Three inexpensive bat detectors: 5€ - 50€ - 500€

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http://www.batlife.info/EABDW-3/

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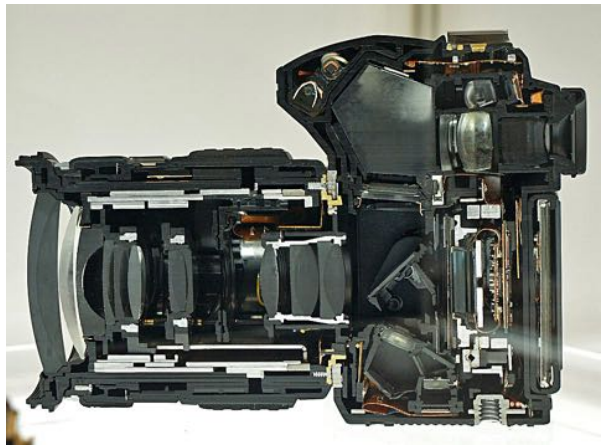
We need different kind of detectors

- When looking for passive detectors, and some active, it seems like you have to buy something in the same price and quality range as buying a DSLR system camera.
- But there is no magic when recording bat sound, except for the fact that the frequency range is about 10 times higher than human audible sound.
- The most critical part when recording bat sound is the microphone, and that will be covered in other presentations during the workshop.

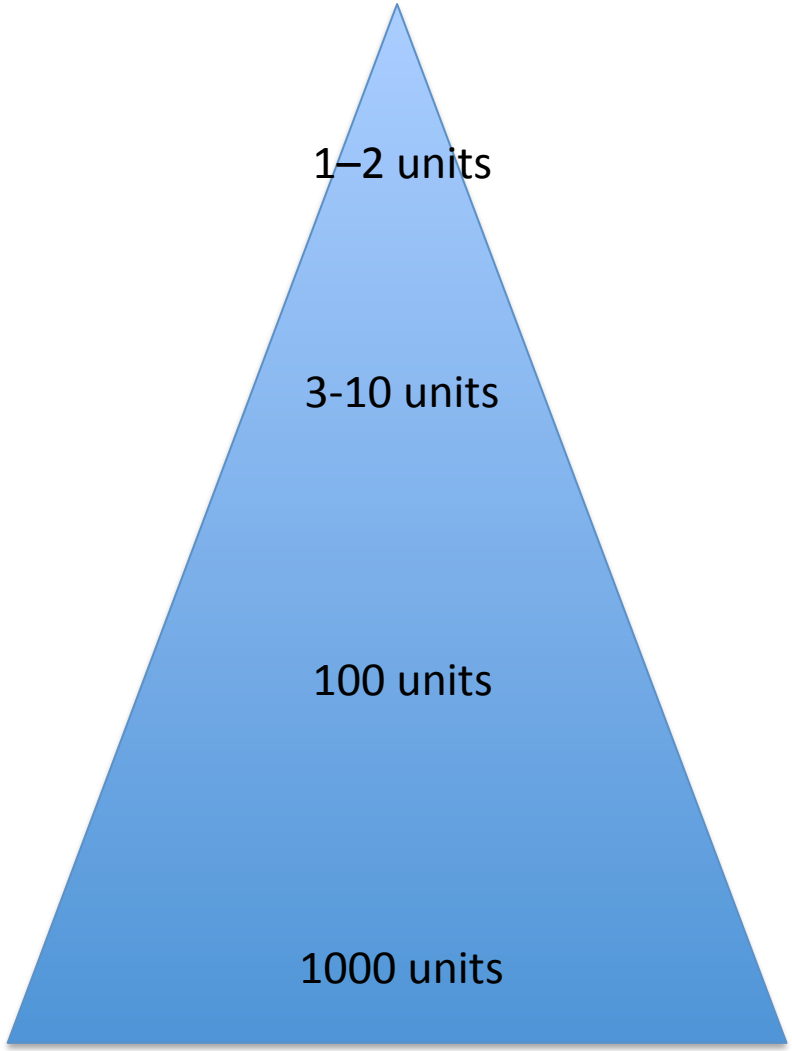


Cutaway view of a DSLR camera.
Photo: Hanabi123, CC BY-SA 3.0

This presentation will cover three alternatives to the common commercial detectors:

JOTA-JOTI Bat detector The most inexpensive handheld detector.	**AudioMoth** A small and inexpensive passive detector, based on open hardware and open source software.	**CloudedBats-WURB** My own detector, based on open source software and standard hardware components.

