Dou It Yourself Proximity Warning Device

Brief outlook on the concept, design and test prototype

Presented by «Linar Laboratories»

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Idea

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Goals

- Meet assigned tech. specifications
- No soldering skills required to build device
- Parts are easily available at local store, e-store, Ebay or Taobao
- No h/w tools required to install firmware(s)
- Application software is h/w independent, simple enough to be altered by a user

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Technical specifications

- Operation range:
  - at least within 1.5 kilometers in radius
- Tracking:
  - at least 7 objects simultaneously
- «From-Position-to-Mark» latency:
  - not more than 2-3 seconds

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Choices of ISM band radio inter-communication

- «RF Module» (868/915 MHz)
- ZigBee (868/915 MHz or 2.4Ghz)
- Wi-Fi (2.4Ghz or 5.8Ghz)
- ADS-B (ES 1090Mhz or UAT 978Mhz)*

* ADS-B is not at ISM band(s). It operates at one of «aviation» frequencies.

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«RF Module» (868/915 MHz)

PROS

- Great «range to power consumption» ratio
- Compact size
- Same band that FLARM* already uses

CONS

- Only a few USB-to-RF dongles are available on the market, most are «short range»
- No common, transparent interface to Linux

* FLARM® - is a registered trademark of FLARM Technology GmbH.

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ZigBee (868/915 MHz or 2.4Ghz)

PROS

- Great «range to power consumption» ratio
- Compact size

CONS

- Only a few USB-to-RF devices are available on the market, most are relatively expensive
- No common, transparent interface to Linux yet

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Wi-Fi (2.4Ghz or 5.8Ghz)

PROS

- Good range at reasonable power consumption
- Numerous USB-to-WiFi «extended range» devices are available on the market
- Great unified interface in Linux for data capture/injection (mac80211)
- Low price for «mass products»

CONS

- Some countries apply limitations on transmission power or outdoor use
- Reception noise level can be high near congested areas due to wi-fi hotspots, microwave equipment, etc.

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ADS-B (ES 1090Mhz or UAT 978Mhz)

PROS

- Becoming a standard for aviation use within next few years (EU till 2018, US till 2020)

CONS

- No transceivers available on the mass product market yet
- No common, transparent interface to Linux

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Decision

- Make use Wi-Fi technology first
- Keep an eye on RF868/915 and ZigBee, modular USB design will allow to detach Wi-Fi then attach another RF hardware if necessary
- Think about and try to make few steps toward further transition onto ADS-B (ES 1090)

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Hardware inter-connectivity

In order to

- meet «no soldering» requirement
- make use a variety of inexpensive mass products available on the market
- to satisfy limited space constraints

decision is to utilize USB Bus as a primary internal hardware interface.

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Theory

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Radio signal attenuation

Reduction in power of an electromagnetic wave as it propagates through space can be estimated by:

$$\mathcal{L} = 20 \log_{10} \left(\frac{4\pi d}{\lambda} \right)$$

where

- $\mathcal{L}$ - is the path loss in decibels,
- λ - is the wavelength,
- d - is the transmitter-receiver distance in the same units as the wavelength

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Path loss for typical ISM bands

- 868 MHz (EU)

Distance, km	1	2	3	4	5
$\mathcal{L}$, dB	91	97	101	103	105

- 915 MHz (US)

Distance, sm	1	2	3	4	5
$\mathcal{L}$, dB	96	102	105	108	110

- 2.4GHz

Distance, km	1	2	3	4	5
$\mathcal{L}$, dB	100	106	110	112	114

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868MHz vs. 2.4GHz

PROS

- Transmitter at 868MHz needs 9dBm less power for the same range, or 3X range for same power than 2.4 GHz transmitter

CONS

- Wavelength at 868MHz is 2.8X longer than at 2.4GHz, so 2.4GHz omnidirectional antenna's gain of the same size is higher

TOTAL

- **System** at 868MHz gives approx. 1.5X (3dB) increase in range at the same power and same antennas size

