SoftRF

Part 2

Multifunctional DIY IoT-based general aviation proximity awareness system.

Revision: 2.0

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Intro

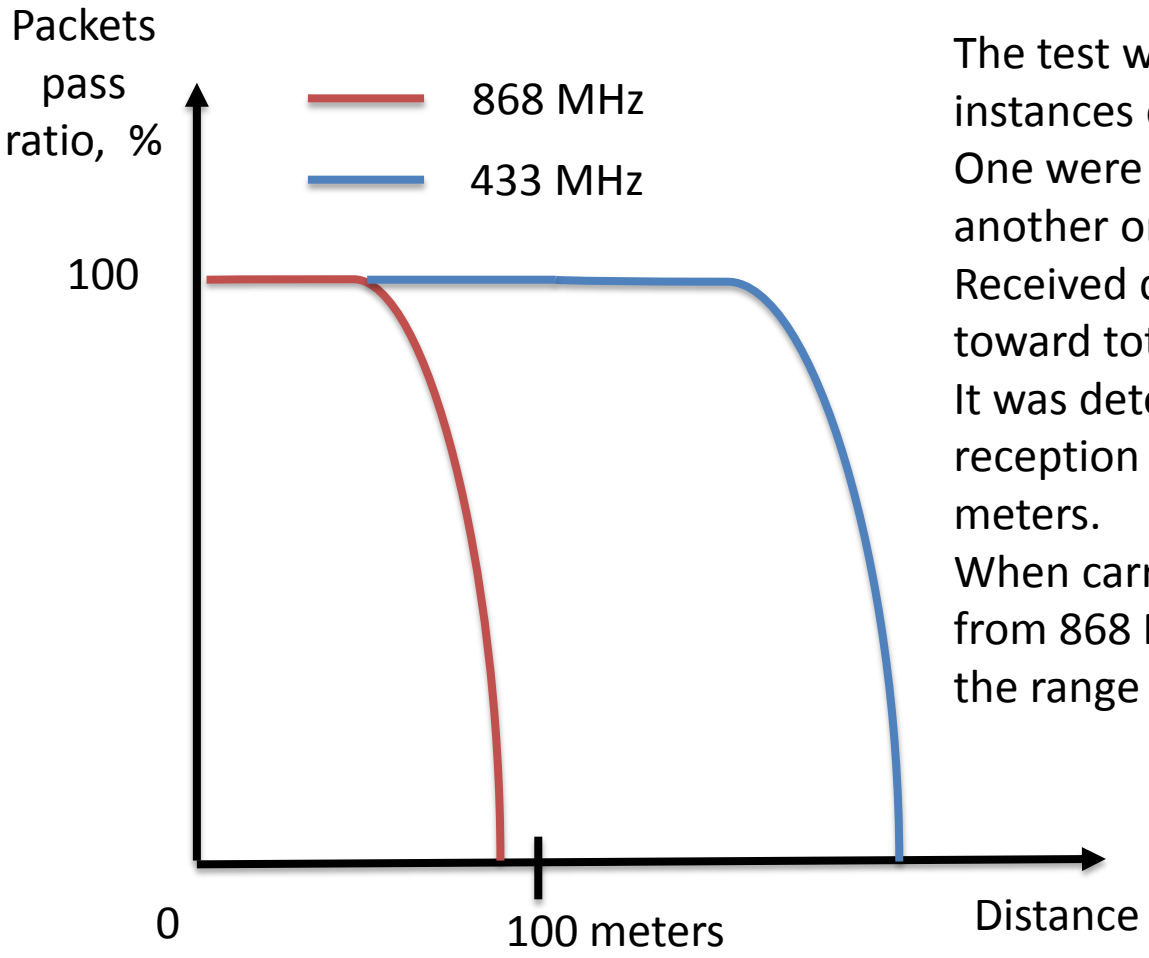
This document is the SoftRF project development update of the progress been made in year 2016.

Author is taking assumption that you are already familiar with last release of the project's white paper.
If not, please, read this document first:

SoftRF overview. Part 1.

At the end of the previous story a prototype unit were created to pass through preliminary field testing.

First SofRF concept
Outdoor test result

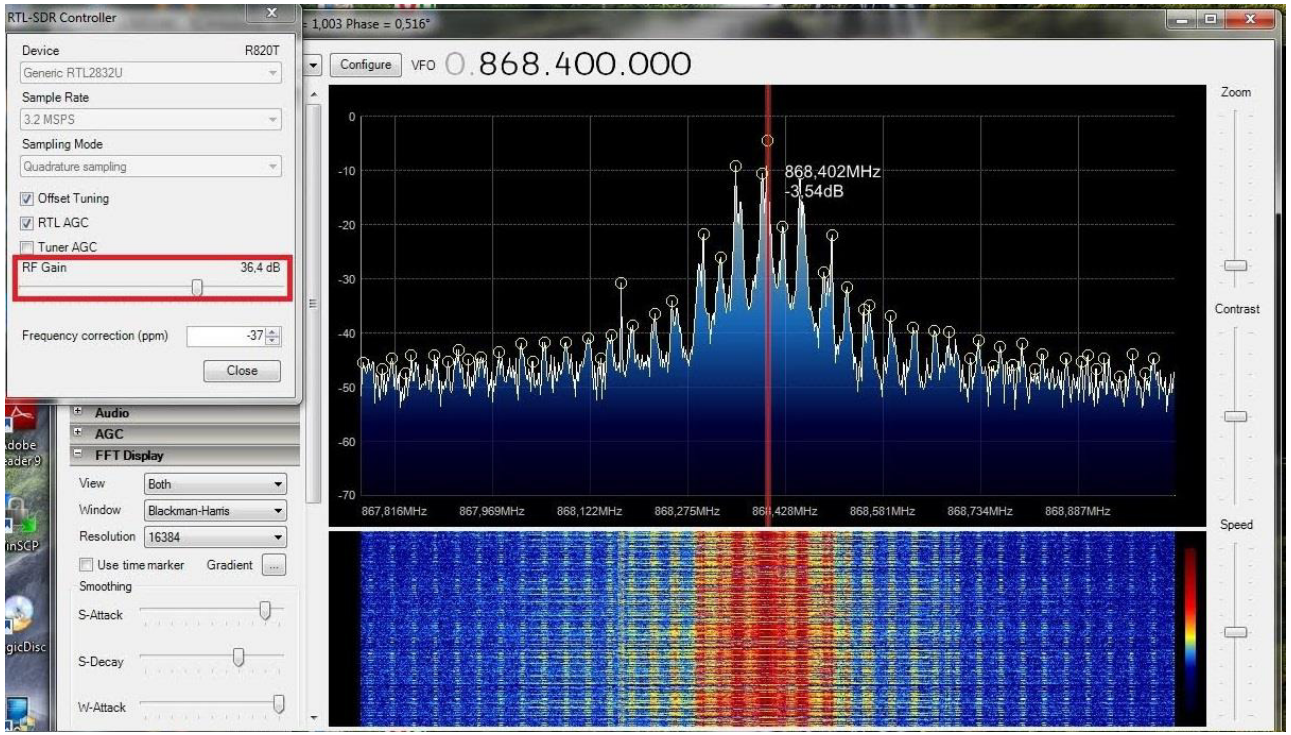


The test was performed between two instances of SoftRF hardware.
One were acting as a transmitter and another one – as a receiver.
Received data packets were accounted toward total packets been sent.
It was determined that there were no reception any more beyond 100 meters.
When carrier frequency was reduced from 868 MHz down to 433 MHz then the range has become better.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