What can I get for 5000 € ?



1-2 units: Top of the line detectors. For example one Pettersson D1000X.

3-10 units: Many alternatives.
One is the CloudedBats-WURB with Pettersson M500-384.

100 units: AudioMoth detectors.

1000 units: JOTA-JOTI Bat detectors.

And all of them are motivated, it’s depends on your needs...

The 5 € bat detector: JOTA-JOTI Bat Detector

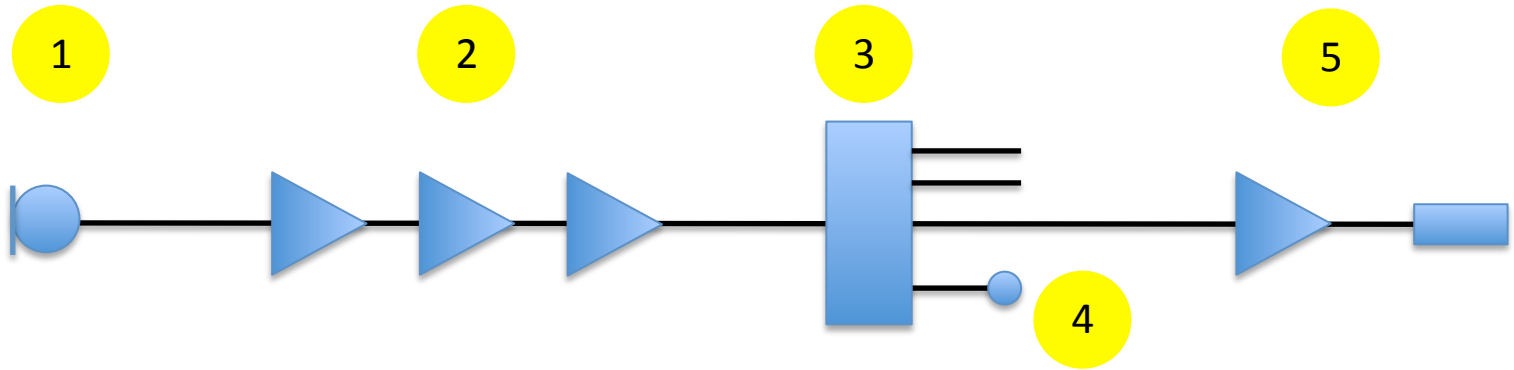
Why should we even talk about a detector that is nothing more than a toy for children?

- We need more toys and entry level models.
- Many schools learn children how to solder. Then it is better that they build bat detectors than digital doorbells.
- Children, and others, can have their own unit. That is important.
- This is a fun gift as a complement to flowers and chocolate. Guess what the discussion at the dining table will be...
- It is worth 5 € to hear a child:
  “Come outside everyone, I can hear bats...”.

JOTA-JOTI Bat Detector - schematic

It is a frequency division detector, and the construction is very simple. It consists of:

1. A microphone.
2. Three small amplifiers connected after each other.
3. A digital divider where it is possible to select if the frequency should be divided by 16, 32 or 64.
4. A LED that will indicate when sound is present.
5. Another amplifier and a 3.5 mm headphone connection.
6. The unit is powered by a 9 V battery.