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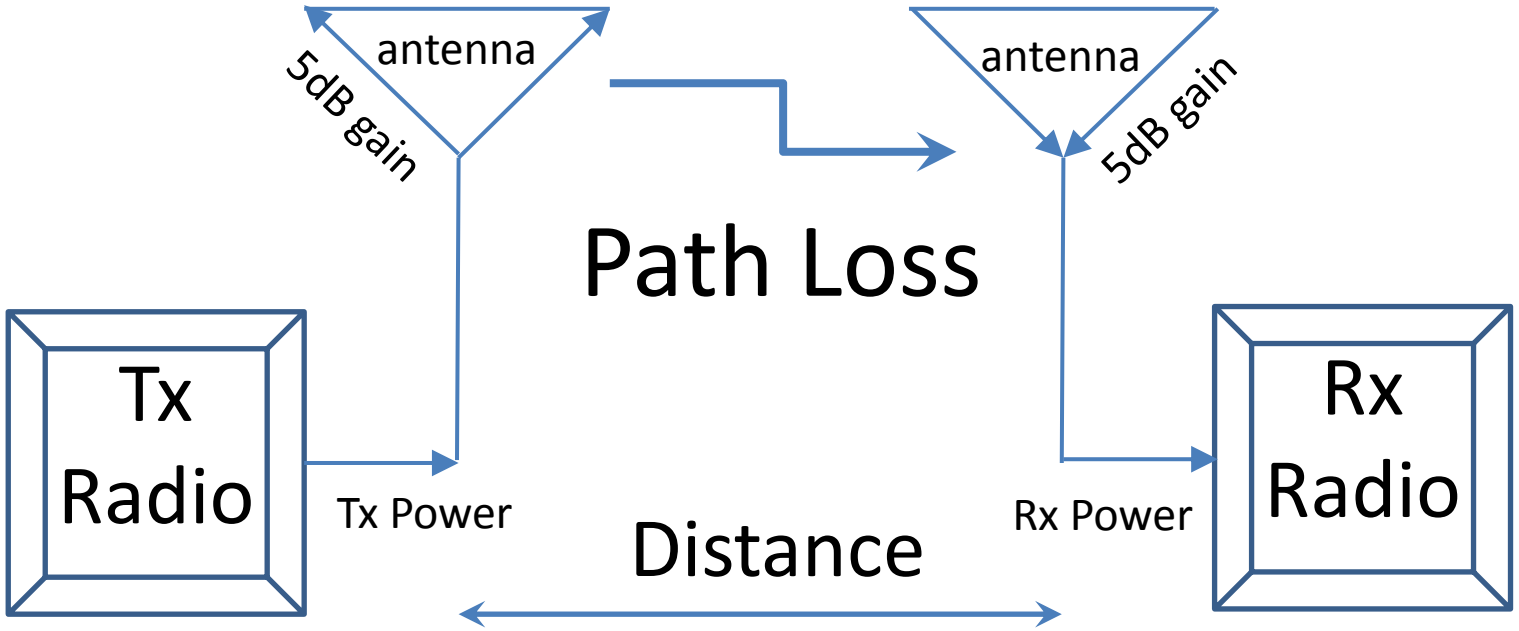
Wireless Distribution System



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Reception Signal Quality

- Margin – is the ratio by which the Rx signal exceeds the minimum amount for proper operation
- How typical Wi-Fi margin values affect reception quality:

Margin, dB	<10	10-20	>20
Reception quality	*No*	*Poor*	*Good*

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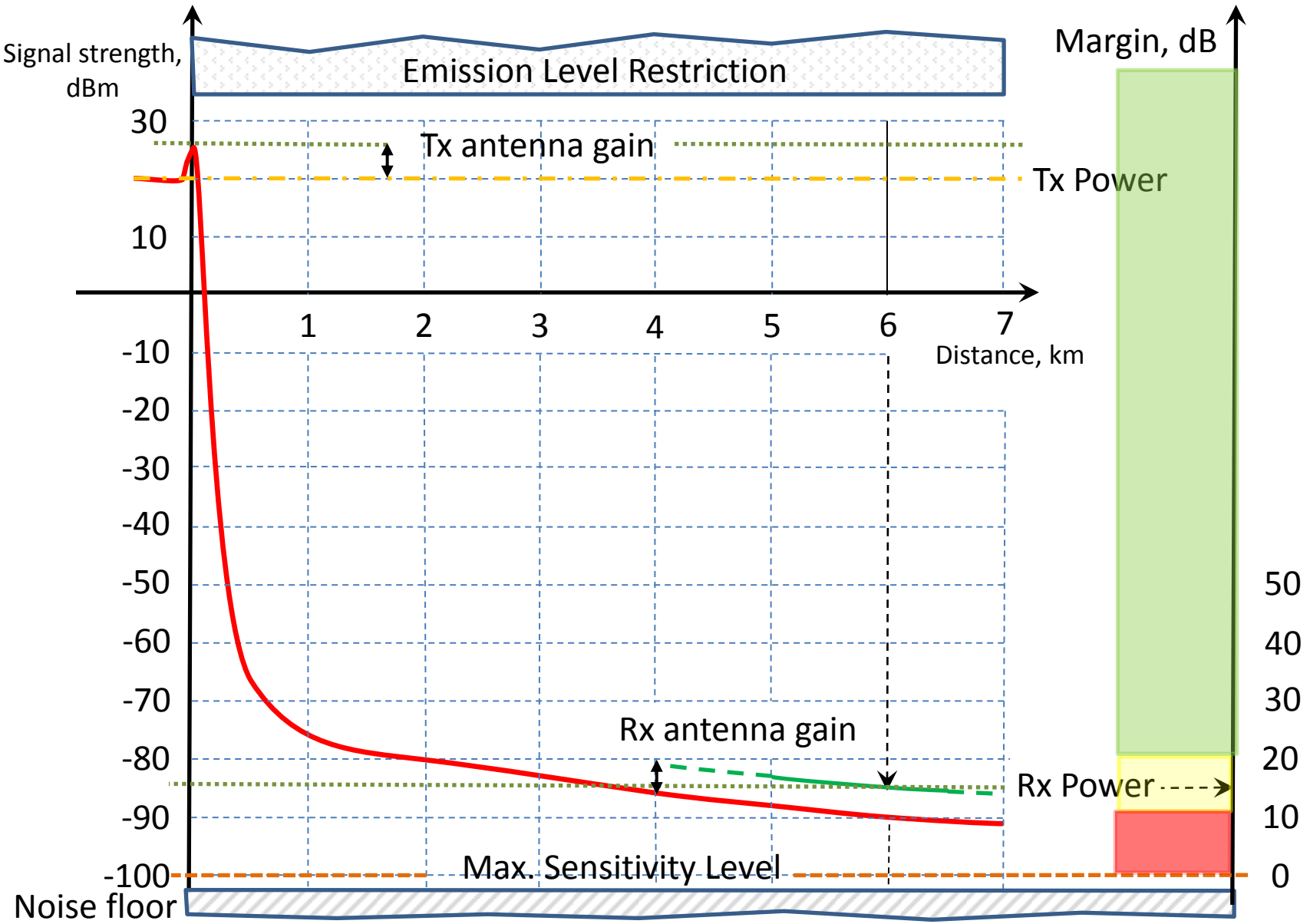

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FCC

At 2.4 GHz for Tx antenna gain ≤ 6 dbi:

- Max Tx Power: 30 dBm;
- Max EIRP: 36 dBm;

Sensitivity -100 dBm, Tx/Rx antenna gain 5dBi:

Distance, sm	1	3	5	8	10
$\mathcal{L}$, dB	104	114	118	122	124
Rx power, dBm	-63	-73	-77	-81	-83
Margin, dB	37	27	23	19	17

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ETSI

At 2.4 GHz:

- Max EIRP: 20 dBm;

Sensitivity -100 dBm, Tx/Rx antenna gain 5dBi:

Distance, km	1	1.6	3	4	5
$\mathcal{L}$, dB	100	104	110	112	114
Rx power, dBm	-75	-79	-85	-87	-89
Margin, dB	25	21	15	13	11

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Long range USB Wi-Fi adapter

Alfa Networks AWUS036H

FCC ID: UQ2AWUS036H
Emission Type: DSSS/OFDM
Wireless: IEEE 802.11b/g
Sensitivity 802.11b 1 Mbps (B/QPSK): - 96dBm
typically @PER < 8%
packet size 1024 and
@25ºC + 5ºC
Max. output power: 24.5dBm (by FCC test)
EIRP : 29-30dBm (with 5dBi antenna)
Linux support:
full-featured “mac80211” open-source driver with packets capture/injection