First SofRF concept
Signal spectrum at 868 band

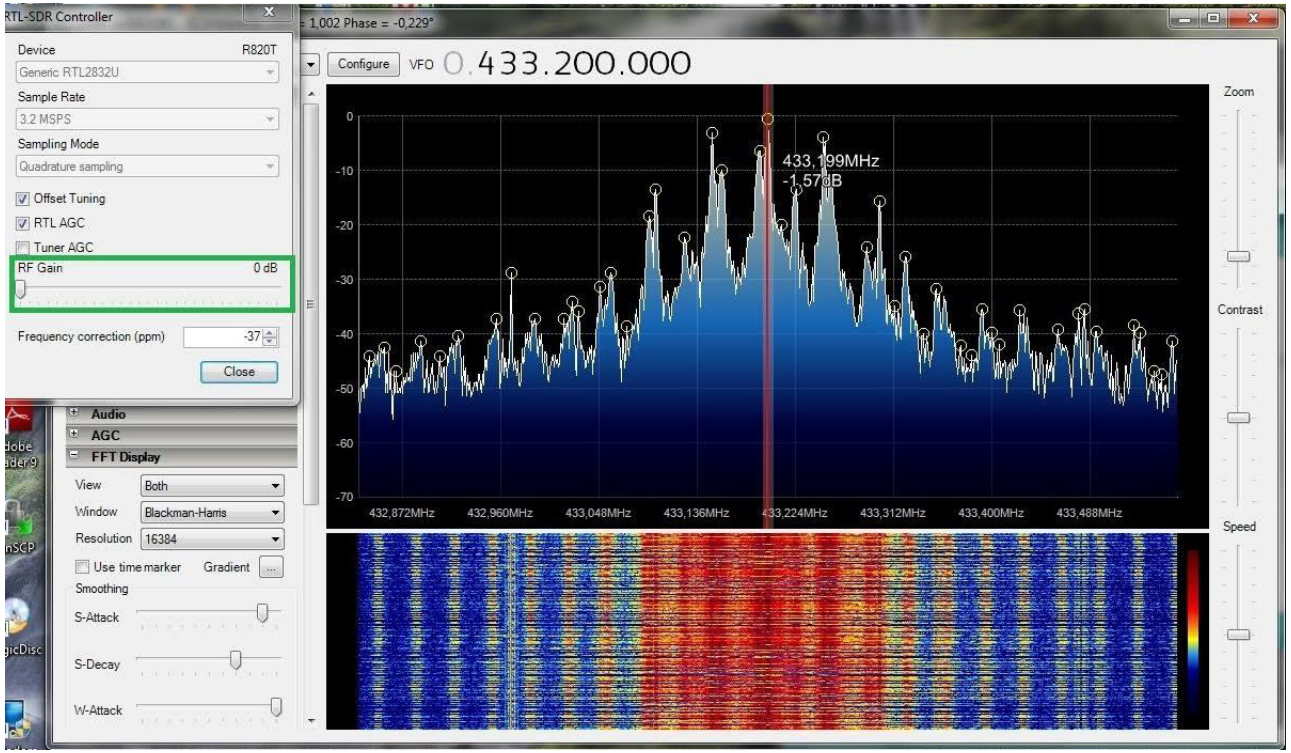
Back in the lab it was determined that **high gain** of analyzer is required to achieve good signal shape at 868 MHz:



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

First SofRF concept
Signal spectrum at 433 band

And **low gain** is sufficient at 433 MHz:



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Generic NRF905 module

Most of these modules are targeted for domestic China market. While 433 MHz band is legal in this country but the 868/915 MHz band is not (yet).

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Generic NRF905 module.

Issue #1.

There are 2 reference designs from Nordic Semiconductors specified in NRF905 datasheet. First one is for 433 MHz band and another one is for 868/915 MHz band.

Values for inductors (L) and capacitors (C) are widely different in these designs.

“433 MHz reference design” is implemented in domestic China NRF905 module.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Generic NRF905 module.

Issue #2.

Least expensive 16 MHz crystals are in use on these modules. The crystal may have as much as 100+ PPM resonance frequency offset range.

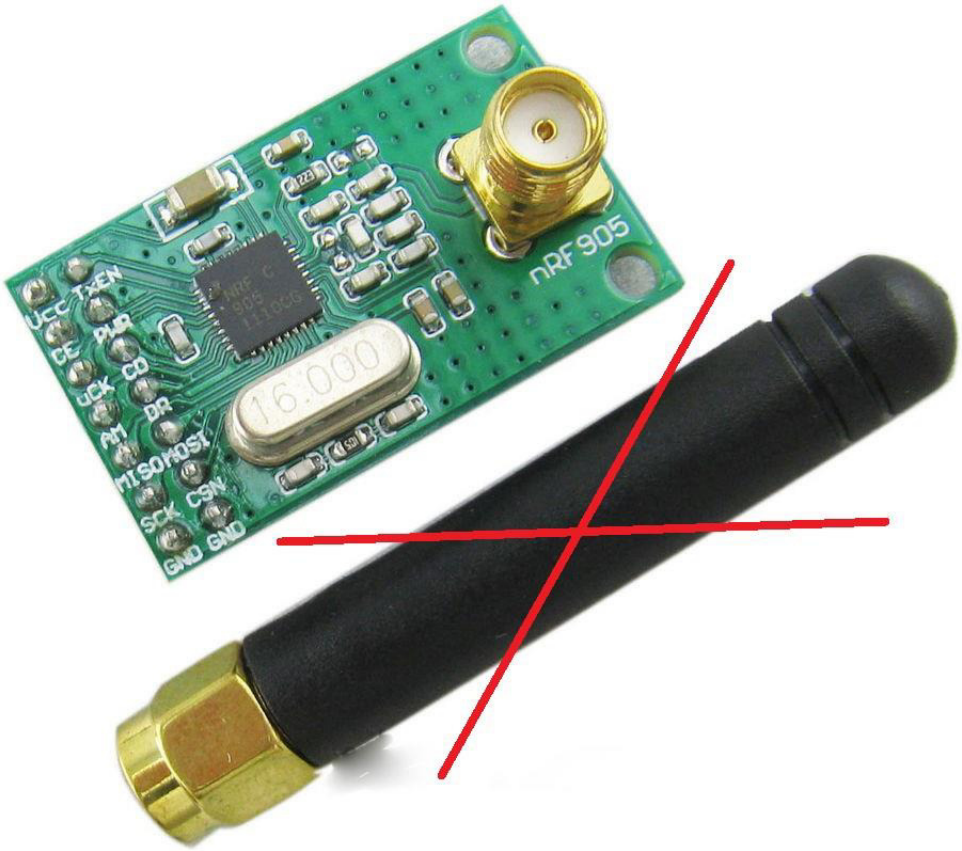
This means that when the module is by software set to operate at 868.4 MHz – it may actually operate at 868.5 MHz.

When two modules are communicating each other, one is on 868.4 and the partner is on 868.5 – they typically still able to talk, but the maximum operating range is deteriorating as much as twice.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Generic NRF905 module.

Issue #3.