JOTA-JOTI Bat-Beacon

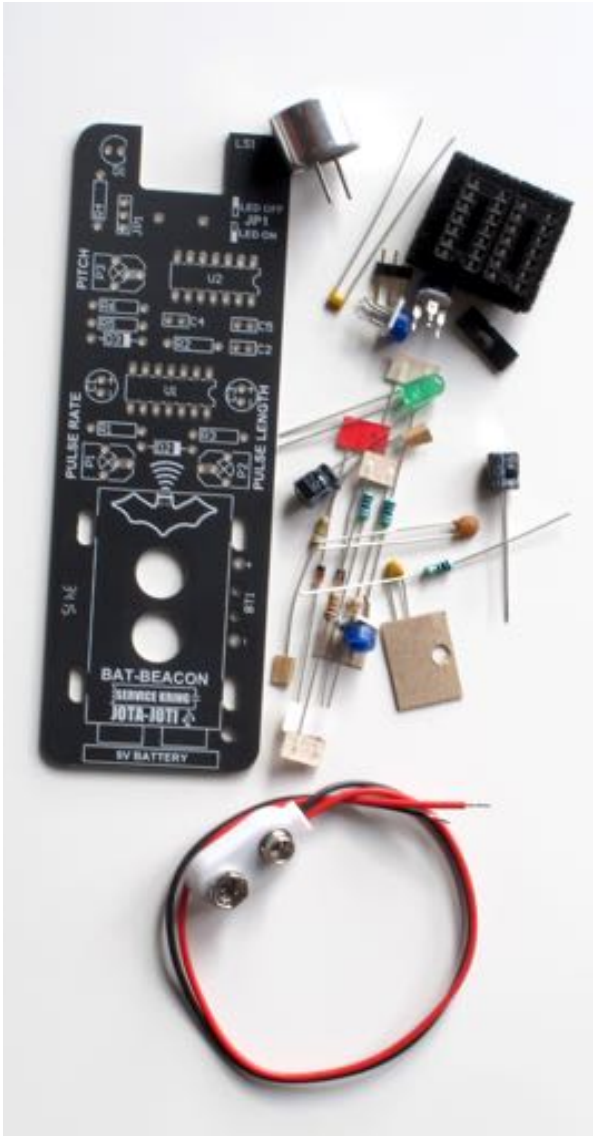
This is another JOTA-JOTI construction kit, and it is a bat sound simulator called “Bat-Beacon”.

You will get your own kit, and there will be a soldering station during the whole workshop.

Pulse rate, pulse length and frequency (pitch) can be adjusted. Range about 22-48 kHz.

- It can be handy to have a simple sound generator when testing detectors.
- Useful when showing people how to use a heterodyne detector before a bat walk.
- It is good to have some basic knowledge in soldering and hardware when detectors get broken or must be adjusted.

Please don’t use it out at night, the bats may be disturbed.



JOTA-JOTI - Links

- Where to buy them:
  http://kitbuilding.org/index.php?lang=en

  http://kitbuilding.org/index.php?option=com_virtuemart&view=productdetails&virtuemart_product_id=64&virtuemart_category_id=12&Itemid=109&lang=en

  http://kitbuilding.org/index.php?option=com_virtuemart&view=productdetails&virtuemart_product_id=67&virtuemart_category_id=12&Itemid=109&lang=en

- Building instructions:
  http://kitbuilding.org/index.php?option=com_phocadownload&view=category&id=3&Itemid=457&lang=en

  BAT-detector:
  http://kitbuilding.org/index.php?option=com_phocadownload&view=category&download=20:manual-bat-detector&id=3:english-en&Itemid=457&lang=en

  BAT-beacon:
  http://kitbuilding.org/index.php?option=com_phocadownload&view=category&download=24:manual-bat-beacon&id=3:english-en&Itemid=457&lang=en

The 50 € bat detector: AudioMoth

I like open source, open data, open access, and all other parts in the concept of Open Science: https://en.wikipedia.org/wiki/Open_science

AudioMoth also adds **Open Hardware**!!!

- Open hardware means that everything needed to build the hardware is open and free. You can check the design, and even fork it and modify it, if you have the required knowledge.

- Open software is the same, but for software. Today, the best new software is released as open source, or have open source equivalences.

- GroupGet means that if you want to build something you can do it together with other people in a way similar to crowdsourcing. For 200 units the price for each is about 50 €.