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AWUS036H

- Max Tx Power: 24 dBm by FCC test ;
- Sensitivity: -96 dBm ;
- Tx antenna gain: 5dBi , EIRP: 29 dBm ;
- Rx antenna gain: 5dBi ;

Distance, sm	1	1.8	3	5	8
$\mathcal{L}$, dB	104	109	114	118	122
Rx power, dBm	-70	-75	-80	-84	-88
Margin, dB	26	21	16	12	8

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Hardware

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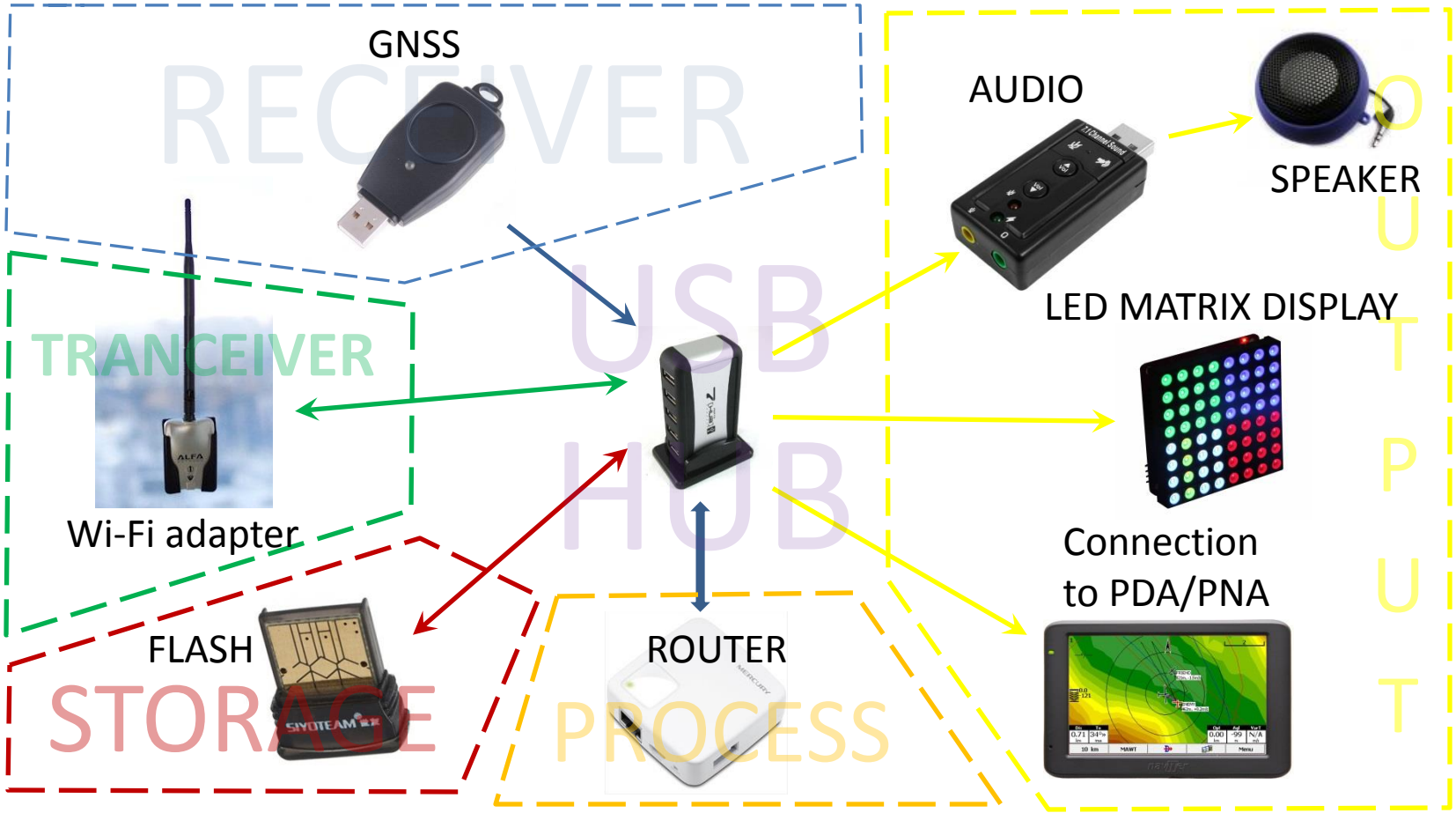
Standard components overview