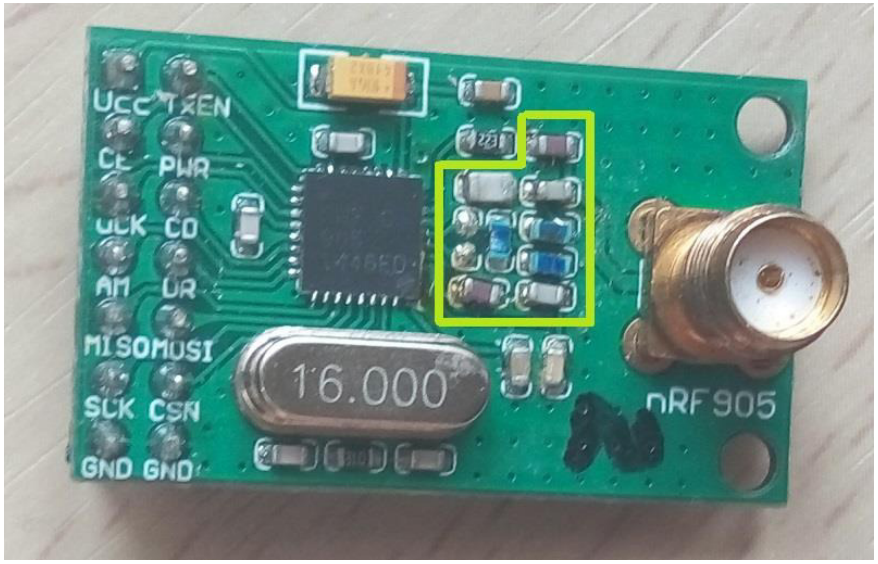


These modules are typically shipped with low quality, ineffective, short rubber duck antenna.

Think to substitute it with a good one as soon as practicable.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Solution 1 for issues #1 and #2. Re-soldering.

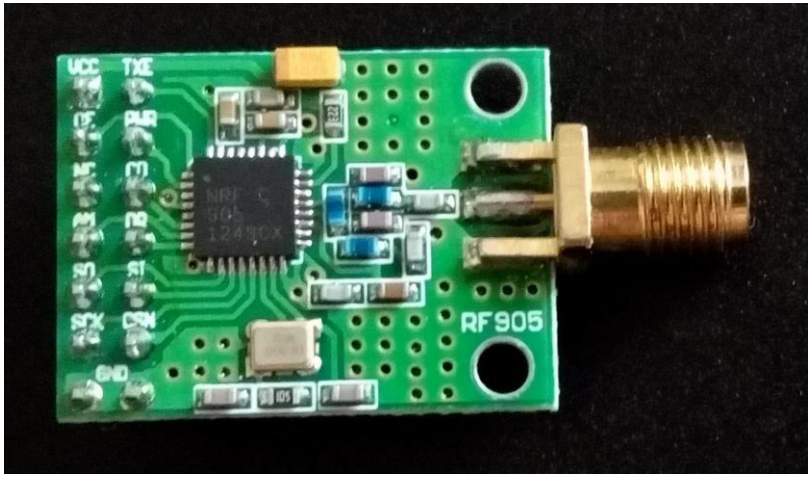


"433 MHz reference design" can be converted into "868/915 MHz" one by re-soldering of all dependent SMD components.

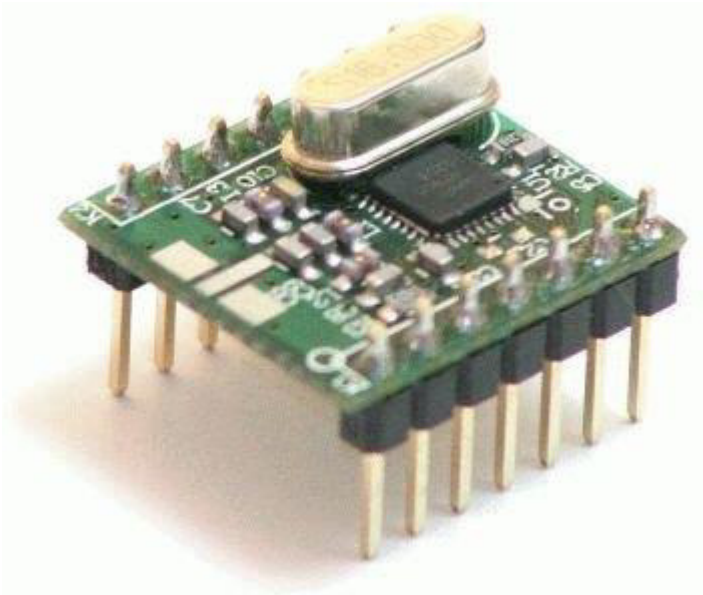
To get appropriate L and C values, please, refer to this Nordic Semiconductor's datasheet . Figure 15 on page 37.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Solution 2 for issues #1 and #2. 868/915 version of NRF905 module.



Fortunately, I've found out that some Chinese manufactures produce export version of the module targeted for EU and US markets. A known good example is this one.



As an alternative source, one may consider to use nRF905-C868 module from Montar Manufacturing, South Africa.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Solution for issue #3
Better antenna choice

VS

or

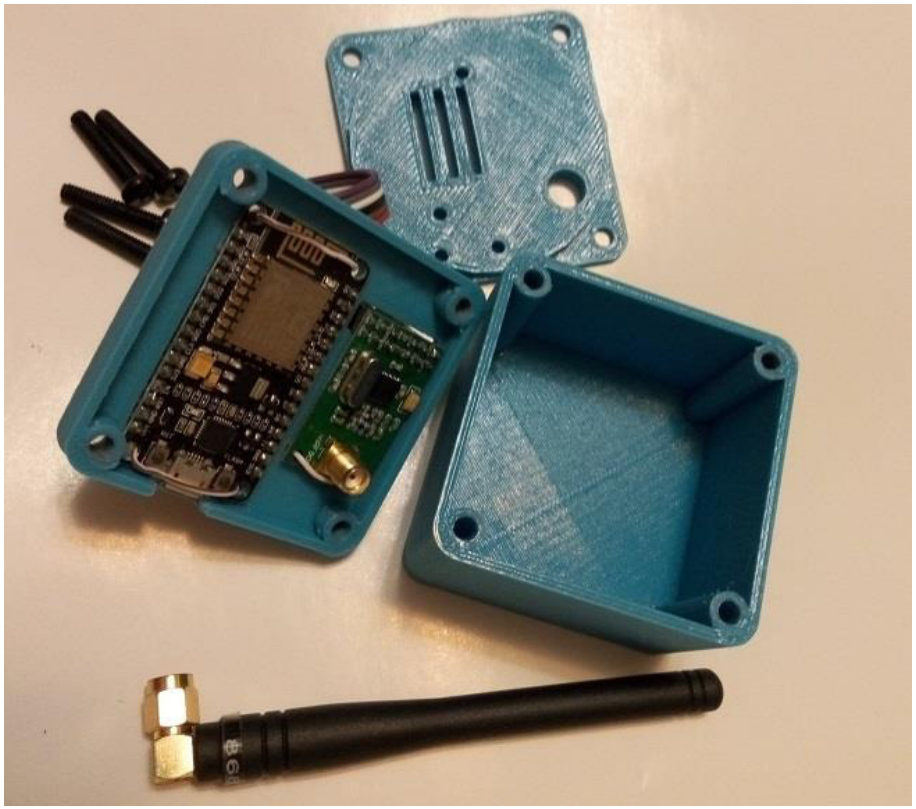
Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

SoftRF Prime Edition

A Prime Edition of SoftRF hardware is a direct successor of “SoftRF concept” that was presented in Part 1.
It has exactly the same electrical components that the concept had, but the issues with NRF905 modules were resolved by re-soldering.
A variety of 868 MHz antennas were also purchased to determine which one is the best.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

SoftRF Prime Edition



The Prime has also retained PCB-less design and “no soldering” rule as much as possible.