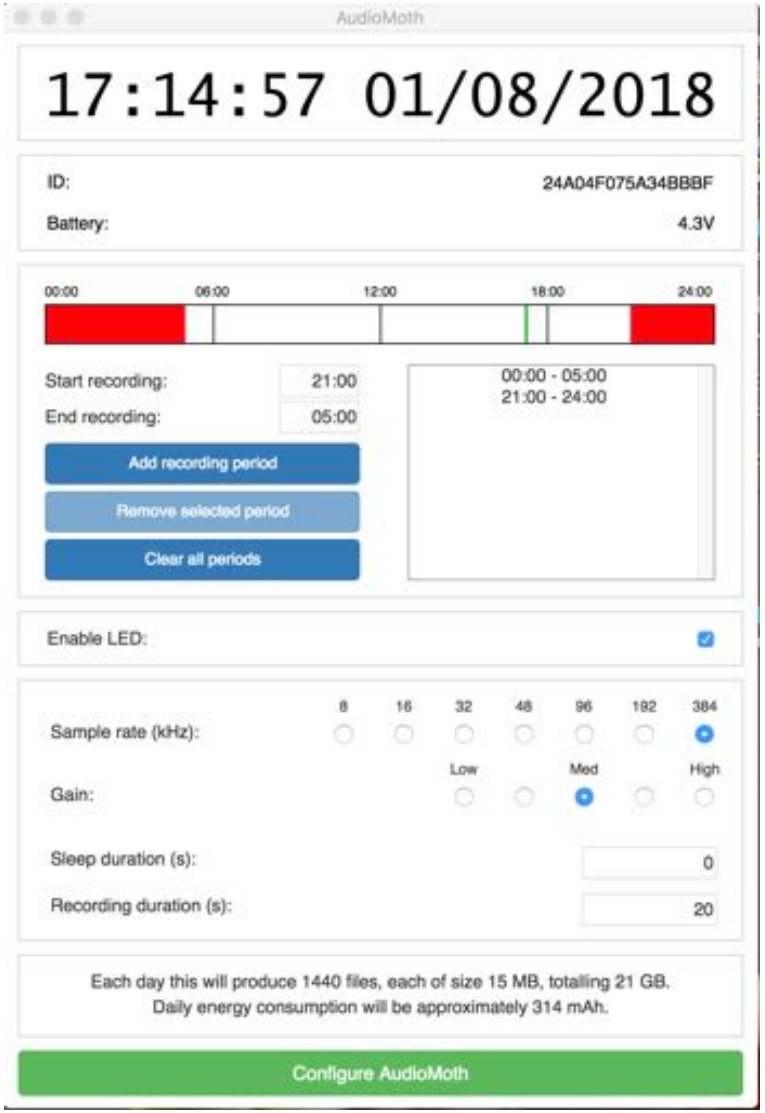
AudioMoth - configuration

AudioMoth configuration is very simple:

- Download the config-application.
  Available for Windows, Mac and Linux.
- Install Micro-SD card and batteries.
- Connect the AudioMoth to the computer with a “USB to Micro-USB” cable.
- The unique unit ID and battery status is read from the AudioMoth.
- Define a recording schema,
  sampling frequency and gain.
- Press “Configure AudioMoth”.

Really handy to configure many units. Just remove the cable, connect it to next unit and press the “Configure AudioMoth” button.

All configurations will be lost when batteries are removed. The configuration tool will give an estimate on how long they will last in current configuration.



AudioMoth – is it good enough for bats?

- AudioMoth is a general purpose passive detector, not primarily designed for bats.
- It is clearly stated that 192 and 384 kHz are in experimental mode.
- Can the design be improved to suit our needs better for bats?

Things I really like

The overall concept and quality; hardware, software, documentation, web pages, etc.

Price level.

Size, weight and power consumption.

Configuration, easy to configure many of them.

High sensitivity.

Open hardware and open source.

Things that I think can be improved

Another, or a replaceable, MEMS microphone.

Anti-aliasing filter. At least for 384 kHz.

Filter to remove sound below 10 kHz.