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Processing module

Brand

- TP-Link

Model

- TL-WR703N

Features

- Atheros AR7240 32-bit CPU (MIPS) @400Mhz
- Atheros integrated wireless 802.11 b/g/n
- 4 MB flash memory
- 32 MB RAM
- USB 2.0 port
- Tiny form factor: 5.7cm x 5.7cm x 1.8cm
- Supported by OpenWrt (Linux) project

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Equivalents of WR703N available on other markets

Mercury MW151RM-3G

Fast FWR171-3G

TP-Link MR3020

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Storage module

The router being used as a processing module has limited internal storage size.

Software pack that manages the system requires 50-100 Mbytes of permanent memory to store programs and data.

This USB-Drive provides enough memory to meet the requirement mentioned above.

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GNSS module

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Bus interconnect

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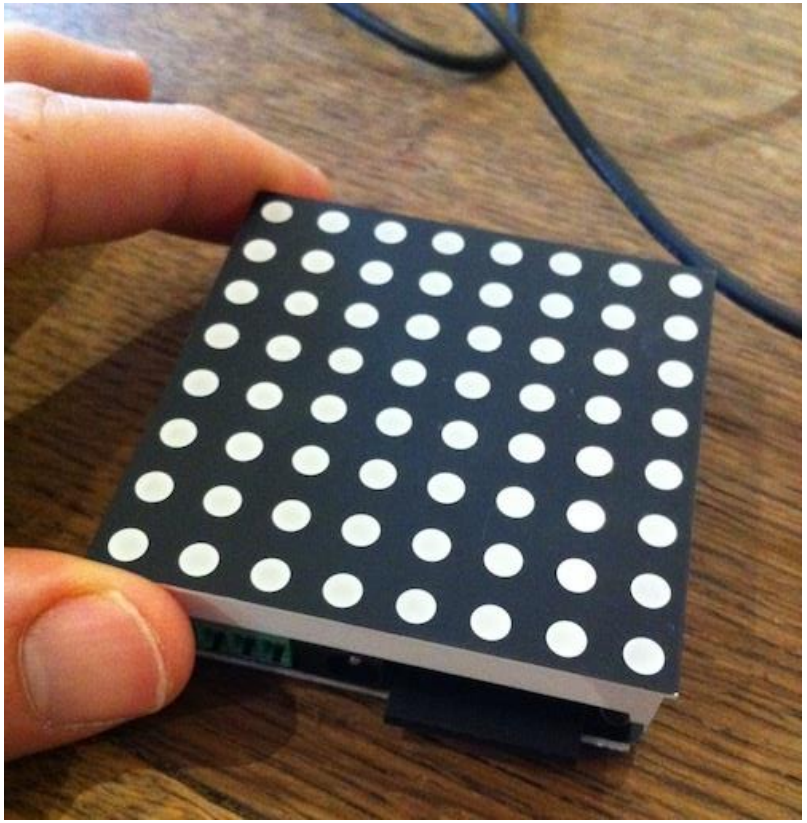
USB Display



The display consists of:

- 60x60mm 8x8 RGB LED matrix (on top) ;
- USB LED display controller (on the bottom) ;

The controller is either:

- «Rainbowduino» by Seeed Studio, or ;
- «Colorduino» by Itead Studio ;

- both are supported.

