT+QGPS=1" | socat - /dev/ttyUSB2,crnl
}

^D

chmod 755 /etc/init.d/modem-gps-init
```

Another modification: By default in GL-X750 one Ethernet port is set up as WAN and another is LAN. You can reassign them both as LAN. It is done in web UI of the router. One LAN port will go to main boat computer and another lan port you can connect to M5Stack LAN base module. Or even have a ethernet hub inside if you plan bigger boat LAN (in that case you can leave one port as WAN and connect the router via hub).

GL-X750 aka Spitz router power supply is 12v (No need for buying step-down converter).



If you just need chart plotter capabilities it seems you do not even need raspberry pi. You could just install KPlex on GL-X750 router make sure the modem you picked when you buy the router has GPS. And then you use OpenCPN installed on an android tablet connected via WiFi to KPlex. And with this you have LTE internet on your boat and local private WiFi.



FlashDrive Stick inserted into the router USB port is automatically shared on network via samba. You should mount it using this command from Raspberry Pi:

```
sudo mount -t cifs //gl-x750/SamsungUSB /media/Share -o user=guest,vers=1.0
```

## Local WiFi, VNC, etc

Raspberry Pi4 supports only one band in access point (AP) mode. So it is either 2.4GHz or 5GHz but not both. I've set it up to be on 5G for faster speed. For IoT devices I've enabled 2G band on the router.

On the screen shots below their SSIDs are "boatWiFi-5g" and "boatWiFi-IoT".

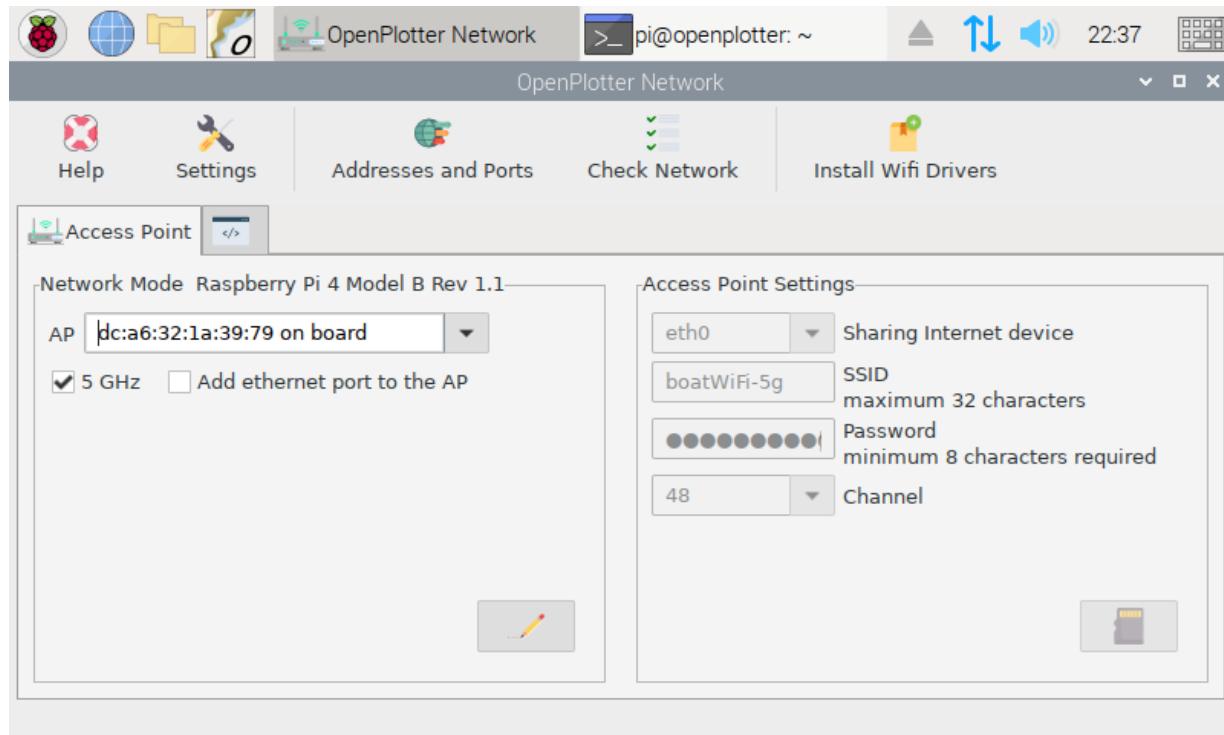


Figure 30. Boat Network Settings

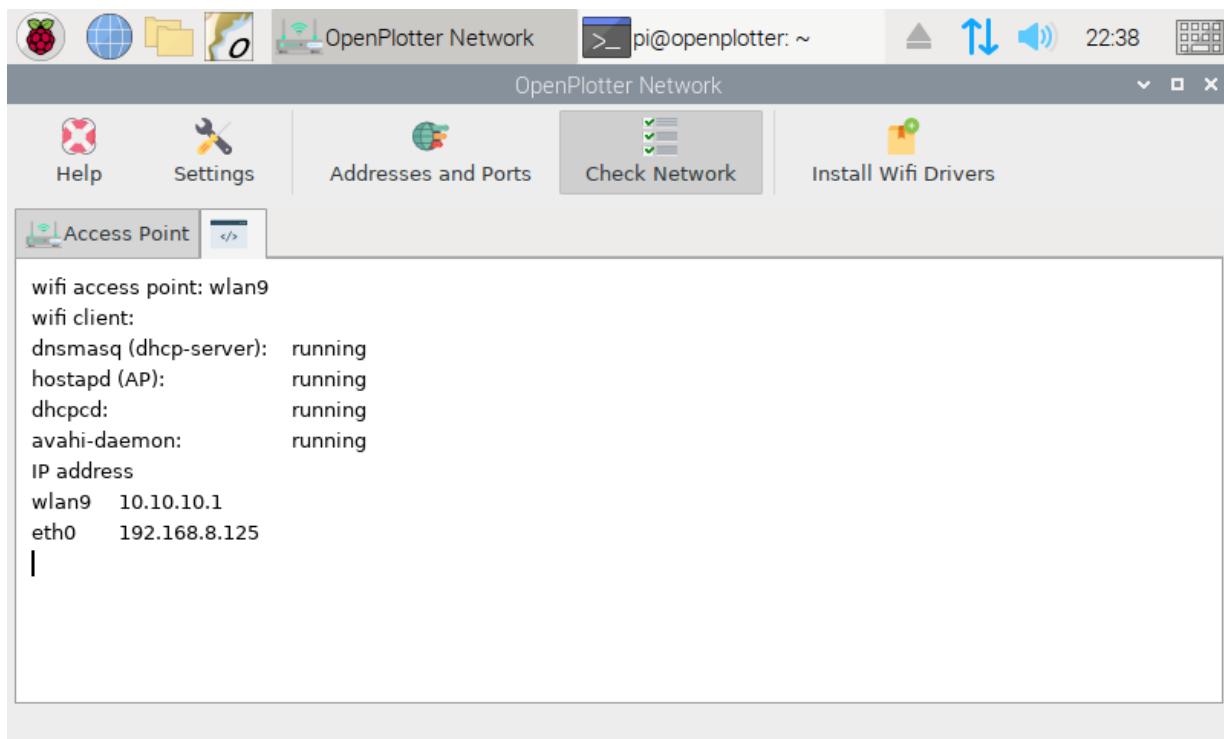


Figure 31. Boat Access Point Status

## VNC

<https://www.realvnc.com/raspberrypi/>

## WiFi Gateway

<https://www.gl-inet.com/products/gl-ar750/>

In web UI of your OpenWrt router:

1. Click internet.
2. Add repeater.
3. Connect to marina WiFi

The UI should look like this when you set up LTE and port WiFi connections:

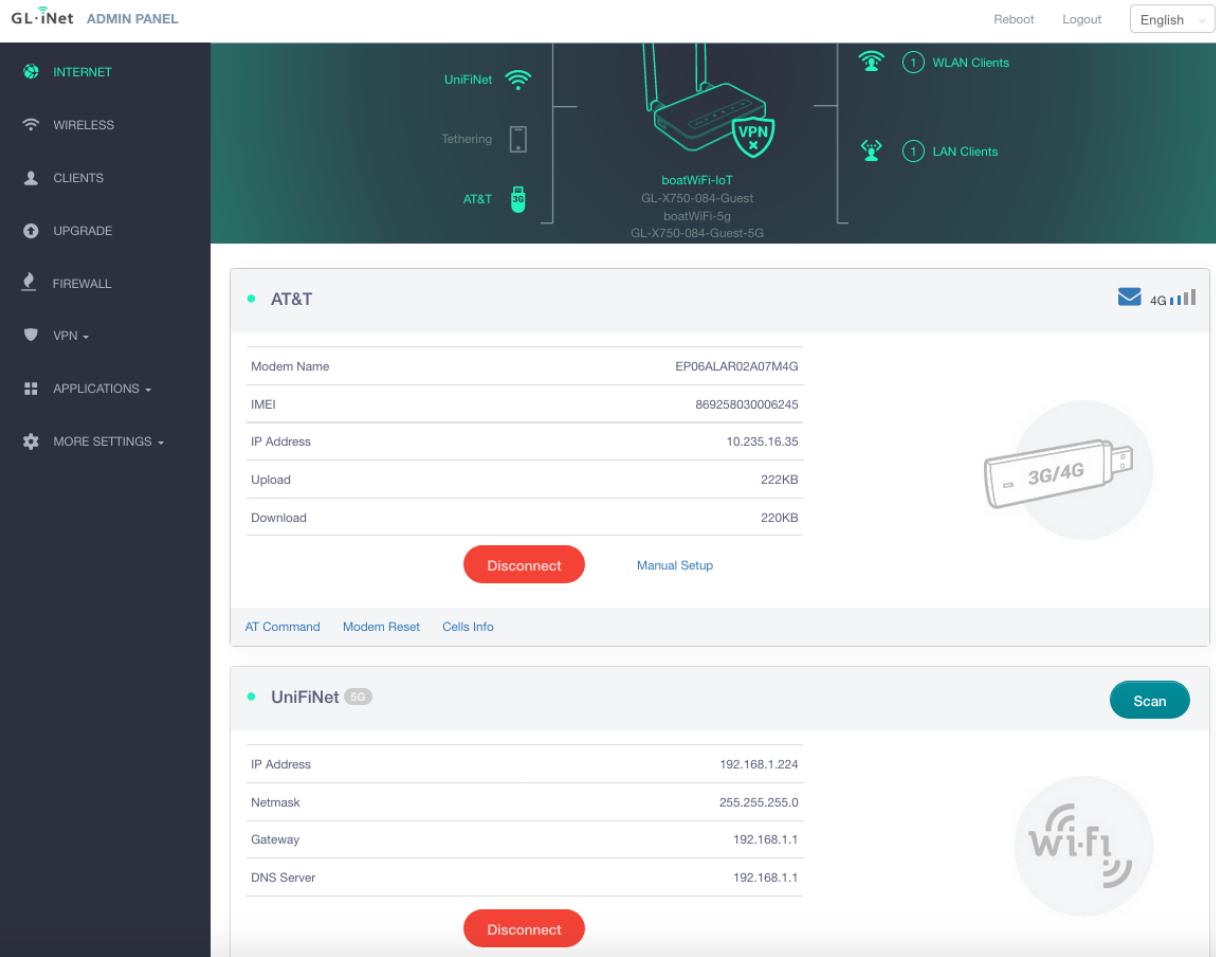


Figure 32. OpenWrt WAN Settings

On the screenshot above UniFiNet would be marina's WiFi SSID.

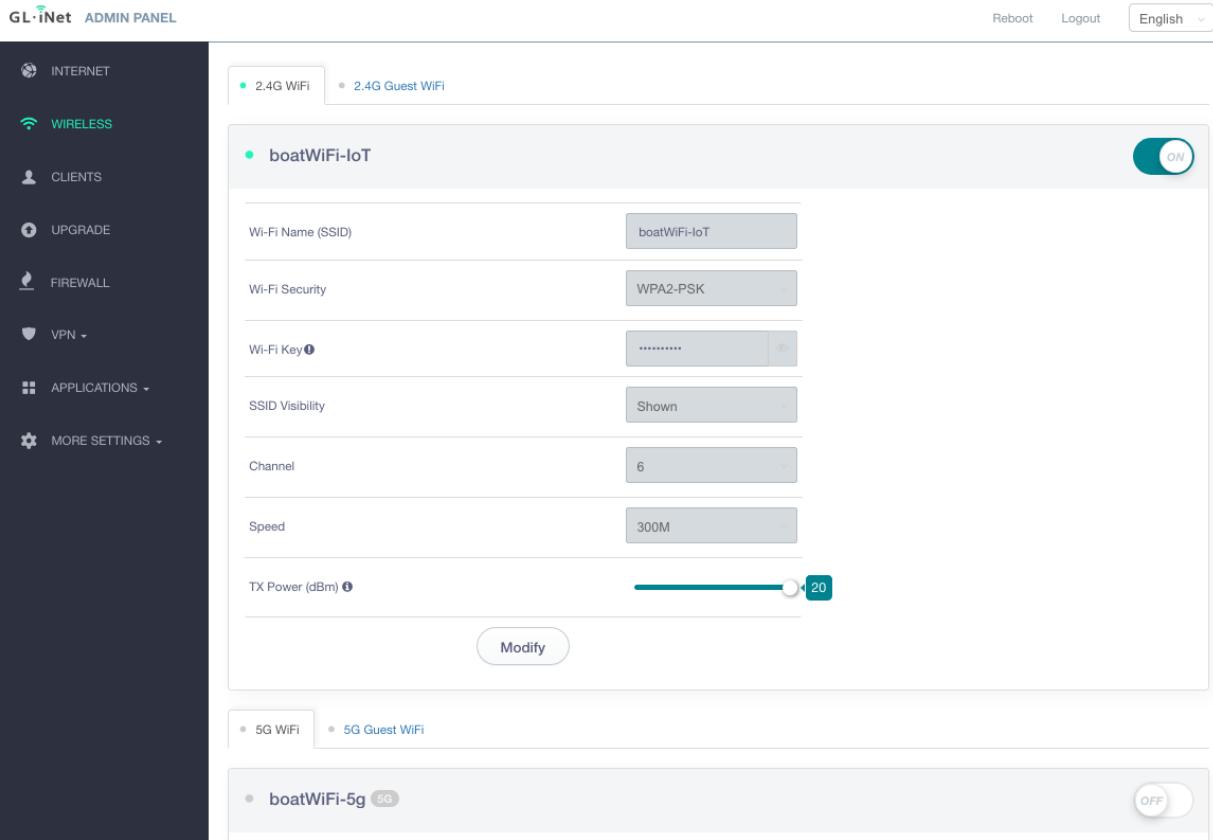


Figure 33. OpenWrt Local WiFi Settings

## OpenVPN

<https://openvpn.net/>

## OpenWrt

<https://openwrt.org/>

## LongFi Helium

<https://www.helium.com/>

## Boat IoT, MQTT, M5Stack

M5Stack is programmed using Arduino IDE. I've set it up on iMac following these instructions:

<https://docs.makerfactory.io/m5stack/core/quickstart/macos/>

The basic steps are:

- Install cp210x driver
- Install Arduino IDE

- Register board manager
- Download and install m5stack libraries (m5stack core development kit, m5ez, ezTime)

NMEA Display software for M5Stack <https://github.com/andyrbarrow/MQTTNMEADisplay>

<http://forum.openmarine.net/showthread.php?tid=1819>

I've made my own custom version. It doesn't require MQTT. It can connect via TCP to SignalK NMEA stream or to Kplex. The code for the sketch is located here:

<https://github.com/bareboat-necessities/my-bareboat/tree/master/m5-boat-display>

Currently it supports GPS and Wind displays. I have an idea how to display more from AIS in future.



Figure 34. M5Stack Boat Display

**MQTT**

<http://mqtt.org/>

<http://mosquitto.org/>

**M5Stack ESP32**

<https://m5stack.com/>

**RTL 433**

[https://github.com/merbanan/rtl\\_433](https://github.com/merbanan/rtl_433)

**Boat Cellular LTE Voice and Data Gateway**

**SMS**

**OpenAirInterface**

<https://www.openairinterface.org/>

#### **1.3.4. Testing the Boat Gateway**



Figure 35. Boat Router Testbed

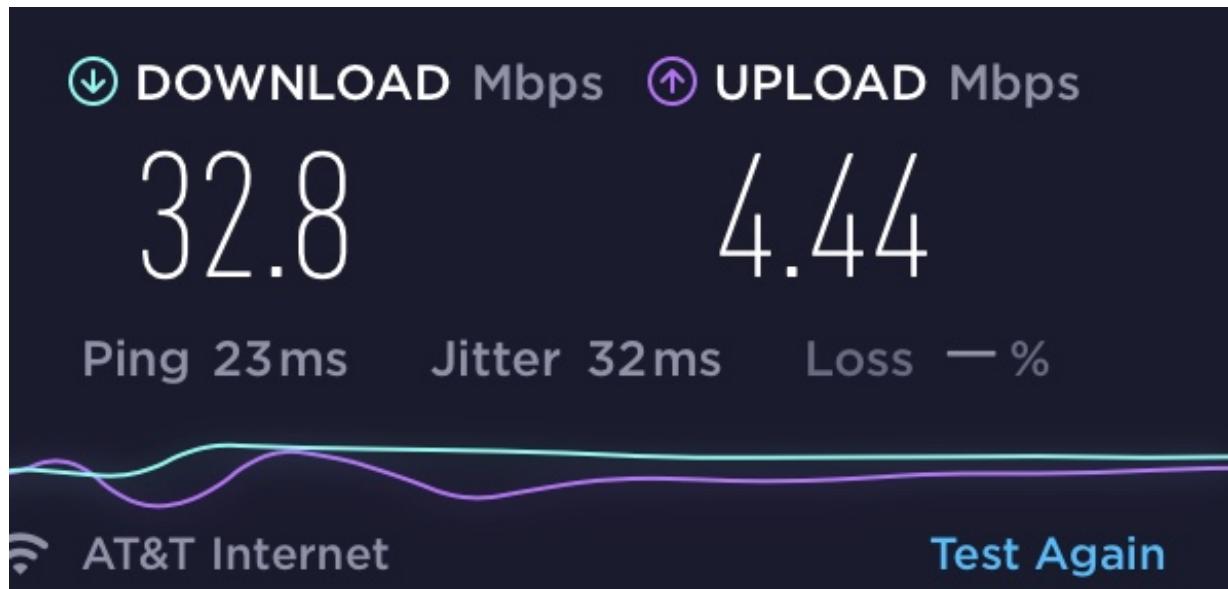


Figure 36. Boat Router LTE Speed

### Good

- LTE speed is good even with two little antennas it came with.
- Time to acquire a GPS location fix is very short with external antenna. I do not have exact time but it's under few minutes even inside the house. Having external GPS antenna made a huge improvement.
- Power usage of the whole gateway box is well under 2 watts. 2 watts is under speed stress test with uploads over LTE.

### Not so good

- External WiFi antenna (the one from the bill of material) did very little to improve the range. (Again I've tested it inside the house, without placing the antenna outside). My modification of the connector inside the router and soldering it might have been not good so you might have better results.
- Bigger LTE antenna (again from the bill of material) didn't give better signal quality (even a bit lower) than original antennas supplied with Spritz router. (Could be different picture on other bands though). With either of antennas LTE performed well.

### 1.3.5. Other Ideas

Rudder Position project

<https://hackaday.io/project/168592-opencpn-chart-plotter-w-autopilot-and-waypoints>

# Chapter 2. Boat Software

## 2.1. Software Data Flow

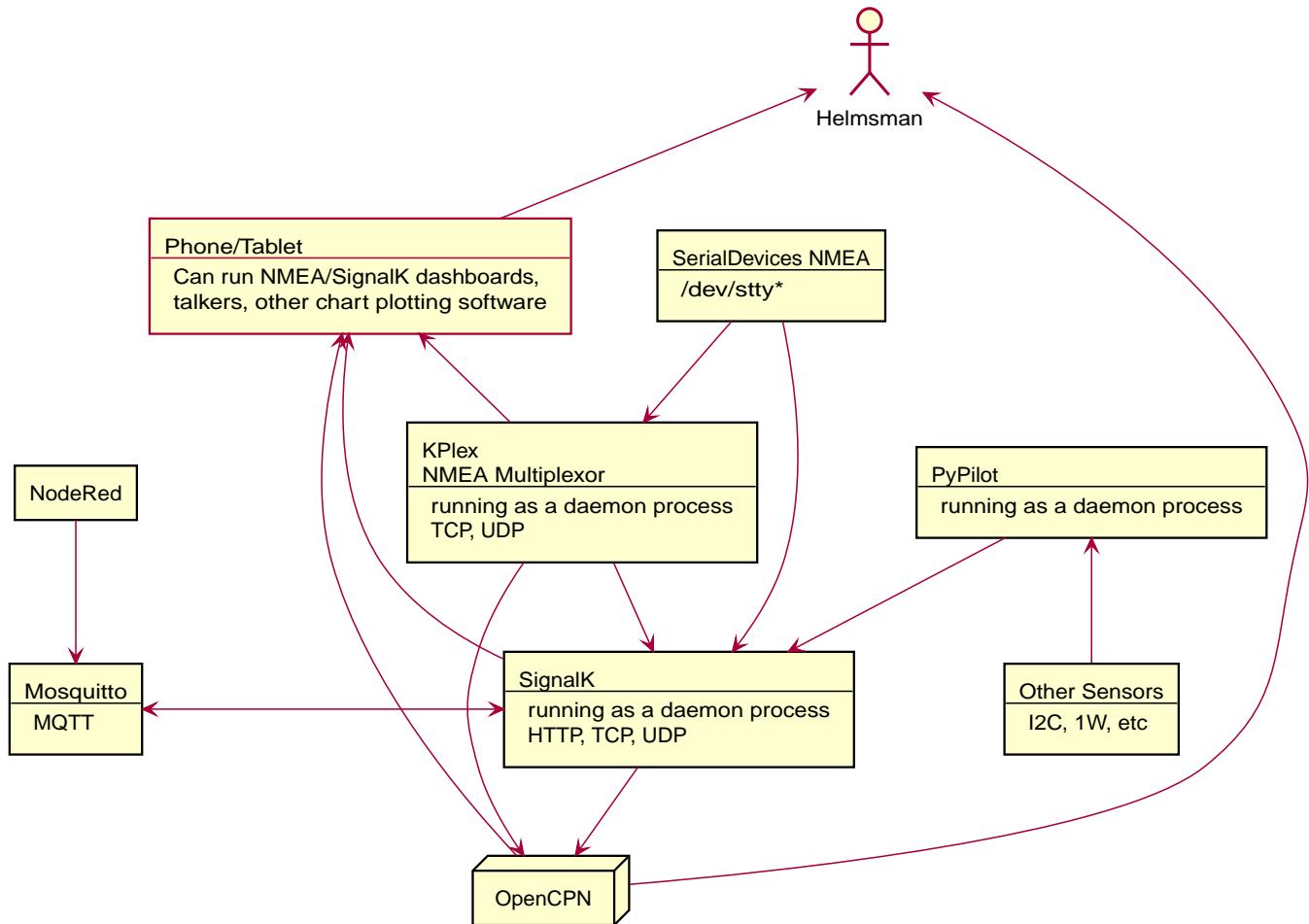


Figure 37. Software Architecture

## 2.2. Network Diagram

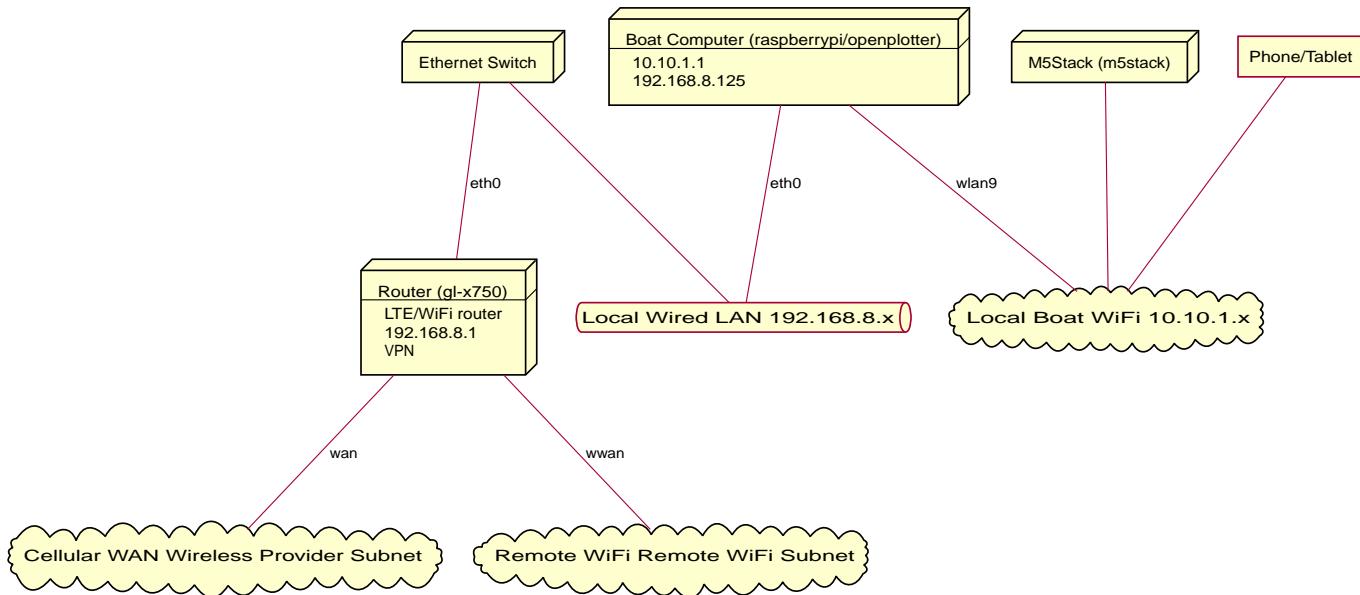


Figure 38. Network Diagram

Issuing this command:

```
ifconfig -a
```

On a router and on the boat computer will give good idea of the current configuration and status of local network (TCP/IP) interfaces.

On your boat computer install nmap

```
sudo apt install nmap
```

and use

```
nmap -sP 192.168.8.0/24
```

To discover all network devices on your boat local network. After you done with all the set up there would be Pi, router, m5stack.

## 2.3. Important local URLs on your boat

- Router admin UI <http://192.168.8.1> or <http://gl-x750>
- SignalK web UI <http://localhost:3000>
- Connects to K Plex running on the router

```
telnet gl-x750 10110
```

- Connects to SignalK running on the boat computer (Should be configured to output NMEA data, with a SignalK NMEA translation plugin)

```
telnet localhost 10110
```

- Connects to SignalK running on the boat computer (SignalK protocol)

```
telnet localhost 8375
```

- Chronograf <http://localhost:8888>
- Grafana <http://localhost:3001>
- Freeboard (in-browser chart plotter) <http://localhost:3000/@signalk/freeboard-sk/>
- Instruments Dashboard <http://localhost:3000/@signalk/instrumentpanel/>
- KIP Dashboard <http://localhost:3000/@mxtommy/kip/>
- SailGauge Wind Display <http://localhost:3000/@signalk/sailgauge/>
- Music Player (Mopidy) <http://localhost:6680>

## 2.4. Openplotter

### 2.4.1. Basic Installation Steps

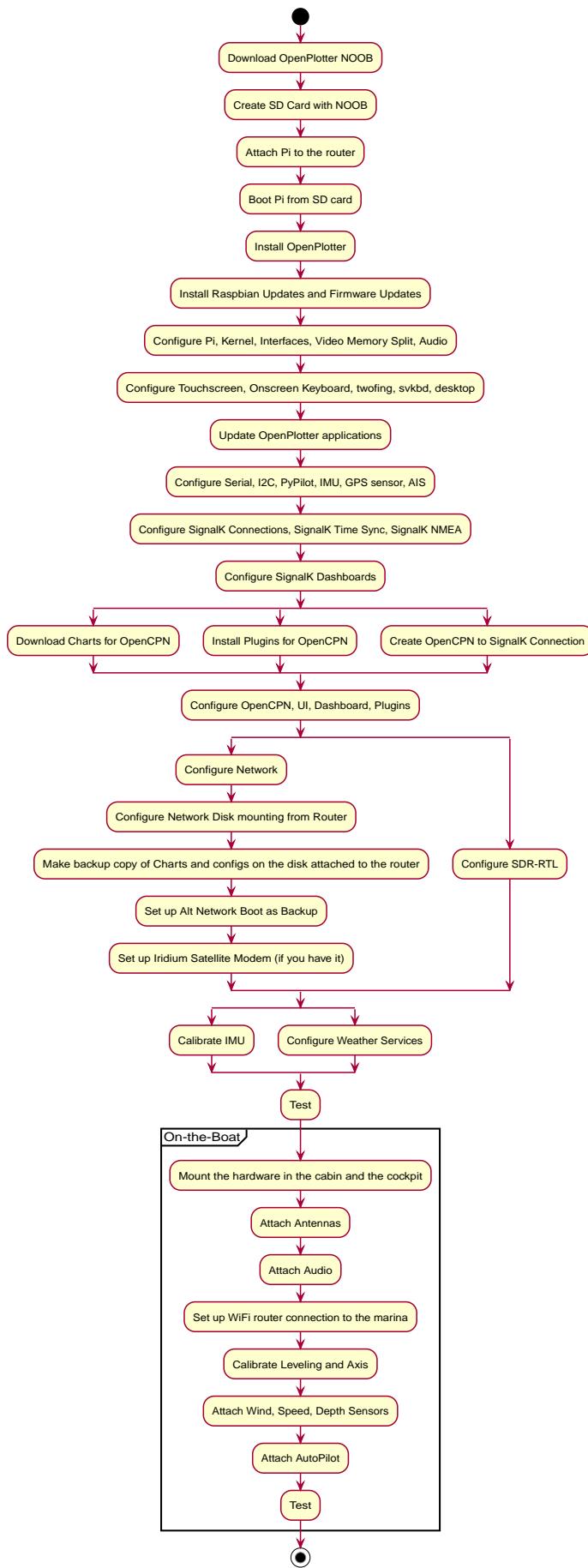


Figure 39. Basic Installation Steps

## 2.4.2. Installation

After completing installation you can see which packages got installed.

```
sudo apt list --installed | grep opencpn  
sudo apt list --installed | grep openplotter
```

To see which available OpenCPN packages are there:

```
apt-cache search opencpn
```

I also like to add firefox as additional browser in case chromium fails to display some page.

```
sudo apt install firefox-esr
```

## 2.4.3. Initial Settings

You would need to enable SPI, I2C, Serial Port, 1-Wire and Remote GPIO and disable Serial Console in Raspberry Pi Configuration utility. See:

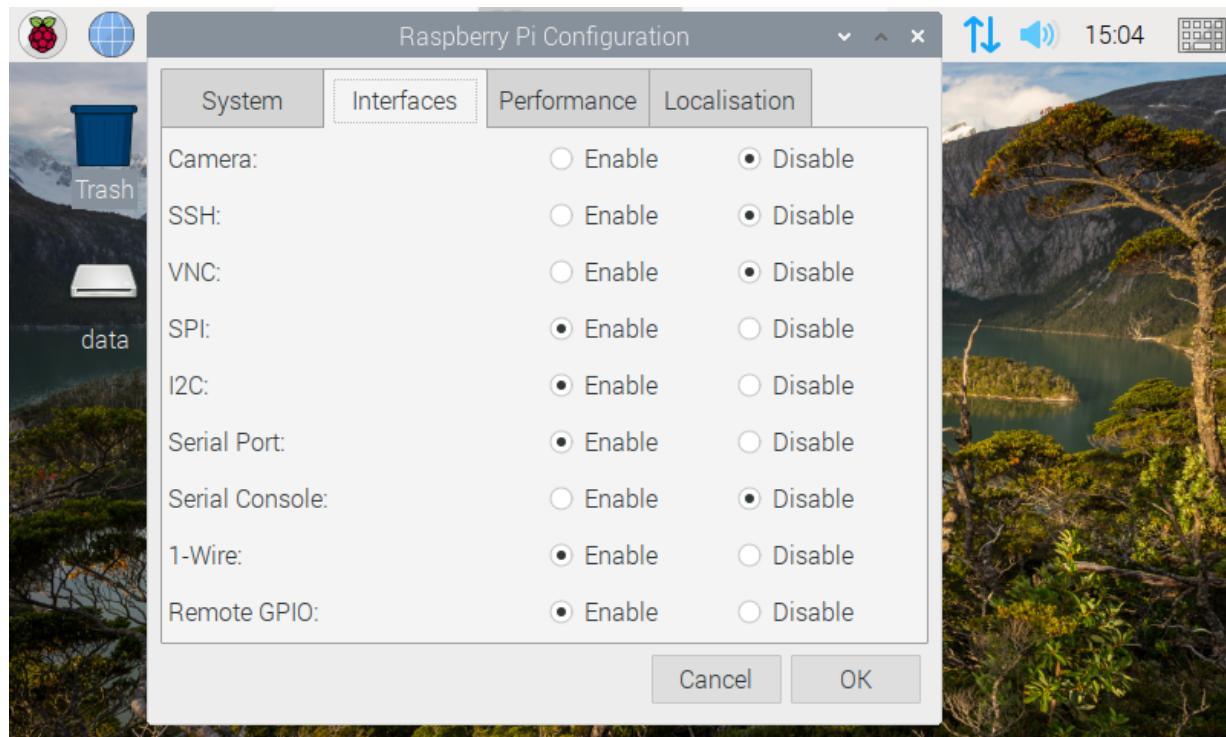


Figure 40. Raspbian Interfaces Settings

Reboot after changing settings in Raspberry Pi Configuration screen.

In Openplotter Serial you need to enable UART. This will disable Bluetooth. Reboot after it.

Your /boot/config.txt should look like this (I've stripped the commented lines):

```
arm_64bit=1

disable_overscan=1

dtparam=i2c_arm=on
dtparam=spi=on
dtparam=audio=on

[pi4]
dtoverlay=vc4-fkms-v3d
max_framebuffers=2

[all]
gpu_mem=512
enable_uart=1
dtoverlay=w1-gpio
dtoverlay=pi3-disable-bt
```

- arm\_64bit=1 is for enabling 64-bit linux kernel.
- gpu\_mem=512 reserves 512Mb of memory to the graphic video card.

#### 2.4.4. Setting Serial Devices