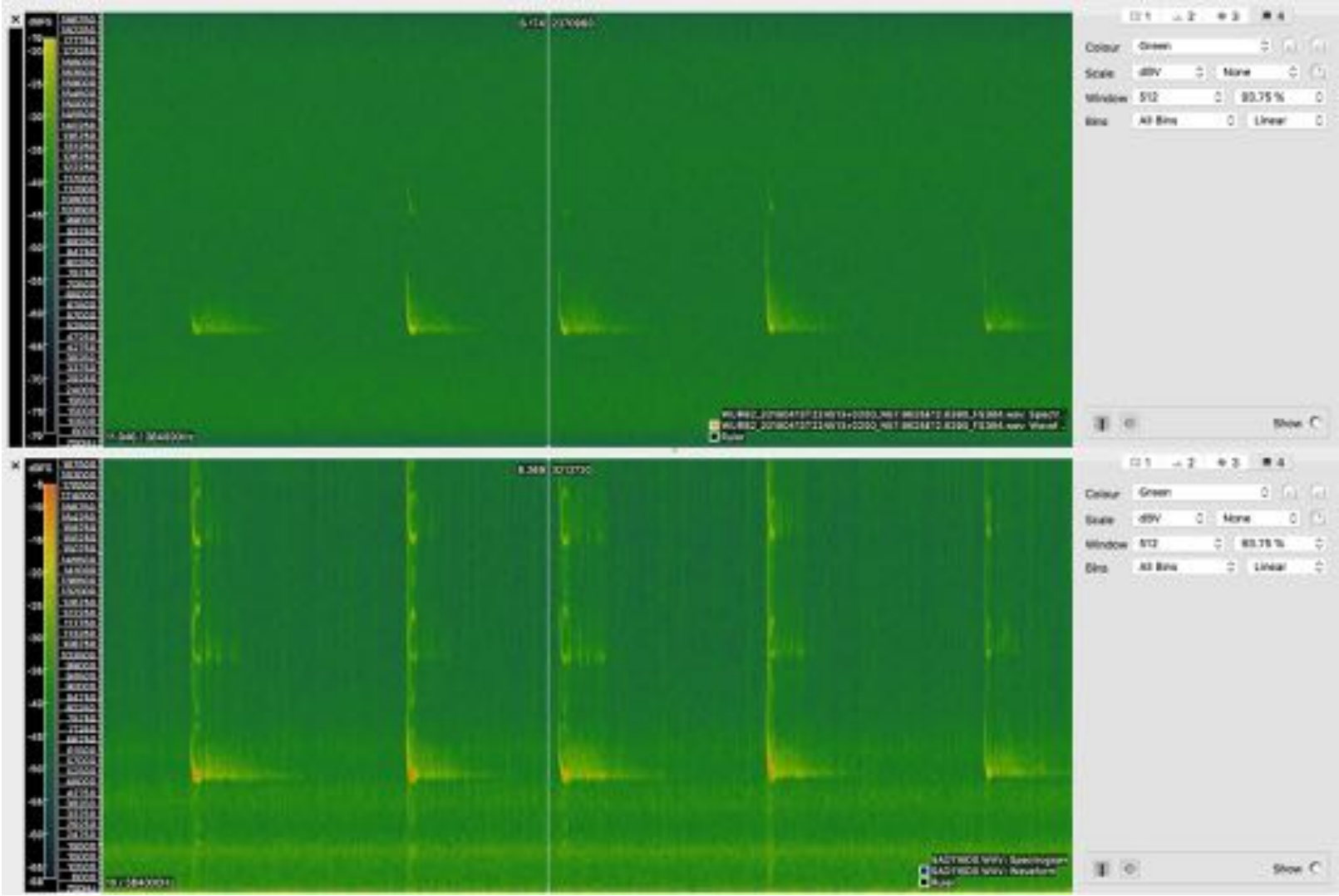
Sound detection to avoid empty files.

Support for “slow” Micro SD cards when running at 192/384 kHz.

During the EABDW-3 Workshop we will have 2, or maybe 4, AudioMoth’s available.
(One unit is “hardware modified” by me and nearly destroyed...)

AudioMoth − problem to be discussed

Example comparing Pettersson M500-384 (upper part) and AudioMoth (lower part). It illustrates the problem with some kind of distortion before the ADC (Analogue to Digital Converter) in combination with the lack of an anti-aliasing filter. To be discussed during the workshop...