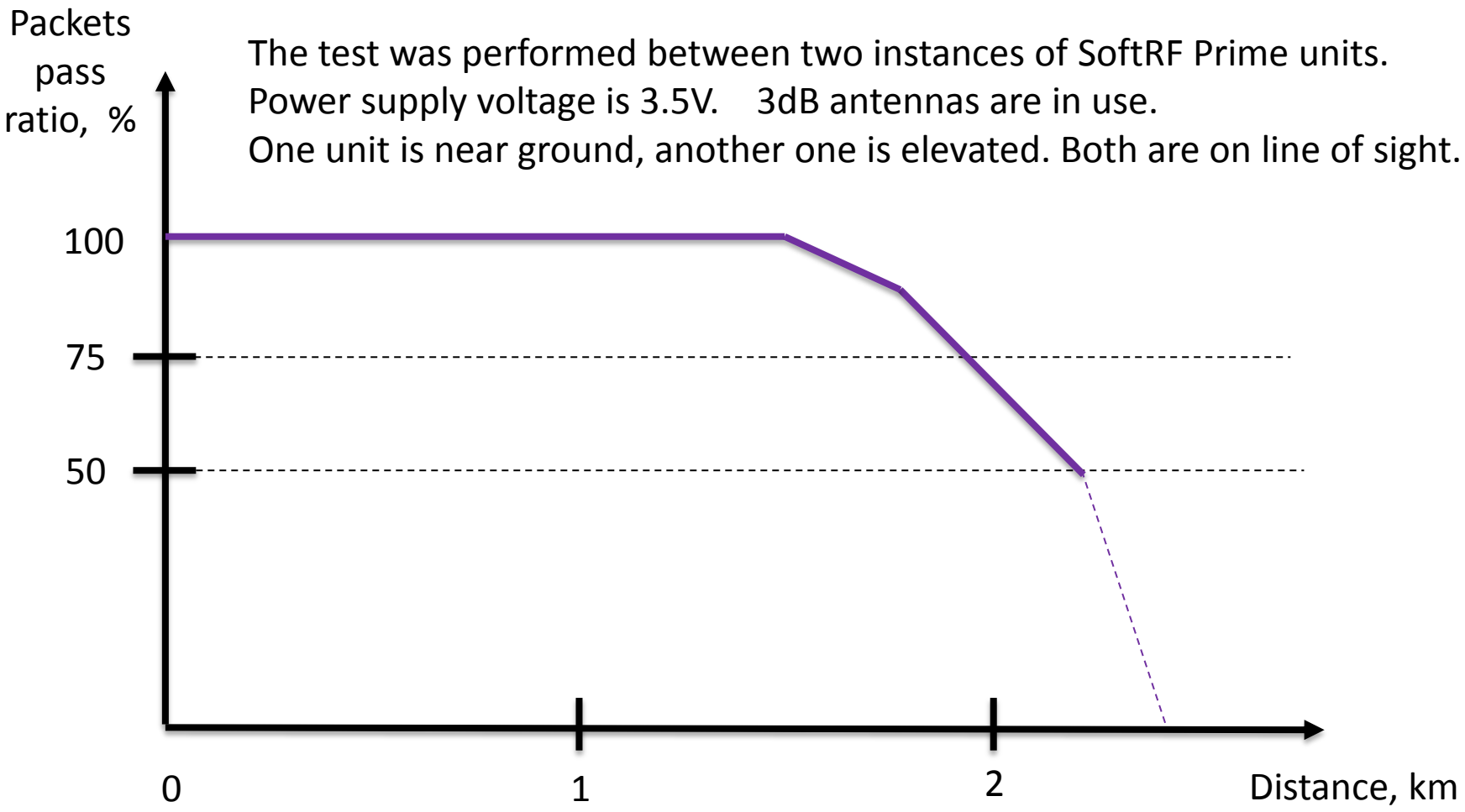
A custom 3D printable plastic shell was developed to protect the electronics from environment factors.
The 3D model of this enclosure is shared at Thingiverse.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Performance

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Operating range



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

NRF905 vs RTL-SDR Rx performance

One of the test goals was to compare SoftRF receive performance with some other of open source RF solutions.

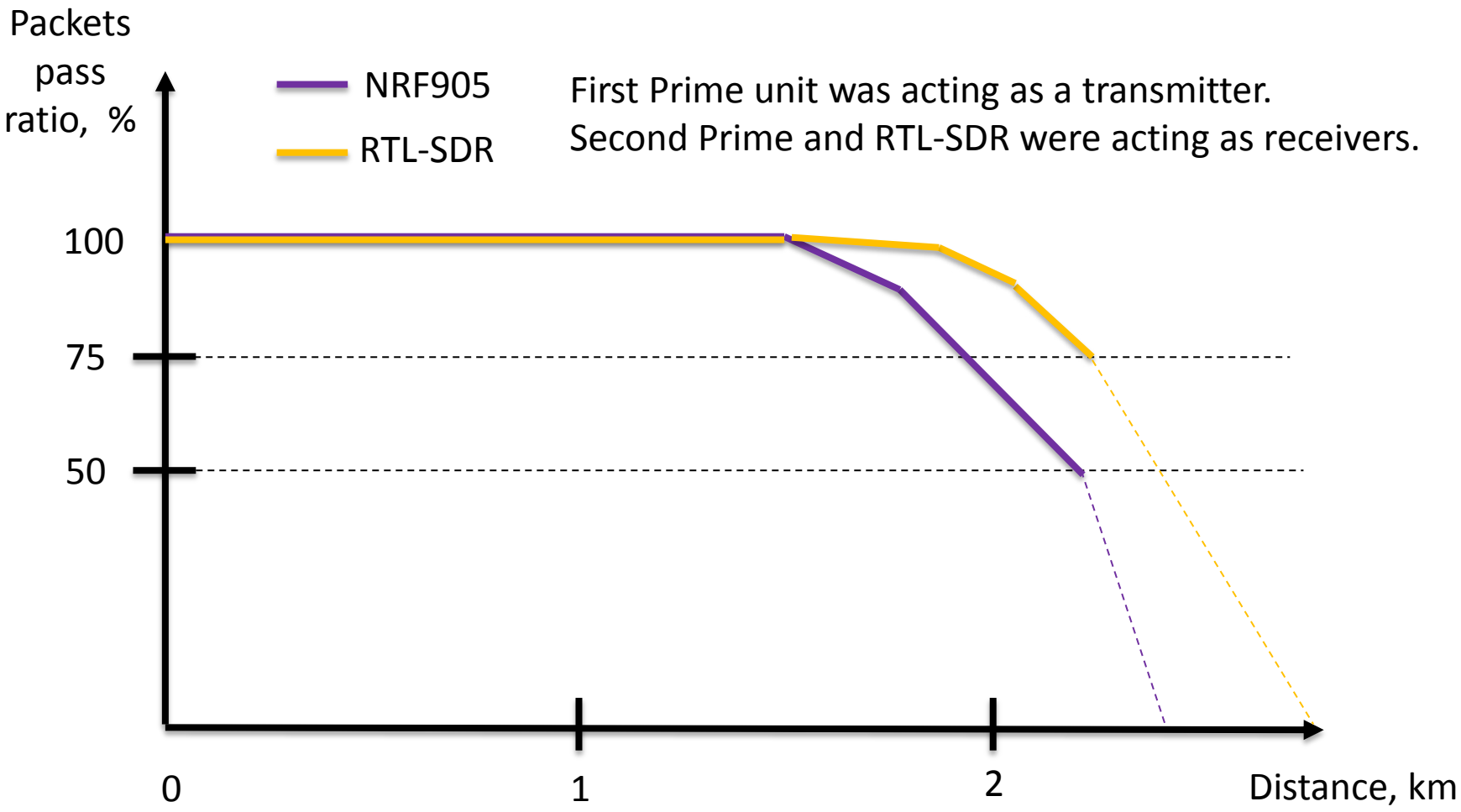
One of these, RTL-SDR was tested in factory configuration with “stock” antenna.