```
pi@raspberrypi:~ $ lsusb
Bus 002 Device 004: ID 05e3:0612 Genesys Logic, Inc. Hub
Bus 002 Device 003: ID 090c:1000 Silicon Motion, Inc. - Taiwan (formerly Feiya Technology Corp.) Flash Drive
Bus 002 Device 002: ID 05e3:0612 Genesys Logic, Inc. Hub
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 009: ID 067b:2303 Prolific Technology, Inc. PL2303 Serial Port
Bus 001 Device 013: ID 0000:0009
Bus 001 Device 014: ID 1c4f:0034 SiGma Micro
Bus 001 Device 011: ID 0c45:8101 Microdia
Bus 001 Device 010: ID 1a2c:2124 China Resource Semico Co., Ltd
Bus 001 Device 008: ID 05e3:0610 Genesys Logic, Inc. 4-port hub
Bus 001 Device 007: ID 0403:6001 Future Technology Devices International, Ltd FT232
Serial (UART) IC
Bus 001 Device 006: ID 05e3:0610 Genesys Logic, Inc. 4-port hub
Bus 001 Device 005: ID 16d0:0b03 MCS AIS Receiver [dAISy]
Bus 001 Device 004: ID 0bda:2838 Realtek Semiconductor Corp. RTL2838 DVB-T
Bus 001 Device 003: ID 05e3:0610 Genesys Logic, Inc. 4-port hub
Bus 001 Device 002: ID 2109:3431 VIA Labs, Inc. Hub
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
```

lsusb command will output all devices connected to USB bus.

Run

```
openplotter-serial
```

and set aliases to each serial device OpenPlotter recognizes. Aliases should be marked to be associated with unique device IDs. See:

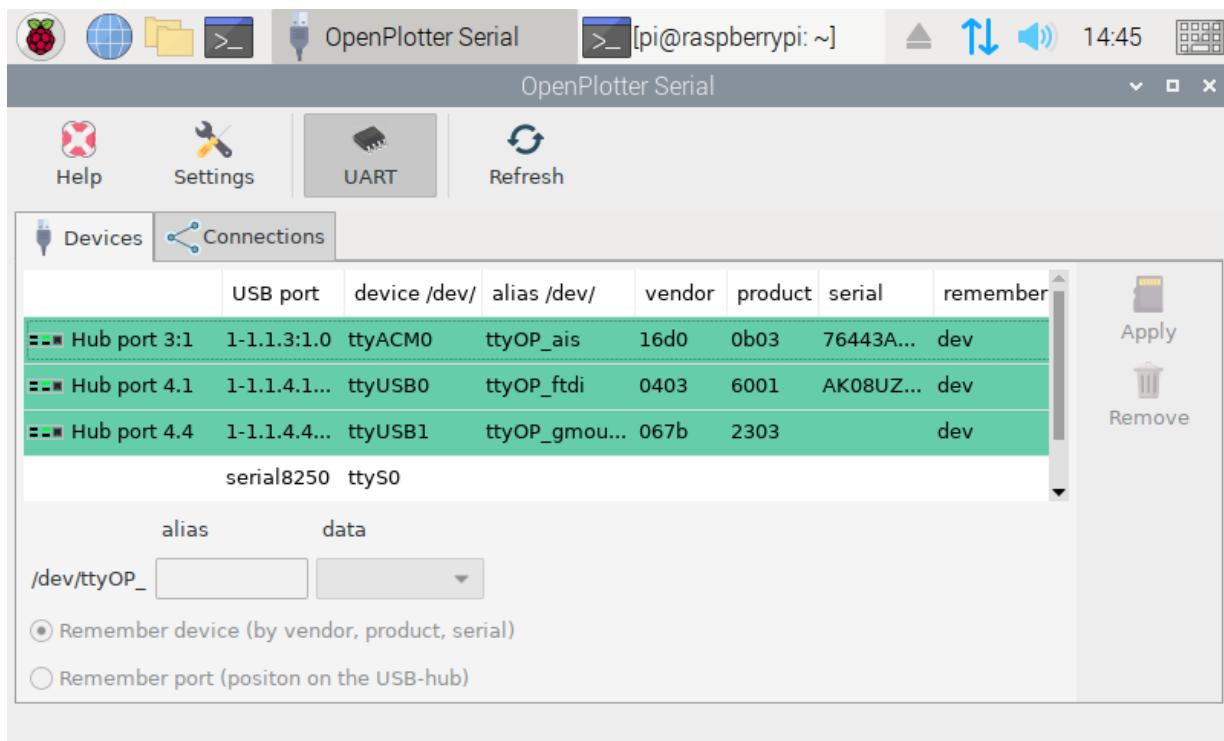


Figure 41. Openplotter Serial Devices

After that create connections to SignalK

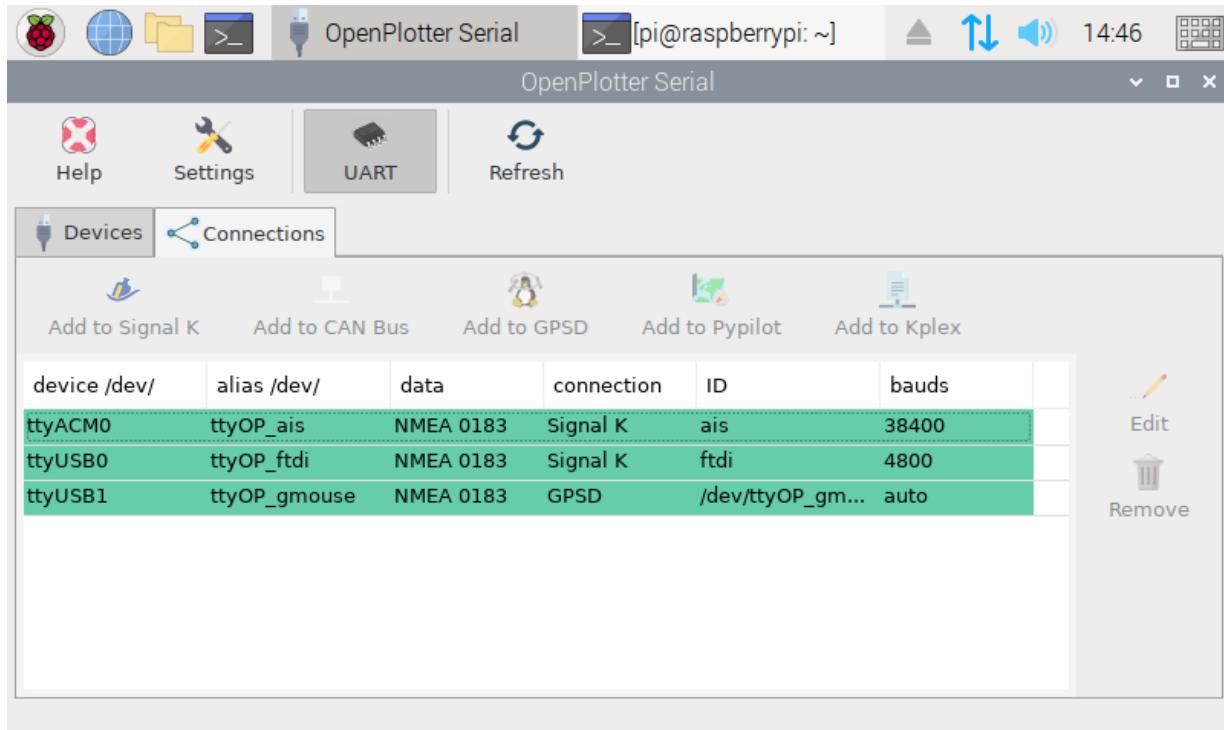


Figure 42. Openplotter Serial Connections

## 2.5. Geolocation

BU-353S4 GPS USB mouse by default is using binary SiRF protocol. You need to switch it once to NMEA before first use.

```
sudo apt install gpsd-clients
```

Do

```
lsusb
```

Plug in USB mouse into raspberry pi USB port. Do lsusb again to see which new USB device appeared. Use that device port in the command below.

```
sudo stty -F /dev/ttyUSB0 4800  
sudo gpsctl -n /dev/ttyUSB0
```

To obtain a fix GPS receiver needs a clear sky view. You need to have it outside. Chances are it is not going to find a location from inside your house.

## 2.6. Charts and OpenCPN

### 2.6.1. Charts

You download charts via OpenCPN chart downloader plugin.

#### NOAA RNC Regions

Num	Description
02	Block Island, RI to the Canadian Border
03	New York to Nantucket and Cape May, New Jersey
04	Chesapeake and Delaware Bays
06	Norfolk, VA to Florida - The Intracoastal Waterway
07	Florida East Coast and the Keys
08	Florida West Coast and the Keys
10	Puerto Rico and US Virgin Islands
12	Southern California - Point Arena to Mexican Border
13	Lake Michigan

Num	Description
14	San Francisco to Cape Flattery
15	Pacific NorthWest - Puget Sound to Canadian Border
17	Mobile, AL to Mexican Border
22	Lake Superior and Lake Huron
24	Lake Erie (US Waters)
26	Lake Ontario (US Waters)
30	Southeast Alaska
32	South Central Alaska
34	Alaska - The Aleutians and Bristol Bay
36	Alaska - Norton Sound to Beaufort Sea
40	Hawaiian Islands

## NOAA Nautical Chart MBTiles

Additionally, you can use links for MBtiles from here:

<https://github.com/vokkim/noaa-nautical-charts>

This is a list of available NOAA quilted nautical chart tilesets in MBTiles format. For the original NOAA Chart Tile Service please visit <http://tileservice.charts.noaa.gov/>

[Map of tileset sections] | [https://raw.githubusercontent.com/vokkim/noaa-nautical-charts/master/tileset\\_map.html](https://raw.githubusercontent.com/vokkim/noaa-nautical-charts/master/tileset_map.html)

Figure 43. Map of tileset sections

NOAA Tileset locator

NOAA Chart Tile Service Usage policy

No	Baseline MBTiles	Updates MBTiles
01	Download Baseline	Updates
02	Download Baseline	Updates
03	Download Baseline	Updates
04	Download Baseline	Updates
05	Download Baseline	Updates
06	Download Baseline	Updates
07	Download Baseline	Updates
08	Download Baseline	Updates
09	Download Baseline	Updates
10	Download Baseline	Updates
11	Download Baseline	Updates
12	Download Baseline	Updates
13	Download Baseline	Updates
14	Download Baseline	Updates
15	Download Baseline	Updates
16	Download Baseline	Updates
17	Download Baseline	Updates
18	Download Baseline	Updates
19	Download Baseline	Updates
20	Download Baseline	Updates
21	Download Baseline	Updates
22	Download Baseline	Updates
23	Download Baseline	Updates
24	Download Baseline	Updates
25	Download Baseline	Updates
26	Download Baseline	Updates

## 2.6.2. Touch Screen

One of the issues that kept bugging me was the lack of multitouch support on a touchscreen in OpenCPN and Raspbian UI in general. Well there is a fix! The solution requires the program called 'twofing'. It is easy to install. I've combined the script for my Argonaut M7 waterproof display.

See: [https://github.com/bareboat-necessities/my-bareboat/blob/master/twofing/rpi\\_twofing\\_install.sh](https://github.com/bareboat-necessities/my-bareboat/blob/master/twofing/rpi_twofing_install.sh)

Now zooming works with two fingers, there is a right click emulation with two fingers touch as well. With few modifications it can work for other screens. You will need to find out vendorID, productID and name for your touch screen display. I have Argonaut M7 gen2 screen. It gives me VendorID: 0000, ProductId: 0009, Name: 'Argonaut. Touchscreen'. For Argonaut M7 gen1 I've seen in posts VendorID: 04d8, ProductId: f724 and reported device name as 'Microchip Technology, Inc.'.

Another issue with twofing and Chromium browser is that latest Chromium browser does handle multi touch fine by itself and twofing interferes with that. To fix that you need to add "chrome" into 'profiles.h' 'blacklist' variable in twofing code. Edit 'profiles.h', recompile it and copy into /usr/bin/ :