AudioMoth - Links

- Main pages:
  https://www.openacousticdevices.info
  https://www.openacousticdevices.info/audiomoth

- Public discussions:
  https://www.openacousticdevices.info/support

- Hardware:
  https://circuithub.com/projects/OpenAcoustics/AudioMoth
  https://datasheet.octopart.com/SPM0408LE5H-TB-Knowles-Acoustics-datasheet-10100519.pdf

- Software:
  https://github.com/OpenAcousticDevices
  https://github.com/OpenAcousticDevices/AudioMoth-Firmware-Basic/wiki
  https://github.com/OpenAcousticDevices/AudioMoth-Project/wiki

- Join a GroupGet and buy your own:
  https://groupgets.com/manufacturers/open-acoustic-devices/products/audiomoth

The (up to) 500 € bat detector: CloudedBats-WURB

In my opinion there are some problems in common with many detectors:

- They are too expensive if you want to use many of them in a survey.
- They are designed as “black boxes” that can’t be modified.
- Embedded software is not open source.
- WiFi is mostly missing.

Therefore, I decided to design my own detector. Why?

- I can do it, and it is extremely fun.
- I want to promote open source software and open data.
- Working with bat sound is a real challenge that forces me to learn new stuff all the time.

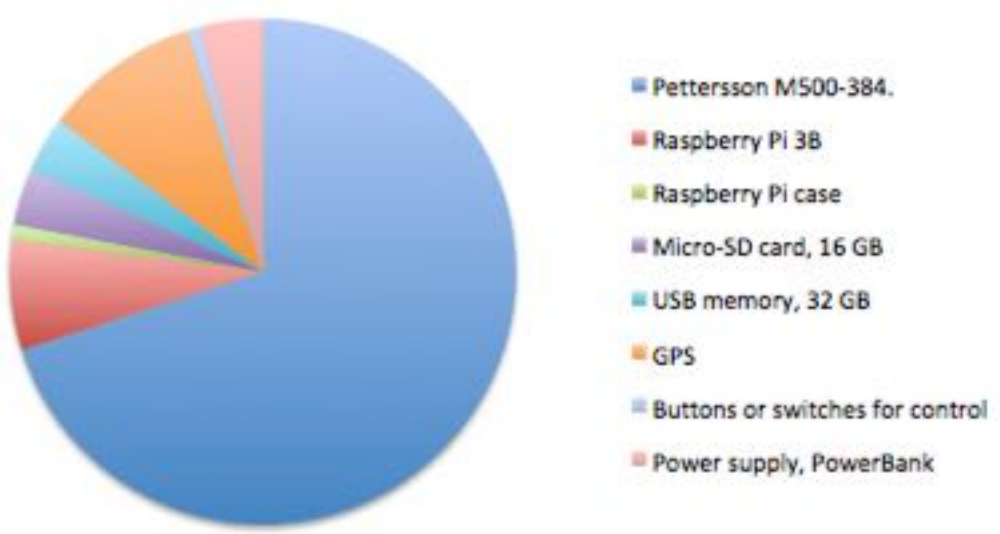
You can’t buy a CloudedBats-WURB detector, you have to build it yourself. Software and instructions can be found here: https://github.com/cloudedbats/cloudedbats_wurb

CloudedBats.org

CloudedBats-WURB – Hardware parts

A “standard WURB” consists of:

- Pettersson M500-384 or M500.
- A Raspberry Pi 3B computer.
- Raspberry Pi case.
- Micro-SD card with software.
- USB memory.
- GPS.
- Buttons or switches for control.
- Power supply with Micro-USB.