RTL-SDR was driven by “Flare” NRF905 software decoder developed by Stanislaw Pusep.

Preamp gain was set at 49.6 dB.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

NRF905 vs RTL-SDR Rx performance



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Compatibility

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

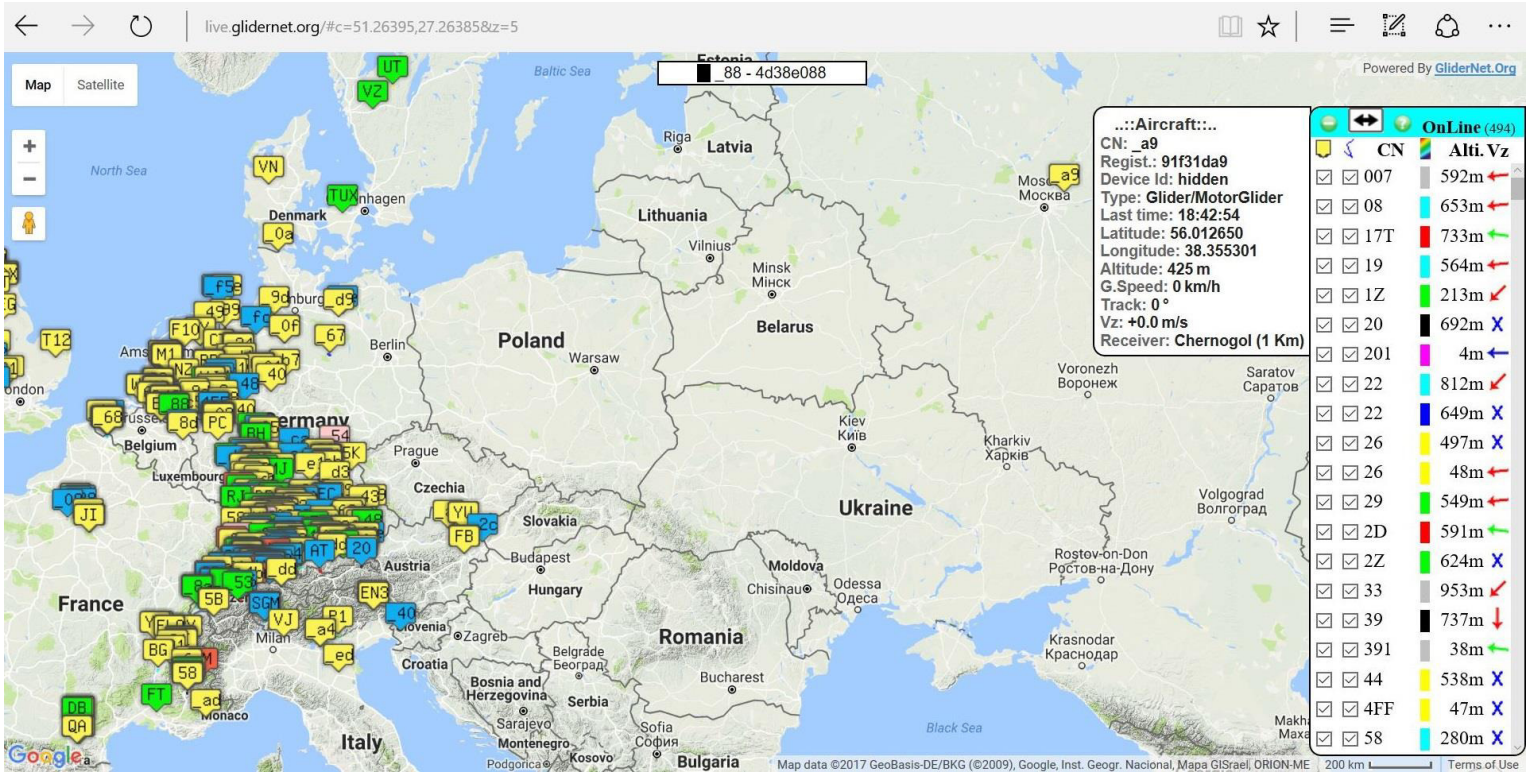
Radio

SofRF does implement a fraction of closed FLARM™ radio protocol version 6. On the picture below you can see a field test when SoftRF Prime and LX9000/FLARM units are able to see each other.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Radio

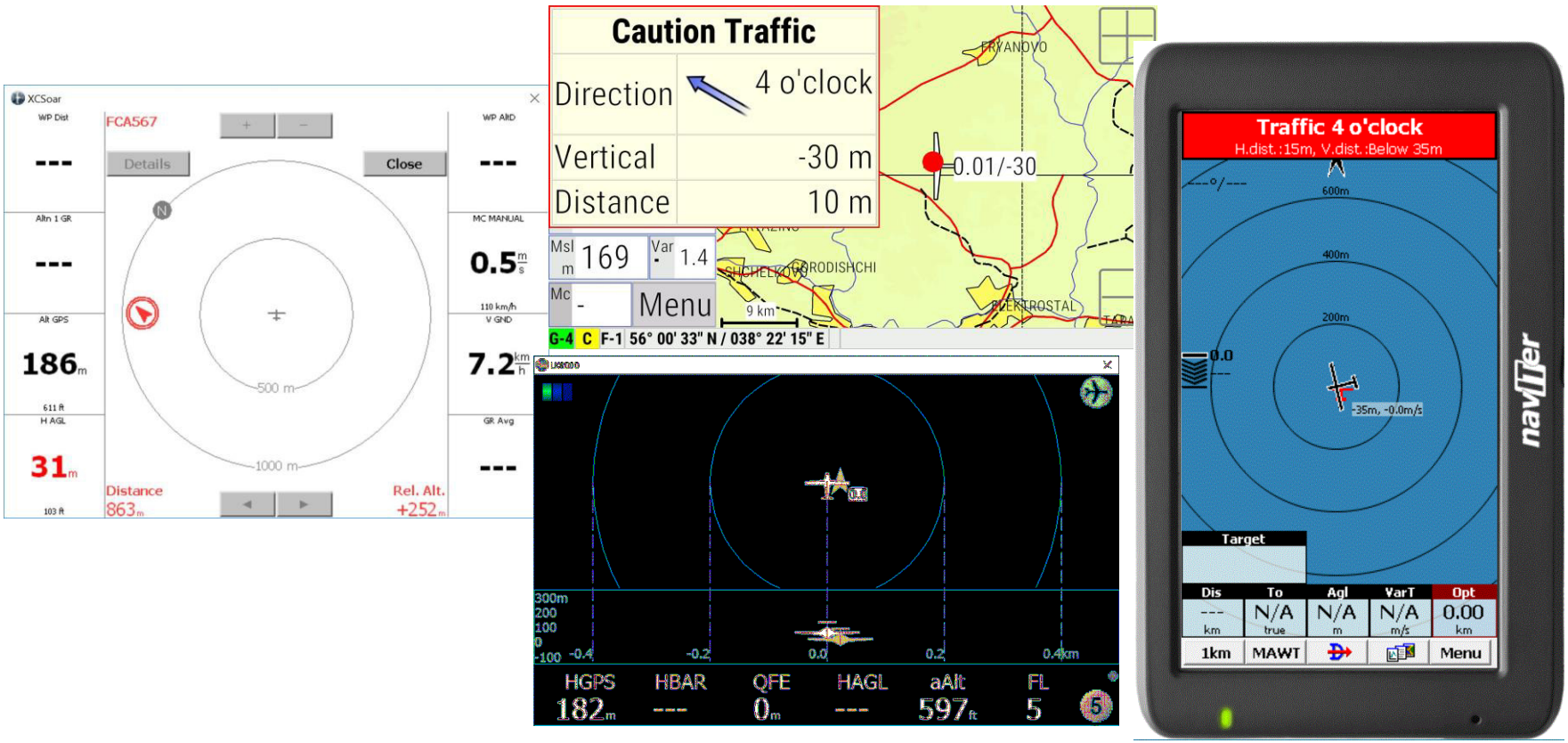
It was also verified that SoftRF can operate with Open Glider Network.
On this screenshot you may see that infra of OGN can receive signal from a SoftRF unit located near city of Moscow.