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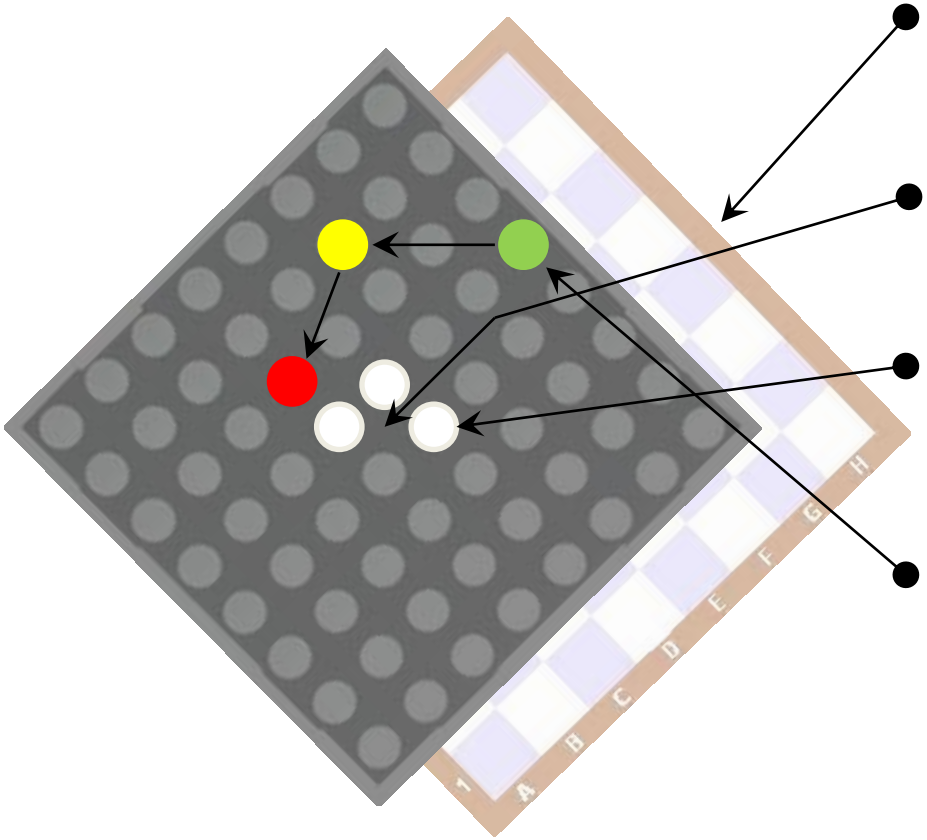
LED display purpose



- The display depicts a «chess board» been rotated at 45 degrees ;
- Position of the observer is in the center of the «board» ;
- Three white colored LEDs in the center of display depicts an «arrow» in the direction of motion (or «north-up») ;
- Red, yellow and green LEDs depicts a traffic in the vicinity of observer ;

«Closer to center» means «closer to observer», warning level is color-encoded ;

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Audio module

USB Sound Card is employed to provide voice and audio traffic alerts for sailplane pilots with no necessity to look at the instrument panel.

The speaker delivers these alerts from device to the pilot’s ears.

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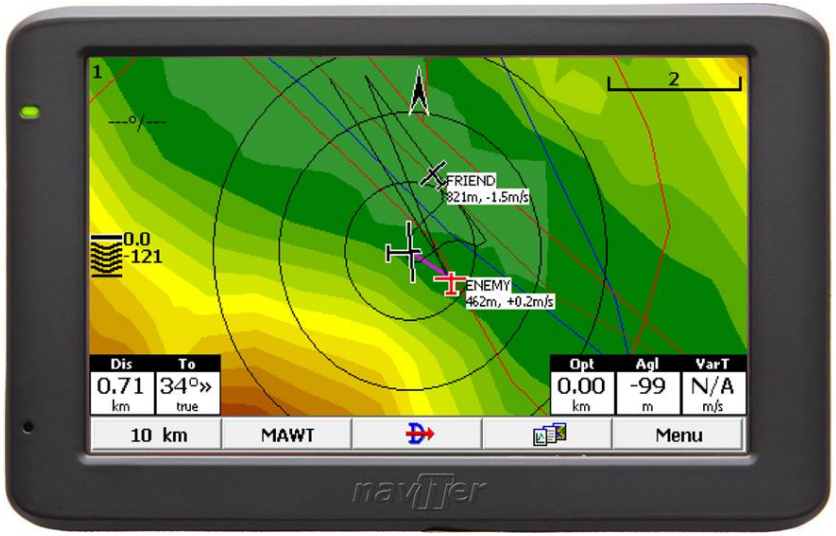
External output interface