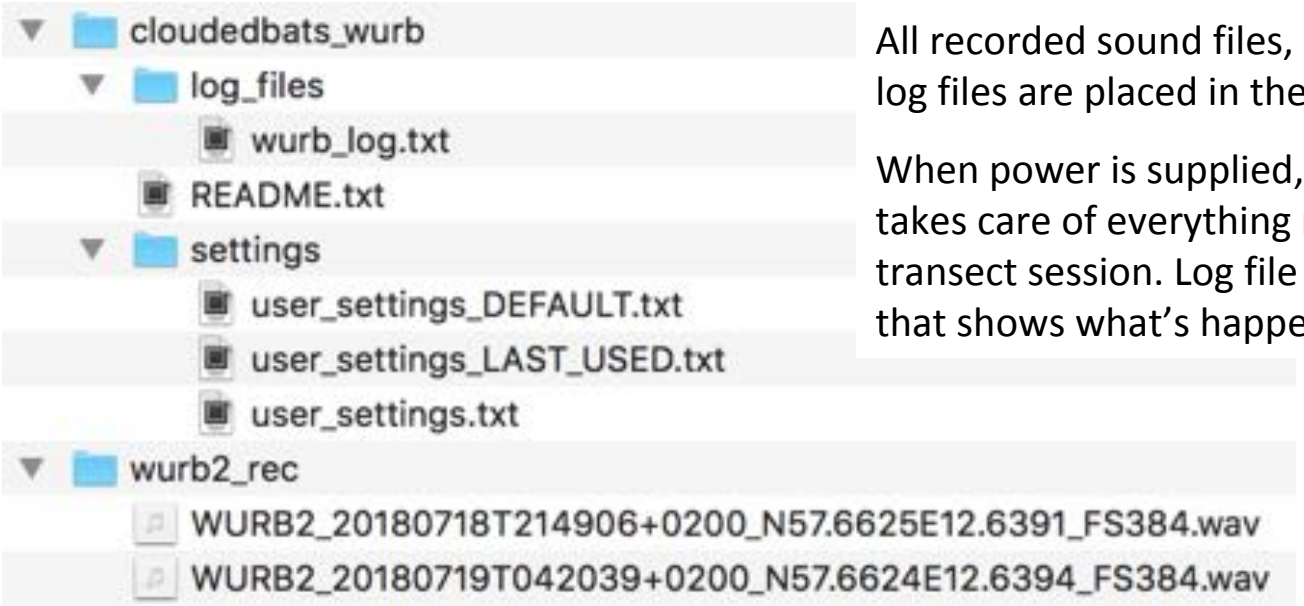


M500-384: 350 €
Raspberry Pi 3B: 35 €
Raspberry Pi case: 5 €
Micro-SD card, 16 GB: 18 €
USB memory, 32 GB: 18 €
GPS: 50 €
Buttons or switches: 4 €
PowerBank: 20 €
Summary: 500 €

The most expensive part can be replaced with, for example, Dodotronic 192 kHz, 200 €. There are GPS units available for 20 €, and you probably already have a power source for your smart phone that can be used. Raspberry Pi Zero W (14 €) is also an option.

The Raspberry Pi is a computer (small, but powerful) and the power consumption is high. This is a drawback compared to many other detectors. For future work in the CloudedBats project I will need both more computational horsepower and WiFi.

CloudedBats-WURB – Sound files and config/log files



All recorded sound files, configuration files and log files are placed in the **USB memory**.

When power is supplied, the detector itself takes care of everything needed for a night or transect session. Log file example on next slide that shows what's happening at start-up.

All recorded sound files are named like this with parts separated by underscore:
"**Prefix**" – "**Time** in the compact ISO format" – "**Position** in latitude/longitude" -
"**Recording format** (TE or FS) and **sampling frequency** in kHz".
Add a new underscore at the end and write comments if you want.

WURB2_20180718T214906+0200_N57.6625E12.6391_FS384.wav

The most important metadata is time and position, and I want that to be a part of the file name. Hidden metadata embedded in the file may be problematic for some people. I will probably add support for GUANO metadata, but then it should be added at a later step in the data flow.