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Data

SofRF does implement a fraction of open FLARM™ DATA protocol version 3.
It is known to work with XCSoar, Cumulus, LK8000, SeeYou Mobile.

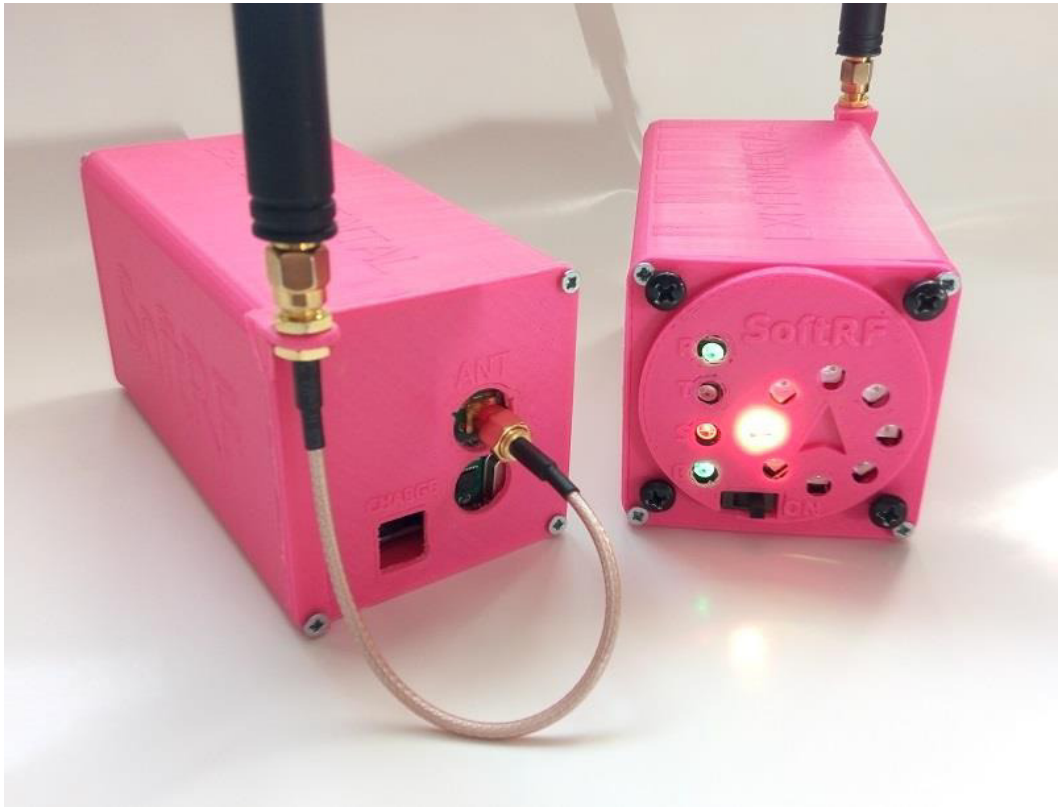


Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Hardware

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Standalone Edition



Based on successful tests of the Prime and taking into account expected demands of soaring and GA societies it was decided to develop autonomous, standalone version of SoftRF.

Standalone Edition:

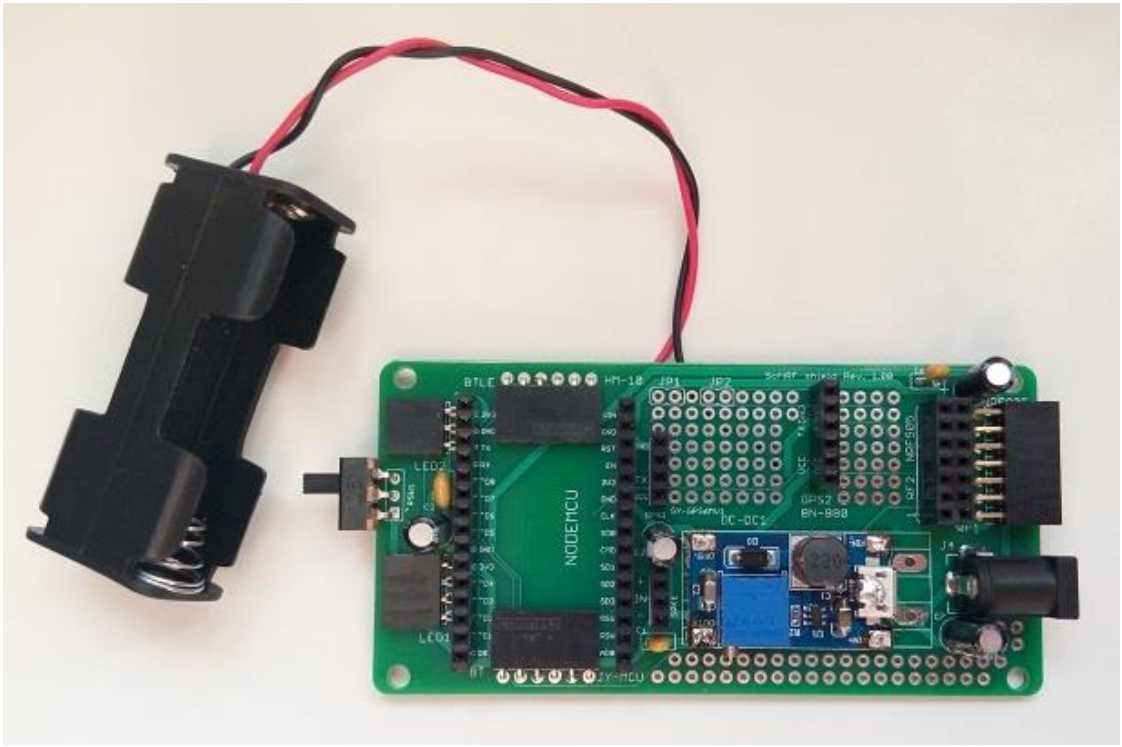
- has own GNSS receiver ;
- has “smart” firmware ;
- gives traffic alerts with LEDs and audio ;
- supplies NMEA data to onboard flight computer by Bluetooth or Wi-Fi ;
- is self-powered.