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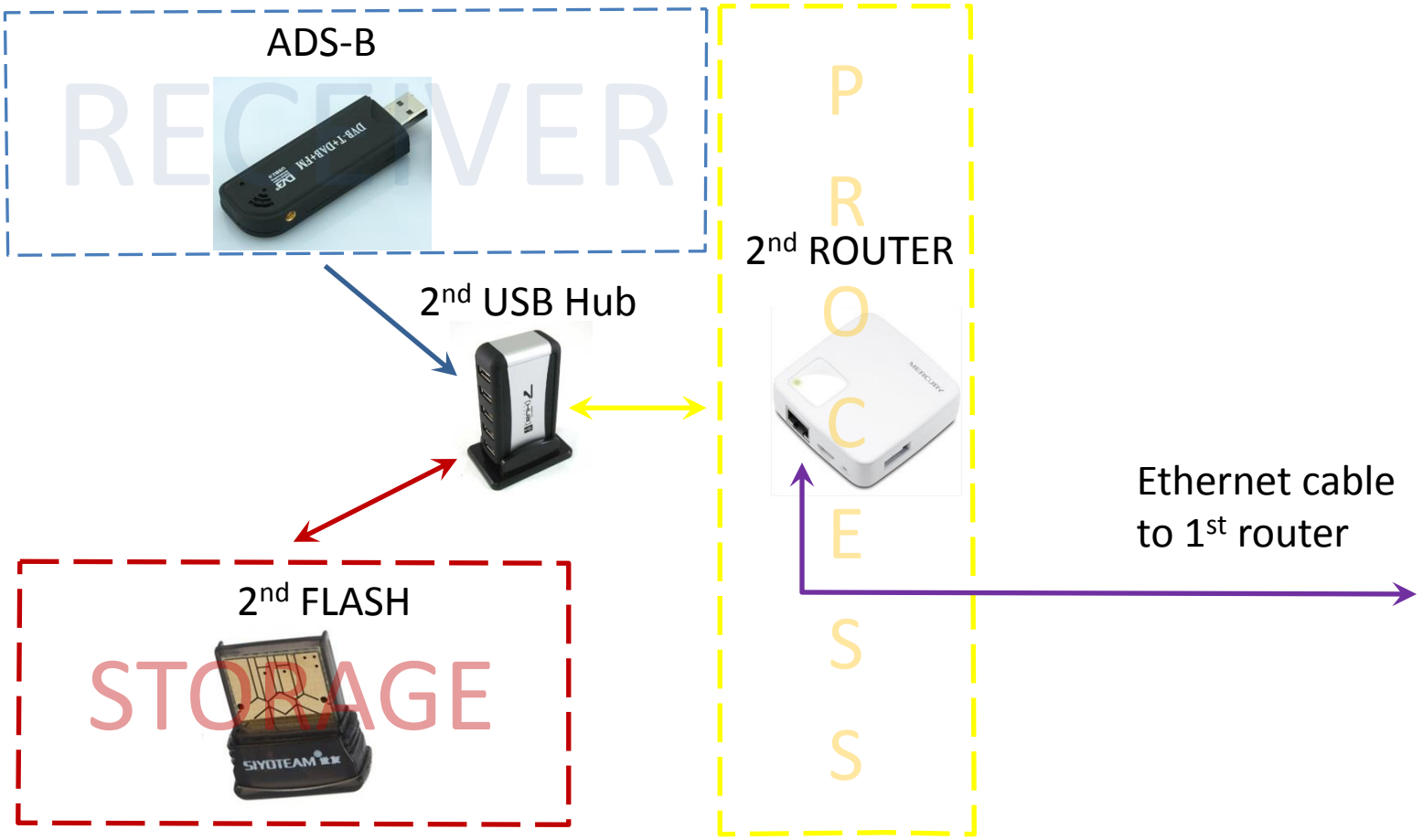
ADS-B «receive-only» option



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ADS-B (contd.)

DRAFT

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Software

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Overview

- **Application software**:

  This software drives the system components to perform the specified task;

  It is mostly developed by the author of this presentation ;

  It is written in Python language ;

- **System software** consists of:

  Firmware for processing module ;

  Operating System extension for processing module ;

  Firmware for LED display module ;

  System software is primarily developed by Linux/OpenWrt and Arduino communities.

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Prototype

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Prototype

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Testing

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Thank you for your attention!

For more details about the topics presented in this slideshow, please, visit:

https://github.com/lyusupov/Argus

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