```
rm *.o twofing  
make  
sudo cp twofing /usr/bin/
```

One more issue is entering the text on a touchscreen. I've added virtual on screen keyboard. I've compared several and the one I liked the most is svkbd.

I've made a script to install it. See: [https://github.com/bareboat-necessities/my-bareboat/blob/master/svkbd/rpi\\_svkbd\\_install.sh](https://github.com/bareboat-necessities/my-bareboat/blob/master/svkbd/rpi_svkbd_install.sh)

With 'twofing' fix and an on-screen svkbd keyboard OpenCPN is much more usable on my touch screen display. Smooth Panning/Zooming, OpenGL, and Touchscreen should be all enabled in OpenCPN settings.

The sound didn't work out of aux port. By default Raspberry Buster uses HDMI audio output and Argonaut M7 doesn't have a speaker. This command switches it to aux (You will need to add it into linux startup scripts if you want it on every boot):

```
amixer cset numid=3 1
```

## 2.7. Compass / IMU / Barometer / Thermometer

Launch

```
openplotter-i2c
```

and create sensors and connections as per screenshots below:

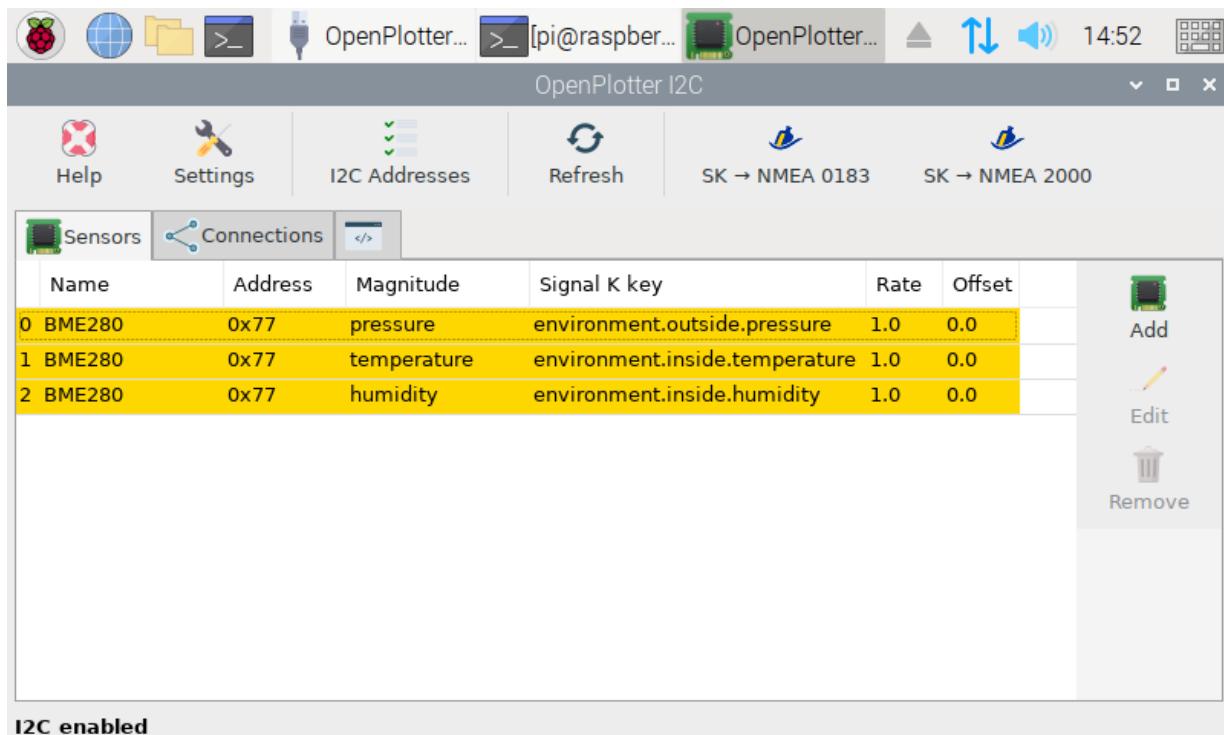


Figure 44. Openplotter I2C Sensors

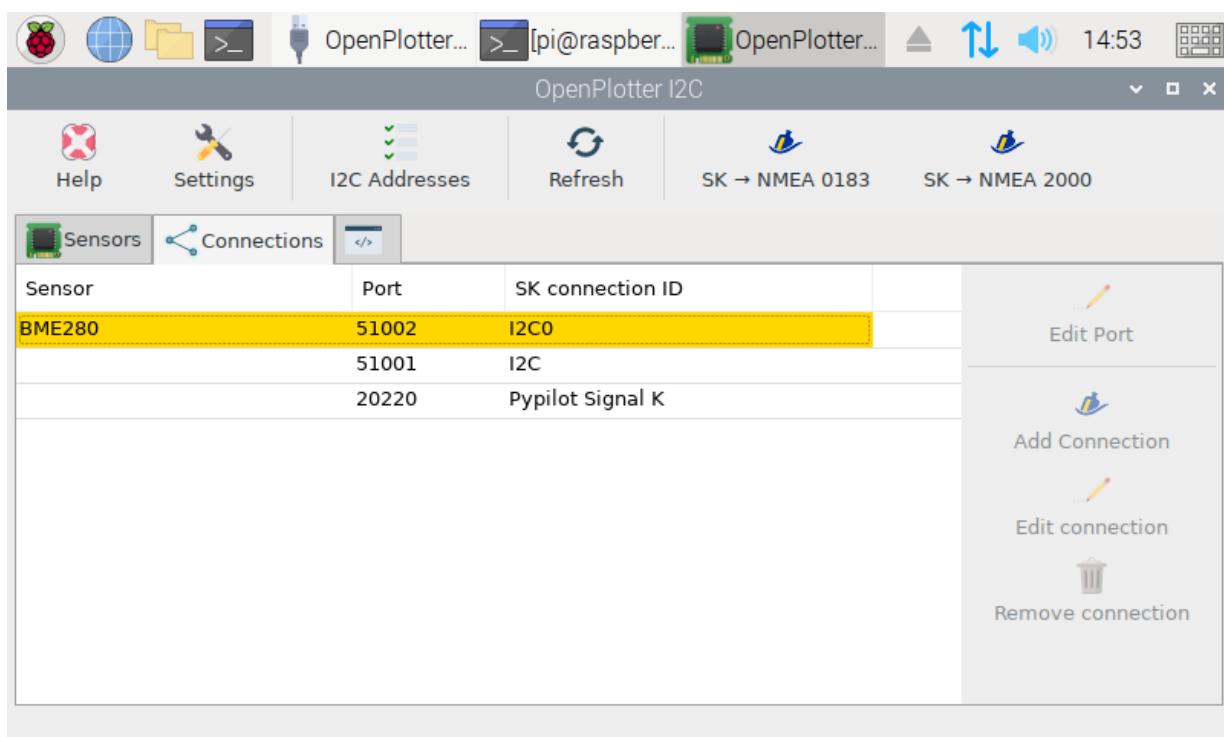


Figure 45. Openplotter I2C Connections

To add compass you need to launch

```
openplotter-pypilot
```

Create a connection like that:

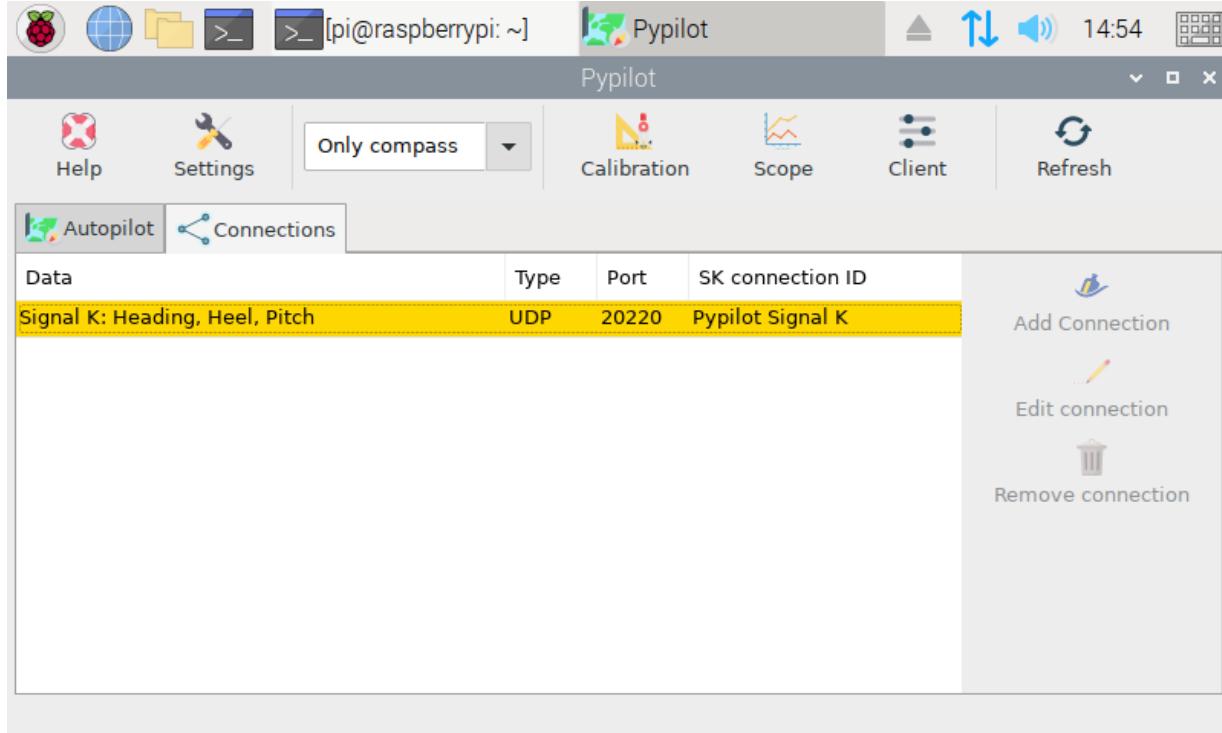


Figure 46. Openplotter PyPilot Connections

Check your set up

```
openplotter-startup check
```

## 2.7.1. SignalK Connections

1. Set up SignalK to Sync up time with GPS.
2. Set up SignalK to translate data into NMEA0183
3. The created connections should look like this:

ID	Input Type	Enabled	Logging
ftdi	NMEA0183	Yes	No
ais	NMEA0183	Yes	No
I2C	SignalK	Yes	No
Pypilot Signal K	SignalK	Yes	No
router_GPS	NMEA0183	Yes	No

Figure 47. SignalK Connections

## 2.7.2. Calibration

IMU needs to be calibrated.

See: <https://openplotter.readthedocs.io/en/latest/pypilot/calibration.html>

In case you run into issues doing it you can start

```
pypilot_boatimu
```

and check for errors.

## 2.8. Troubleshooting

Run

```
telnet localhost 10110
```

to see NMEA data from SignalK. This is the stream you would need to set up as a connection in OpenCPN.

Press Ctrl-] to get to telnet prompt and type 'quit' and hit 'Enter' to exit from telnet session.

Sample output:

```
Trying ::1...
Connected to localhost.
Escape character is '^]'.
$IIVTG,281.60,T,292.20,M,0.00,N,0.00,K,A*32
$IIHDG,167.67,-10.60,E,,*39
$IIHDT,157.1,T*20
$IIZDA,200813.020,20,01,2020,,*48
$IIMMB,30.2445,I,1.0242,B*78
$IXDR,P,1.0242,B,Barometer*12
$IIHDG,167.68,-10.60,E,,*36
$IIHDM,167.7,M*25
$IIHDT,157.1,T*20
$IXDR,A,3.2,D,PTCH,A,-91.3,D,ROLL*4B
^]
telnet> quit
```



You would need to calibrate your IMU sensors on your boat after mounting the computer inside the boat. Unfortunately OpenPlotter calibration dialogs are a bit big for the resolution of your cockpit monitor. So for calibration you might need to bring a higher resolution HDMI screen.



When complicated issues arise (if you think it is hardware related) try to find out a chipset of the device in question and start googling the chipset and the symptoms. Usually it gives better results than just searching by the vendor/model.

## 2.9. SDR

### 2.9.1. GQRX

Install SDR receiver app called GQRX

```
sudo apt install rtl-sdr rtl-ais gqrx-sdr
```

Easiest way to try your RTL-SDR dongle is via tuning to FM station.

1. Launch GQRX
2. Set up input SDR dongle and audio output
3. Tune to a FM station (Example 104.3 MHz in my area) (see screen shot)
4. Adjust gain in audio control. You should hear clear radio.

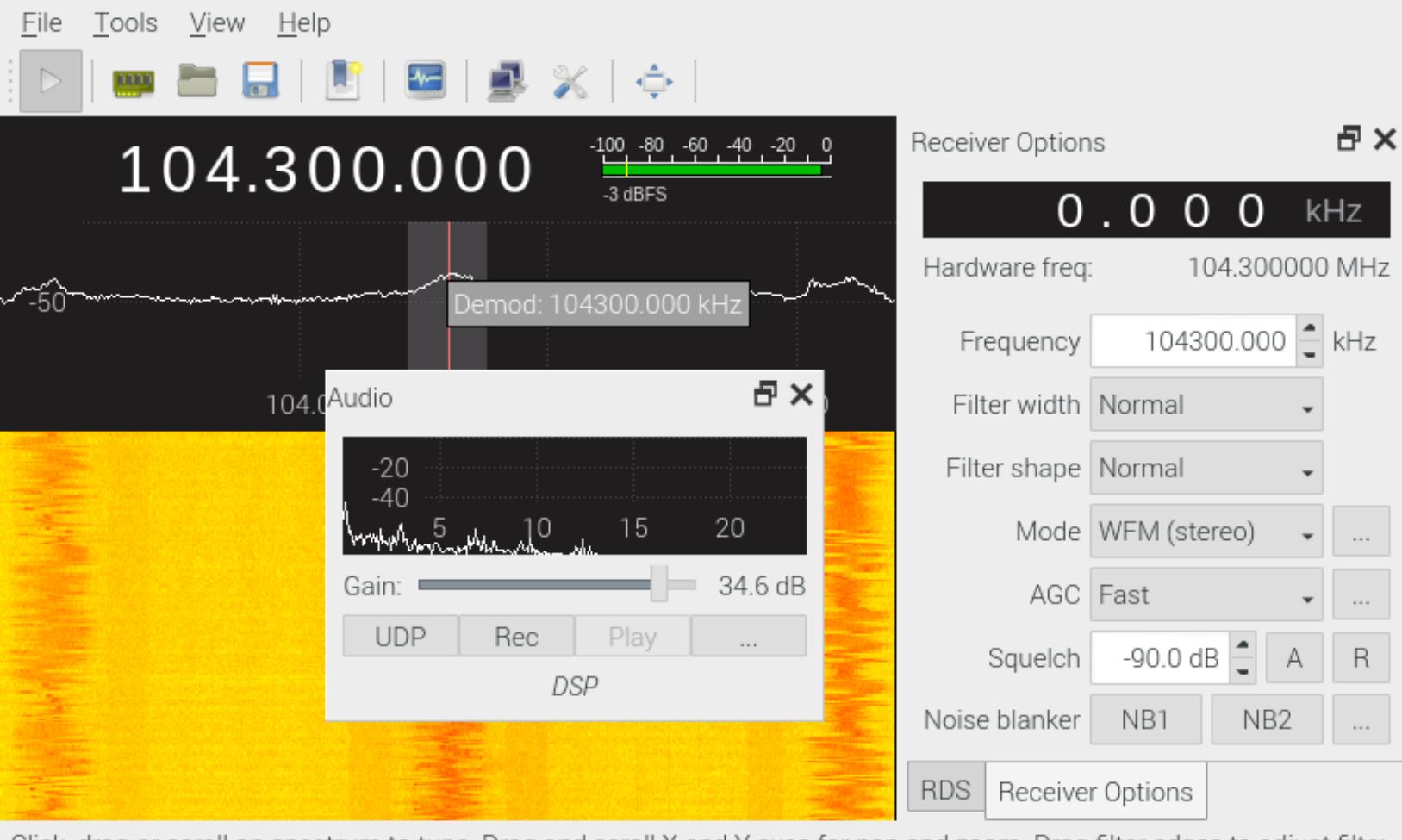


Figure 48. Receiving FM radio with RTL-SDR

See also:

<https://danielpocock.com/quickstart-sdr-ham-radio-gqrx-gnu-radio/>

<https://danielpocock.com/building-loop-antenna-sdr-shortwave-ham-oscal17/>

## 2.9.2. Cubic SDR

Another SDR application available for Raspberry Pi is CubicSDR:

```
sudo apt install cubicsdr
```

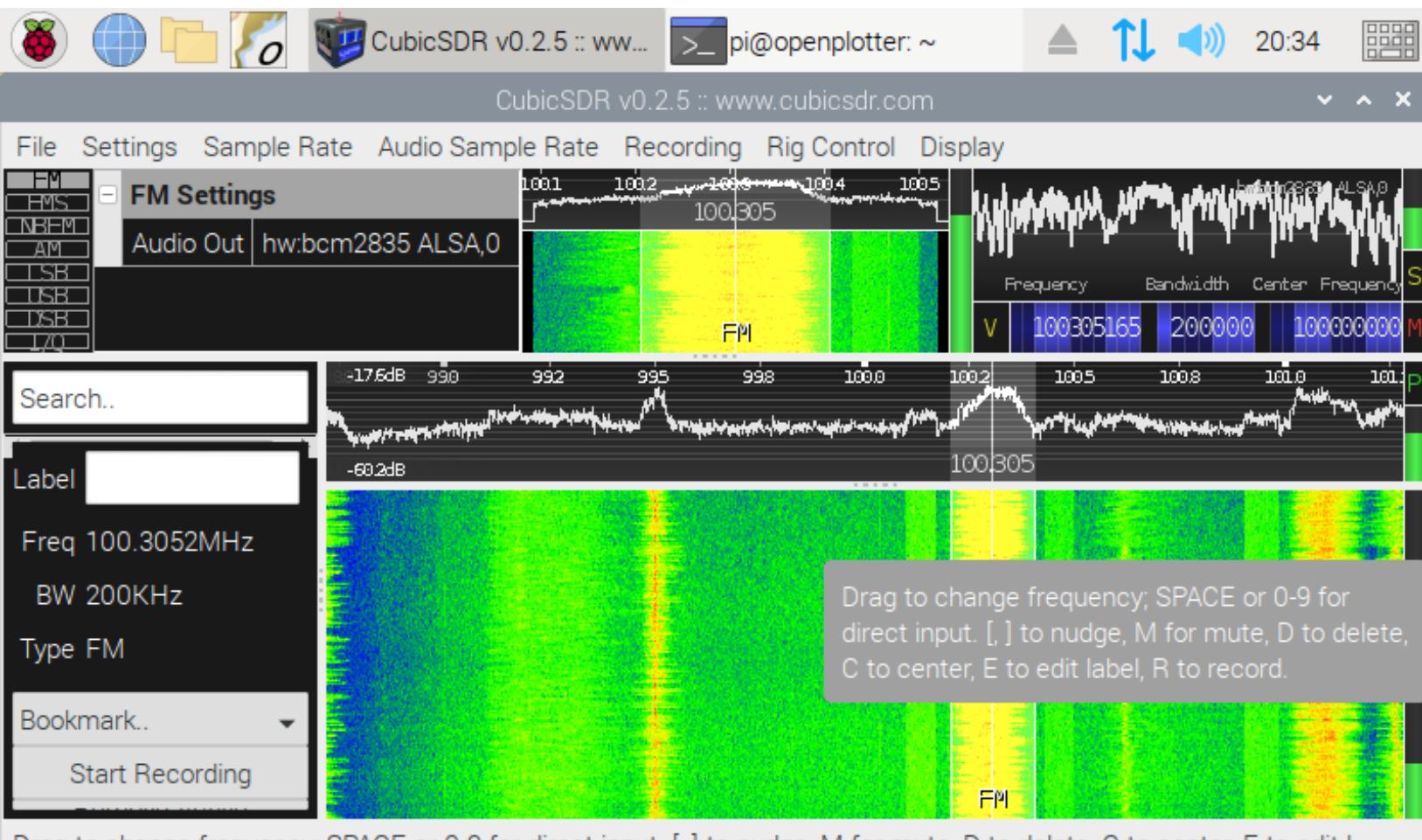


Figure 49. Cubic SDR

## 2.10. NavTex

[https://en.wikipedia.org/wiki/List\\_of\\_Navtex\\_stations](https://en.wikipedia.org/wiki/List_of_Navtex_stations)

Decoder software for NavTex is available here. Download the Java version to work on raspberry pi.  
<http://www.frisnit.com/navtex/>

OpenSource (GPL Licensed) NavTex decoder: <https://arachnoid.com/JNX/>

Item	Description	Cost	Source
Antenna for SDR radio weather fax and NavTex	Active Antenna 10Khz To 30Mhz Mini Whip Hf Lf Vlf Vhf Sdr Rx With Portable Cable <a href="https://a.aliexpress.com/_sUWwnl">https://a.aliexpress.com/_sUWwnl</a>	\$26.10	AliExpress

RTL SDR v3 in Direct sampling mode allows listening to HF signals between about 500 kHz to 28.8 MHz

More info here : <https://www rtl-sdr com/rtl-sdr-blog-v-3-dongles-user-guide/>

## 2.11. AIS

Setting up dAISy AIS is very straight forward. It does require higher baud rate, so make sure you specify it correctly. After plugging into USB and antenna and registering in openplotter-serial in device mapping and connections it should start giving AIS targets sentences via NMEA. If it doesn't see any ships close by then it doesn't send any sentences.

### 2.11.1. AIS with SDR

<https://pysselilivet.blogspot.com/2018/06/ais-reciever-for-raspberry.html>

## 2.12. Other Free Chart Plotting Software and Weather Routing

There are multiple ways to receive weather predictions:

- Download GRIB files via internet. (Only works if internet is available). You have this functionality as a part of GRIB OpenCPN plugin.
- GRIB files via SSB radio (out of scope here)
- Weather FAX (some people just connect radio to computer audio input, record audio file and convert it using utility into image). You have this supported via OpenCPN WeatherFax plugin. It would be nice to completely automate this process using RTL-SDR.

See: <https://www rtl-sdr com/tag/weather-fax/>

- Images from NOAA satellites via radio. RTL-SDR can be used to automate this as well.

See: <https://www.instructables.com/id/Raspberry-Pi-NOAA-Weather-Satellite-Receiver/>

Discussion about WeatherFax on Raspberry Pi <https://www.raspberrypi.org/forums/viewtopic.php?t=260690>

### 2.12.1. QtVlm

OpenCPN Weather plugins provide weather and weather routing functionality.

There is one more (non-opensource) software solution called 'QtVlm'

<https://www.meltemus.com/>

which is available for Raspberry Pi.

I've installed and played with it and I have found it too difficult to use on a small cockpit touchscreen with default settings, but they can be adjusted. It can also use the charts you would download for OpenCPN. So it even can be used as your main chart plotter.

Installation:

```
wget https://www.meltemus.com/index.php/en/download/send/9-raspberrypi/197-qtVlm-5-9-7-6  
mv 197-qtVlm-5-9-7-6 qtVlm-5.9.7-p2-rpi.tar.gz
```

```
gzip -cd < qtVlm-5.9.7-p2-rpi.tar.gz | tar xvf -
```

Running:

```
cd qtVlm  
. ./qtVlm_touchscreen -platform xcb
```

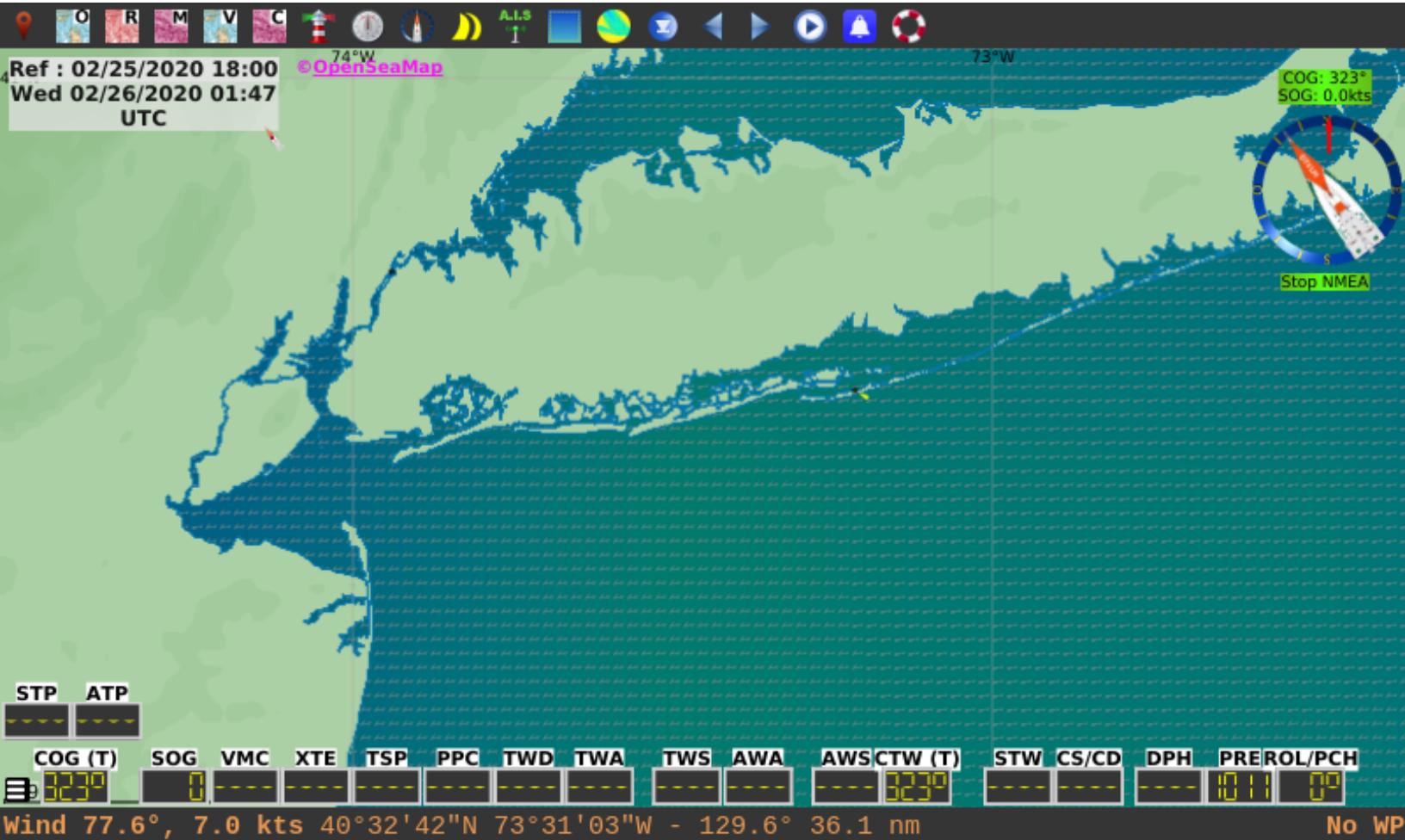


Figure 50. QtVlm

## 2.12.2. AvNav

This is a nice chart plotter which runs in a browser supports number of chart formats (You need to convert them though with the provided utility). Since it is running in Chromium browser, the

touchscreen support is better. This is another option to use as main chart plotter instead of OpenCPN.

References:

- see <https://github.com/wellenvogel/avnav>
- and <https://github.com/free-x/avnav/wiki>
- and <https://github.com/free-x>

Installation:

```
sudo wget -q -O - https://open-mind.space/repo/open-mind.space.gpg.key | sudo apt-key add -  
  
sudo bash -c 'cat << EOF > /etc/apt/sources.list.d/extralist  
deb https://open-mind.space/repo/ buster-stable avnav  
EOF'  
  
sudo apt update  
sudo apt install avnav  
sudo apt install xterm  
sudo apt install mpg123  
  
mkdir -p /home/pi/AvNavCharts/out  
  
sudo adduser avnav audio  
  
sudo systemctl enable avnav
```

Edit config:

```
sudo nano /var/lib/avnav/avnav_server.xml
```

Edit host, NMEA port and http port:

```
<AVNServer>  
...  
<AVNSocketReader host="localhost" port="10110"/>  
<AVNHttpServer navurl="/viewer/avnav_navi.php" httpPort="8099" upzoom="0"  
chartbase="maps" empty="nonexistent">  
<Directory urlpath="maps" path="/home/pi/AvNavCharts/out"/>  
...  
</AVNHttpServer>  
</AVNServer>
```

Running:

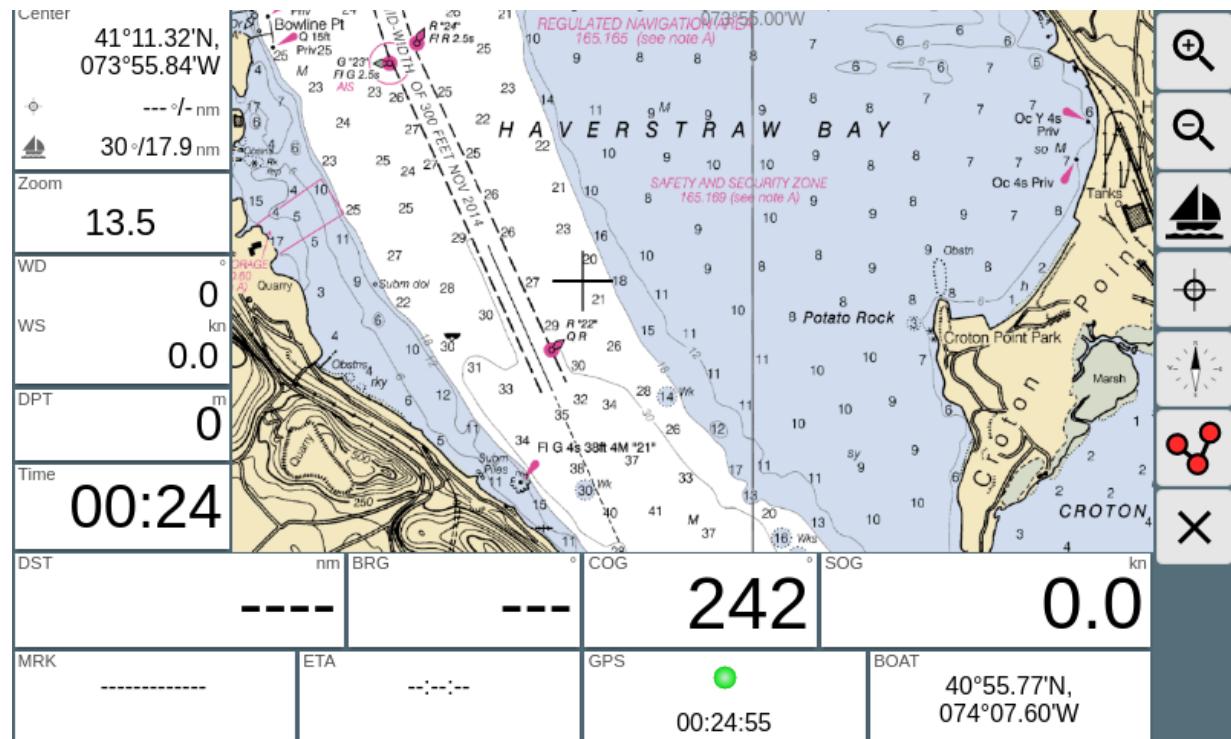
```
sudo systemctl start avnav
```

Open browser with URL: <http://localhost:8099>

Register menu item:

```
sudo apt install xdotool
```

```
sudo bash -c 'cat << EOF > /usr/share/raspi-ui-overrides/applications/avnav.desktop
[Desktop Entry]
Type=Application
Name=AvNav
GenericName=ChartPlotter
Comment=ChartPlotter
Exec=sh -c "chromium-browser -new-window http://localhost:8099; sleep 2; xdotool key F11"
Terminal=false
Icon=globe
Categories=ChartPlotter,OpenPlotter
Keywords=ChartPlotter,OpenPlotter
EOF'
```



## AvNav Charts

You can use mbtiles which you downloaded for OpenCPN. AvNav needs to convert them first. To convert:

```
avnav -g
```

select .mbtiles file, press 'Convert', wait for process to finish. Next

```
chromium-browser http://localhost:8099
```

1. click arrow down icon on right side toolbar, this will bring you to chart upload screen
2. click arrow up icon on right side. select .gemf file and upload the file

For more documentation:

```
git clone https://github.com/wellenvogel/avnav.git  
chromium-browser avnav/docs/en_install.html  
chromium-browser avnav/docs/en_charts.html
```

## 2.13. NMEA Wind Sensor

You can connect via NMEA to your boat computer or for older wind transducers there is a hard way:

<https://hackaday.io/project/12986-nasa-wind-decoder>

## 2.14. Text to Speech

Visual alarms are of no use if you do not watch. So we could add text-to-speech:

```
wget -q https://ftp-master.debian.org/keys/release-10.asc -O- | sudo apt-key add -  
echo "deb http://deb.debian.org/debian buster non-free" | sudo tee -a  
/etc/apt/sources.list  
sudo apt update  
sudo apt install libttspico-utils  
sudo apt install sox
```

Example of playing message:

```

pico2wave -l en-US -w /tmp/pico2wave.wav "Passenger Announcement... \
Follow these few rules, to make your trip enjoyable for everyone on board. \
Move around the boat on its high side. \
Always hold on to something steady, and that does not move: shrouds, grab rails, when \
you are outside of the cockpit. \
If you can not swim, wear a life jacket, if you move outside of the cockpit. \
Watch your head and listen to the crew warnings when you are around the boom. \
The boom can swing fast, if the wind changes. \
In case if someone falls overboard, throw anything, that floats to the victim and \
shout: Man overboard! pointing at the victim. \
Do not put into a marine toilet anything, which you have not eaten or drunk first. \
Do not throw plastic overboard. \
Watch the horizon. If you feel sea sick, try to stay active outside of the cabin." &&
play -qV0 /tmp/pico2wave.wav treble 24 gain -l 6

```

## 2.15. Creating Backup Boot SD Card

Tutorial is here:

<http://pysselilivet.blogspot.com/2017/11/rpi-clone-raspberry-boot-disk.html>

It is based on rpi-clone software <https://github.com/billw2/rpi-clone>

## 2.16. SignalK Applications

### 2.16.1. Freeboard-SK

<https://github.com/SignalK/freeboard-sk>

### 2.16.2. InstrumentPanel

<https://github.com/SignalK/instrumentpanel>

### 2.16.3. SailGauge

<https://github.com/SignalK/sailgauge>

### 2.16.4. Tuktuk Chart Plotter

<https://github.com/vokkim/tuktuk-chart-plotter>

### 2.16.5. KIP Dashboard

<https://github.com/mxtommy/Kip>

## 2.17. Music Player

I've looked at number of media and music player projects available on raspberry pi and the one which works nice on OpenPlotter and cockpit touch display is Mopidy with Spotify extension and MusicBox Web UI extension.

Install from apt.mopidy.com

See: <https://docs.mopidy.com/en/latest/installation/raspberrypi/>

<https://docs.mopidy.com/en/latest/installation/debian/#debian-install>

For Raspberry PI you should first try installing via apt. If pre-build package doesn't exists then you use python3 pip.