For more detailed specifications, please, read [this wiki page](#).

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Shield

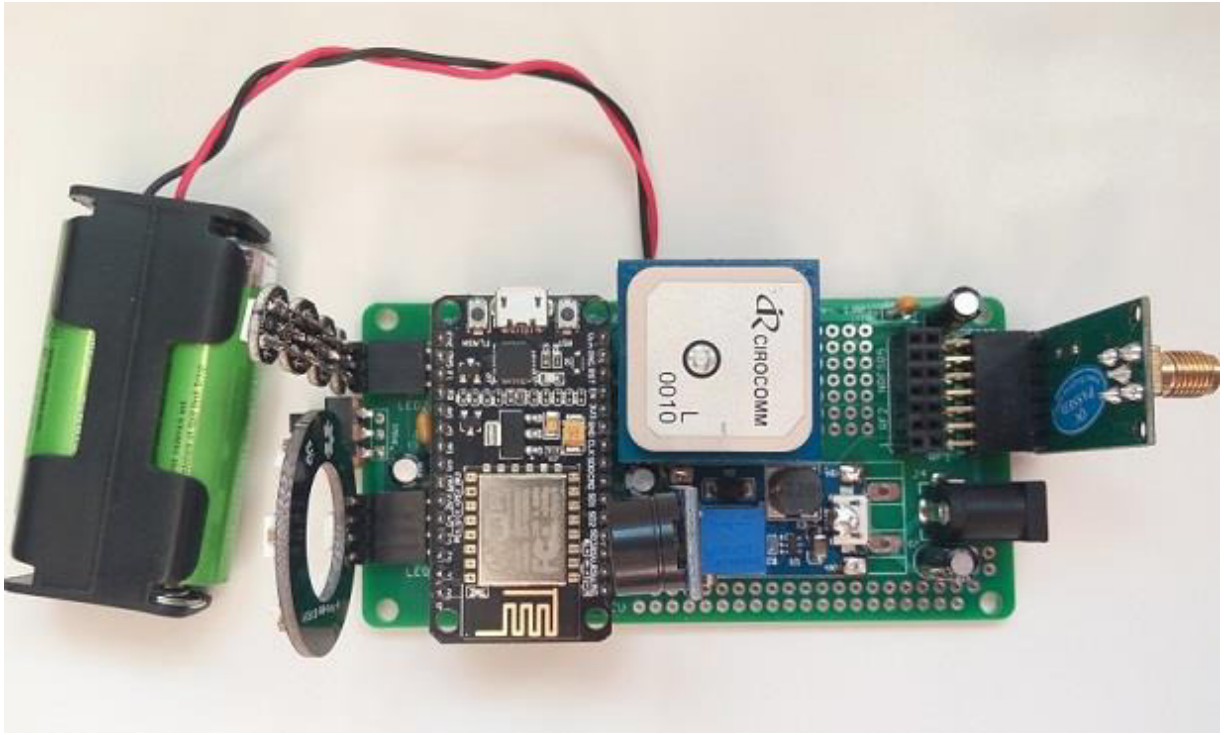
To keep it simple for volunteers to reproduce, it was decided to create a “shield” for all the electronic components. You may already know, this approach is kind of typical for most DIY “Arduino world” solutions.



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Modules

Complete board of electronics consists of the shield itself been stuffed with numerous modules and components that are pretty cheap and easily available for purchase from different sources.
For the list of pluggable parts, please, visit this page.



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Enclosure

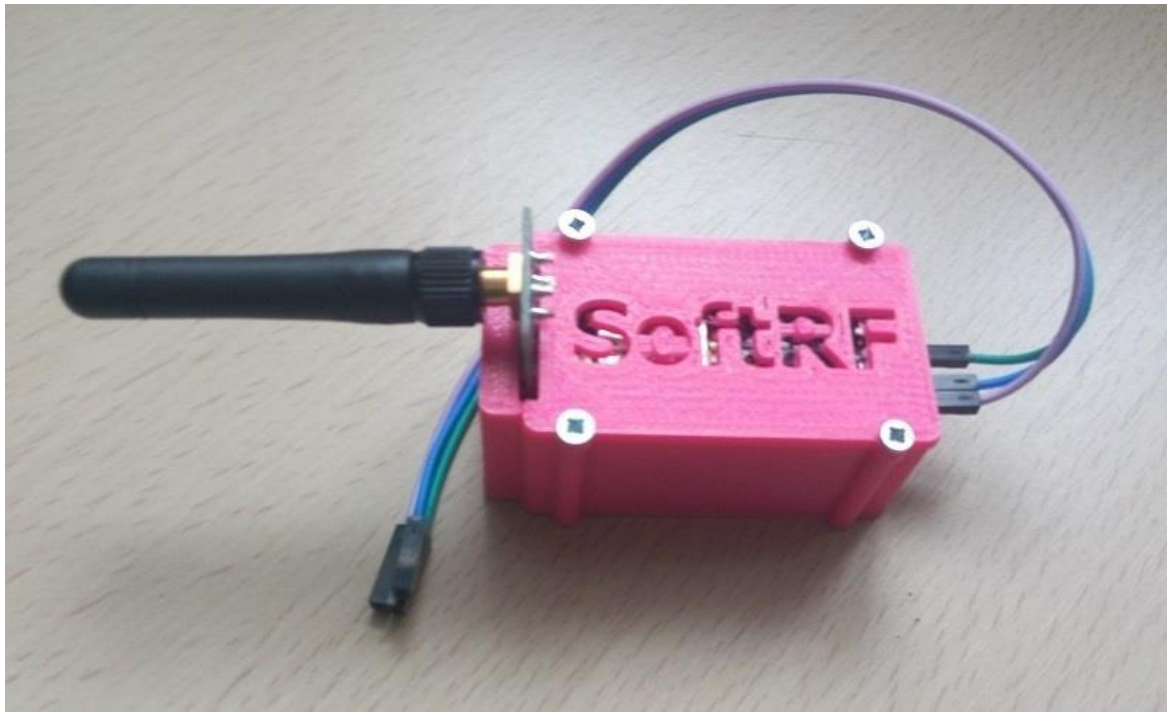
All the electronics is protected by a custom designed case.

Genuine design of this enclosure is shared as well and available for download from [this page on Thingiverse](#).

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

UAV Edition

A version of SoftRF that is targeted for UAV use had also substantial progress of development through year 2016. The unit shown below is to be connected to UAV's autopilot. MAVLINK 1.0 communication protocol is supported. At this moment, the device is "transmit-only", but this is mostly current firmware's limitation.



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Firmware

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

License

Source code of SoftRF firmware was released and still maintained under GNU General Public License version 3.