CloudedBats-WURB − Log file example

```
2018-07-17 04:50:44,704 INFO     : Welcome to CloudedBats WURB
2018-07-17 04:50:44,704 INFO     : Project page: http://cloudedbats.org
2018-07-17 04:50:44,705 INFO     : =============== ^ö^ ================
2018-07-17 04:50:44,705 INFO     :
2018-07-17 04:50:44,706 INFO     : === Check sound cards. ===
2018-07-17 04:50:44,707 INFO     : Connected sound cards for input streams:
2018-07-17 04:50:44,772 INFO     : - Pettersson M500-384kHz USB Ultr: Audio (hw:1,0)
--- some rows removed ---
2018-07-17 04:50:45,080 INFO     : === Startup done. ===
2018-07-18 04:51:47,059 INFO     :
2018-07-18 04:51:47,568 INFO     : GPS reader: First GPS time received: 20180718T214813+0200
2018-07-18 04:51:47,570 INFO     : GPS reader: Raspberry Pi date/time is set.
2018-07-18 21:49:02,138 INFO     : GPS reader: First GPS position received: N57.6625E12.6391
2018-07-18 21:49:02,566 INFO     : Scheduler: Time received from GPS.
2018-07-18 21:49:02,568 INFO     : Scheduler: Position received from GPS.
2018-07-18 21:49:02,573 INFO     : Scheduler: Date: 2018-07-18 latitude: 57.662484842 longitude: 12.639115513
2018-07-18 21:49:02,575 INFO     : Scheduler: Sunset: 21:52 dusk: 22:53 dawn: 03:38 sunrise: 04:38
2018-07-18 21:49:02,596 INFO     : - Event: sunrise Adjust: +10 Calc.time: 04:48:00 Action: scheduler_rec_off
2018-07-18 21:49:02,598 INFO     : - Event: sunrise Adjust: +15 Calc.time: 04:53:00 Action: scheduler_rpi_shutdown
2018-07-18 21:49:02,599 INFO     : - Event: sunset Adjust: -30 Calc.time: 21:22:00 Action: scheduler_rec_on
2018-07-18 21:49:02,602 INFO     : State machine: Event executed: scheduler_rec_on
2018-07-18 21:49:02,603 INFO     : State machine: Old state: wurb_init   New state: rec_auto
2018-07-18 21:49:02,705 INFO     : WURB Main: State machine action: rec_start
2018-07-18 21:49:08,261 INFO     : Recorder: New sound file: WURB2_20180718T214906+0200_N57.6625E12.6391_FS384.wav
2018-07-18 21:49:12,596 INFO     : Recorder: Sound file closed. Length:4.5 sec.
--- some rows removed ---
2018-07-19 04:20:39,321 INFO     : Recorder: New sound file: WURB2_20180719T042039+0200_N57.6624E12.6394_FS384.wav
2018-07-19 04:20:45,331 INFO     : Recorder: Sound file closed. Length:6.0 sec.
2018-07-19 04:48:08,884 INFO     : State machine: Event executed: scheduler_rec_off
2018-07-19 04:48:08,885 INFO     : State machine: Old state: rec_auto   New state: rec_auto
2018-07-19 04:48:08,987 INFO     : WURB Main: State machine action: rec_stop
2018-07-19 04:53:09,206 INFO     : State machine: Event executed: scheduler_rpi_shutdown
2018-07-19 04:53:09,207 INFO     : State machine: Old state: rec_auto   New state: rpi_off
2018-07-19 04:53:09,309 INFO     : WURB Main: State machine action: rec_stop
2018-07-19 04:53:09,409 INFO     : WURB Main: State machine action: rpi_shutdown
```

CloudedBats-WURB − User settings example

 # User settings:
rec_filename_prefix: WURB2
rec_format: FS
rec_max_length_s: 20
rec_buffers_s: 2.0
rec_directory_path: /media/usb0/wurb2_rec

rec_microphone_type: USB
rec_part_of_device_name: Pettersson
rec_sampling_freq_khz: 384
sound_detector: Simple

default_latitude: 56.78
default_longitude: 12.34
scheduler_use_gps: Y
scheduler_wait_for_gps: Y
set_time_from_gps: Y
timezone: Europe/Stockholm

 # Scheduler events:
scheduler_event: scheduler_rec_on/sunset/-30
scheduler_event: scheduler_rec_off/sunrise/+10
scheduler_event: scheduler_rpi_shutdown/sunrise/+15

CloudedBats-WURB - Links

- These two links points to the same GitHub repository:
  http://cloudedbats.org
  https://github.com/cloudedbats/cloudedbats

- GitHub organisation containing source code repositories for all sub projects:
  https://github.com/cloudedbats

- My poster from the 14TH EUROPEAN BAT RESEARCH SYMPOSIUM (http://ebrs2017.eus):
  https://github.com/cloudedbats/cloudedbats/blob/master/doc/EBRS2017_CloudedBats_poster_FINAL.pdf

- Source code repository for the bat detector ”CloudedBats-WURB”:
  https://github.com/cloudedbats/cloudedbats_wurb

- Software installation guide:
  https://github.com/cloudedbats/cloudedbats_wurb/blob/master/doc/cloudedbats_wurb_user_manual.md

- User manual:
  https://github.com/cloudedbats/cloudedbats_wurb/blob/master/doc/cloudedbats_wurb_software_installation.md

Thanks for listening, let’s go and catch some bat sound...