```
# Add the archive's GPG key:  
wget -q -O - https://apt.mopidy.com/mopidy.gpg | sudo apt-key add -  
  
# Add the APT repo to your package sources:  
sudo wget -q -O /etc/apt/sources.list.d/mopidy.list https://apt.mopidy.com/buster.list  
  
sudo adduser mopidy video  
sudo adduser mopidy audio  
sudo xhost +SI:localuser:mopidy  
  
# Install Mopidy and all dependencies:  
sudo apt update  
sudo apt install mopidy mopidy-mpd mopidy-spotify mopidy-tunein  
  
# Install some needed packages  
sudo python3 -m pip install mem systems  
  
# Install Mopidy MusicBox Web Client:  
sudo python3 -m pip install Mopidy-MusicBox-Webclient  
  
# Install YouTube support  
sudo python3 -m pip install --pre Mopidy-YouTube
```

Configure Spotify <https://mopidy.com/ext spotify/>

Edit mopidy.conf

```
nano /home/pi/.config/mopidy/mopidy.conf
```

```
[mpd]
enabled = true
hostname = ::

[http]
enabled = true
hostname = ::

[audio]
#mixer = software
#mixer_volume =
output = alsasink

[spotify]
enabled = true
username = alice
password = secret
client_id = ... client_id value you got from https://mopidy.com/ext/spotify/ ...
client_secret = ... client_secret value you got from https://mopidy.com/ext/spotify/ ...
```

Run:

```
/usr/bin/mopidy
```

Open Chromium browser <http://localhost:6680>

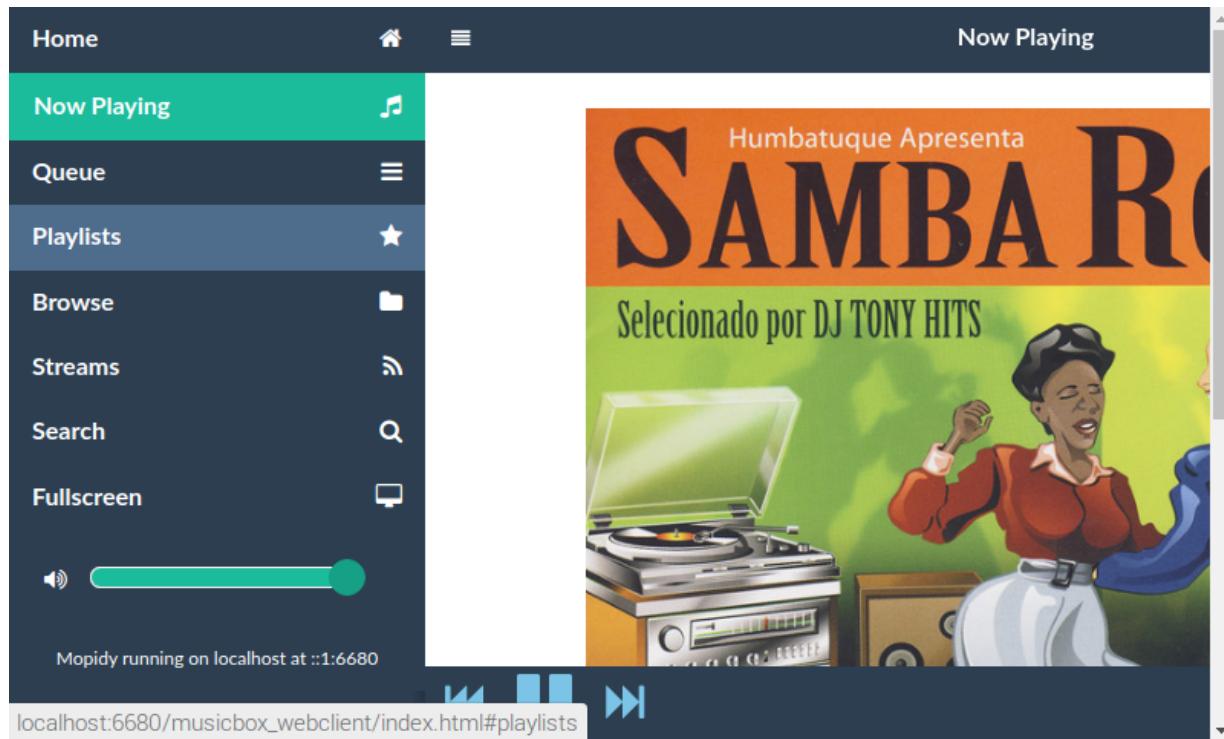


Figure 52. Mopidy MusicBox on Openplotter

Now register mopidy as a service to start automatically

```
sudo systemctl enable mopidy
sudo cp /home/pi/.config/mopidy/mopidy.conf /etc/mopidy/mopidy.conf
sudo cp /home/pi/.config/mopidy/mopidy.conf /var/lib/mopidy/.config/mopidy/mopidy.conf
```

in a file /etc/init.d/mopidy

```
sudo nano /etc/init.d/mopidy
```

make sure you add 2 lines:

```
cp /home/pi/.config/mopidy/mopidy.conf /etc/mopidy/mopidy.conf
cp /home/pi/.config/mopidy/mopidy.conf /var/lib/mopidy/.config/mopidy/mopidy.conf
```

like this (on service startup)

```

start-stop-daemon --start --quiet --name $NAME --pidfile $PIDFILE \
--startas $DAEMON --test > /dev/null \
|| return 1
cp /home/pi/.config/mopidy/mopidy.conf /etc/mopidy/mopidy.conf
cp /home/pi/.config/mopidy/mopidy.conf /var/lib/mopidy/.config/mopidy/mopidy.conf
start-stop-daemon --start --quiet --name $NAME --pidfile $PIDFILE \
--chuid $DAEMON_USER:$DAEMON_GROUP --background --make-pidfile \
--startas $DAEMON -- --quiet --config $CONFIG_FILES \
|| return 2

```

Reboot.

Create a menu link to open Mopidy Web UI directly from desktop menu via this command:

```

sudo apt install xdotool

sudo bash -c 'cat << EOF > /usr/share/raspi-ui-overrides/applications/musicbox.desktop
[Desktop Entry]
Type=Application
Name=MusicBox
GenericName=Music
Comment=Mopidy MusicBox
Exec=sh -c "chromium-browser -new-window http://openplotter:6680/musicbox_webclient;
sleep 2; xdotool key F11"
Terminal=false
Icon=sound
Categories=Sound
Keywords=Sound
EOF'

```

You can use your smart phone to control the player with one of the MPD client applications. I used 'MPDPlayer' on iphone and MPDroid on android. You create connection:

openplotter:6600

or

10.10.10.1:6600

## 2.18. Testing

Another test site:



Figure 53. Test Setup



Figure 54. Cockpit Temporary Testbed



Figure 55. Argonaut M7 in Navpod with OpenPlotter

# Chapter 3. Pole for Sailboat Solar Panel / Wind Generator

This is no welding, no bends solution. The pole is built from universal stainless steel marine components. To reproduce this design you would need only a pipe cutter tool and a drill. The top is quick release adjustable angle (two axis). Removable for winter storage. The solar panel is quickly detachable and removable.

Most of the components are common marine rail fittings for 1" tubing. The top one component to make tee join is aluminum drying or display rack pipe fitting tee connector for 25mm round tube available from many vendors. It works perfectly. I use an eye nut for quick release instead of a regular nut.

<https://www.amazon.com/dp/B07GZTWX85>

There is also a closed body turnbuckle in the design. It needs a securing wire to be fixed in place to prevent unscrewing.

The pipe cutter which worked perfectly easy for me on stainless steel is this one:

<https://www.amazon.com/dp/B077966G15>

The markings say "GT-Q50A" which points to R'DEER tool (Hong Kong brand).



*Figure 56. Solar Panel/Wind Generator/Radar Pole Mast for Sailboat*



*Figure 57. Solar Panel/Wind Generator/Radar Pole Mast for Sailboat View*

# Chapter 4. Mobile Applications (Smart Phones and Tablets)

1. iNavX
2. Navionics
3. OpenCPN
4. SEAiq
5. Marine Traffic
6. Ship Finder
7. PredictWind
8. NOAA Weather
9. Tide Alert
10. US Coast Guard
11. SeaTow
12. Snag a Slip
13. ActiveCaptain
14. CruisersSailingForums
15. Boatsetter
16. GoSailing
17. NauticEd
18. Knot Guide

# Chapter 5. Third-Party Projects

## 5.1. S/Y Curiosity SignalK setup

<https://bergie.iki.fi/blog/signalk-boat-iot/>

## 5.2. Boat Chartplotter using stick PC

<https://www.youtube.com/watch?v=JYhsQSQOEbM&feature=youtu.be>

Marine Chartplotter PC - Open CPN on ASUS QM1

## 5.3. Sailing with Linux (NMEA, GPSd, Iridium)

<https://agile4life.blog/2018/07/16/sailing-with-linux-nmea-gpsd-iridium/>

Instructions on connecting Satellite Iridium phone to Pi for satellite data services.

## 5.4. RaspEx (Ubuntu with OpenCPN)

<http://raspex.exton.se/?p=1234>

Another Raspberry Pi Boating Project

## 5.5. LysMarine

<http://lysmarineos.com>

LysMarine

# Chapter 6. Links

- [OpenCPN](#)
- [OpenCPN Forums](#)
- [OpenCPN dev builds for Pi](#)
- [OpenPlotter](#)
- [OpenPlotter Documentation](#)
- [OpenPlotter builds](#)
- [OpenPlotter 2.x beta install guide](#)
- [OpenPlotter Forums](#)
- [Moitessier HAT](#)
- [PyPilot](#)
- [Rtl Sdr Blog](#)
- [SignalK](#)
- [Kplex](#)
- [CAN Boat](#)
- [Open Boat Projects](#)
- [Squidd.io as an OpenCPN Plugin](#)
- [NavData OpenCPN Plugin](#)
- [KBox and other boat software](#)
- [NMEA2000 Libraries](#)
- [OpenSkipper](#)
- [Marinux](#)
- [Navigatrix](#)
- [LysMarine](#)
- [RaspberryPi](#)
- [M5Stack](#)
- [M5Stack on GitHub](#)
- [OpenAirInterface](#)
- [OpenWrt](#)
- [Mosquitto MQTT Broker](#)
- [NodeRed](#)

- IoT RTL 433
- NMEA Protocol
- AIS NMEA
- OpenSCAD
- PCB Design
- NASA Marine Wireless Wind Instrument
- RigPi
- NOAA APT weather satellite image decoder, for Linux, Windows, RPi 2+ and OSX