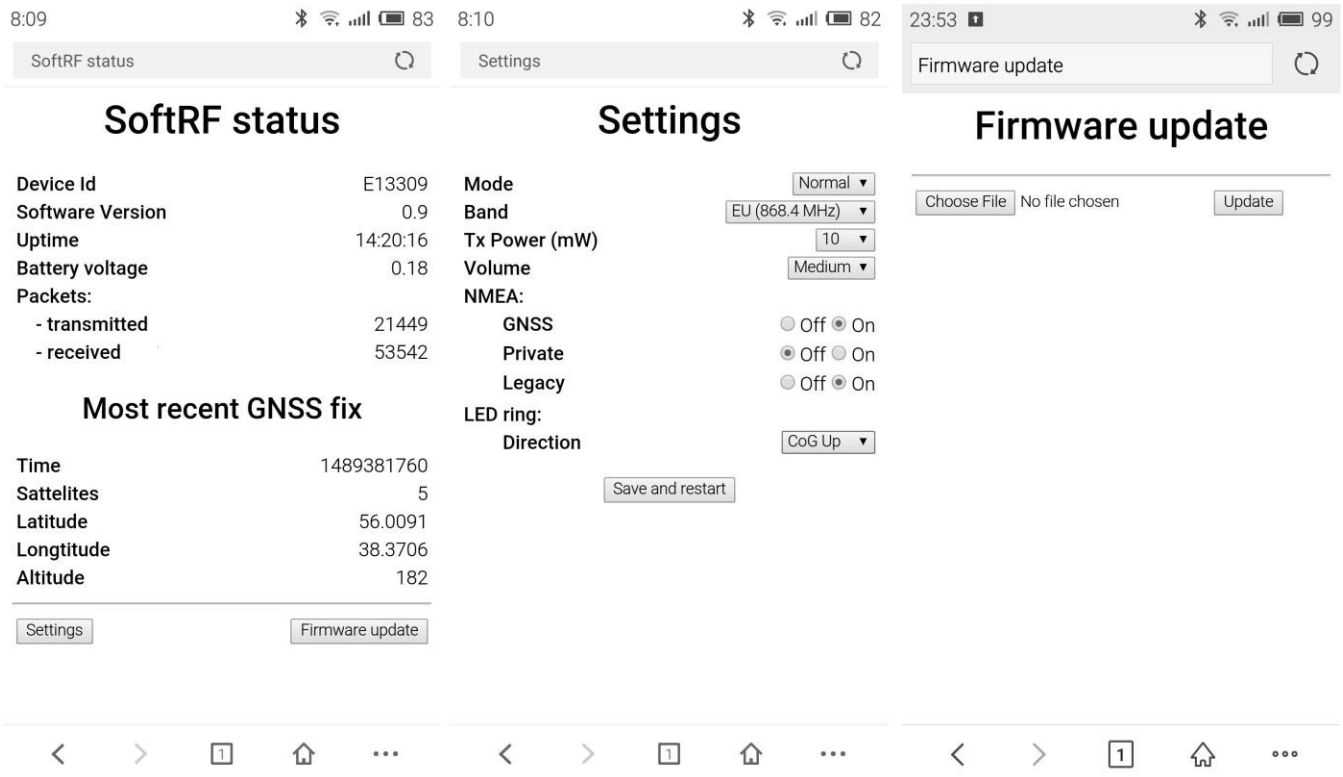
It is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY.

A friendly reminder for authors who has created derivatives of SoftRF firmware since date of the first publication:

In accordance with GNU GPL you have to keep your source code open!

Interface

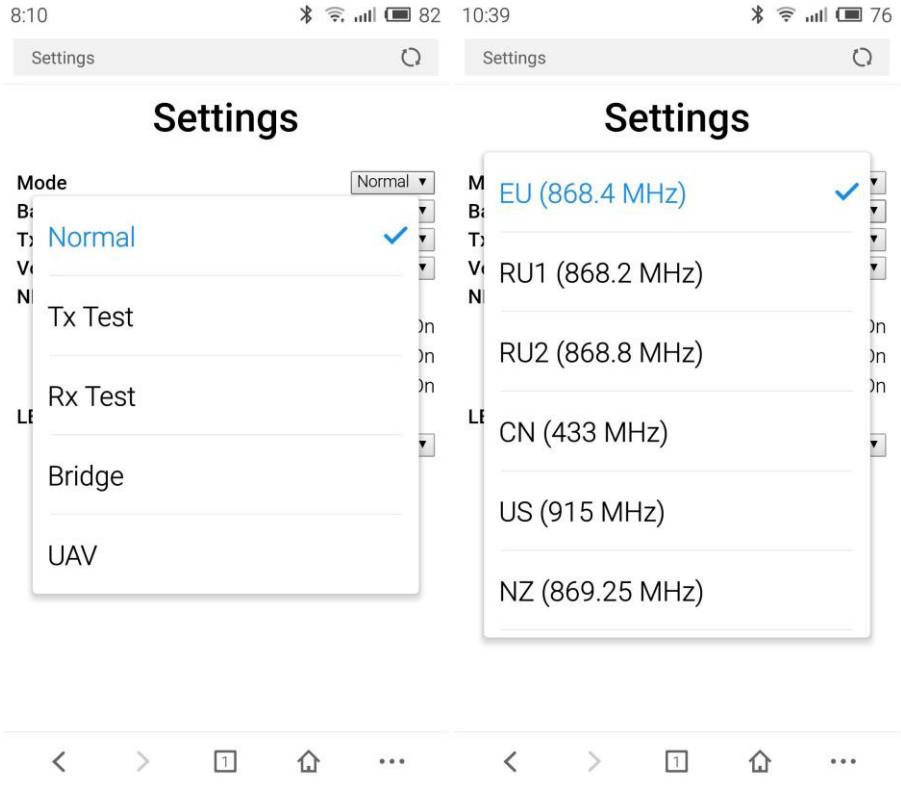
Since the SoftRF is running on a popular IoT platform, it uses pretty recent human interface method – Web over Wi-Fi. No knobs, no buttons any more. Your smartphone is the primary monitoring and configuration tool.



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Interface

The firmware is unified across all the SoftRF editions.
Current role of the unit can be selected in “Settings” menu.
You should also set operating frequency onto which one is legal for your country.



Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Software

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Emulator

While Standalone Edition is a self-contained unit which needs no support from outside, but Prime and UAV, to be effective, both need at least a trustworthy external GNSS source. Software emulator for traffic proximity alerts was developed as an alternative to firmware-based approach.

Emulator is running on an Android tablet as a Python script and is using a built-in GNSS source to get location data and time stamp. Then it emulates FLARM™ radio and data protocols. SoftRF unit is acting as raw data bridge between the tablet and “RF Air”.

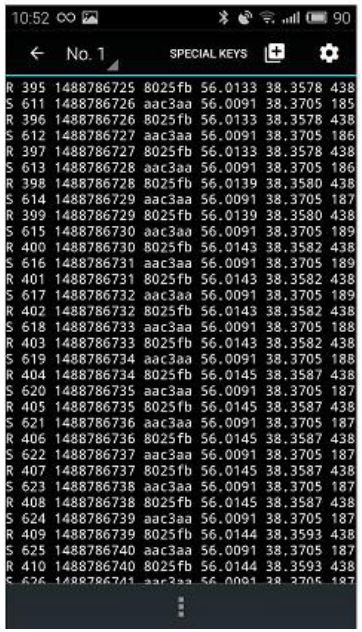
On the left photo an XCSoar for Android is showing a traffic alert with assistance of SoftRF.

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Emulator

Navigation software is running on the same tablet/smartphone and is communicating to the Emulator with local UDP network packets.
No alteration of navigation software is necessary.
Recently released LK8000 for Android is also known to work with SoftRF.

Emulator



LK8000

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.

Test drive

At this moment five Standalone units were manufactured and are currently available for regional soaring and GA pilots in Russia who want to participate in free “3 weeks Test Drive” program.

Thank you for your attention!

Development page of this project is located at GitHub:

http://github.com/lyusupov/SoftRF

Welcome to build!

Welcome to contribute!

Linar Yusupov (linar.r.yusupov@gmail.com). March, 2017.