|  |  |  |
| --- | --- | --- |
| Bird Species | Approximate Low-End Mass [g] | 10% of Mass (short of 15% max) |
| Rock Pigeon | 250 | 25 |
| Starling | 50 | 5 |
| Zebra Finch | 10 | 1 |
| Hummingbird | 3 | 0.3 |

Problems that will need to be solved:

* Different scale/dimensions betw rats and zebra finches
* Not using skull implant/bonding, so need to identify another way

Things we want:

* Panoramic "bird's-eye-view"
* also, eye tracking on top as a modular
* either-or is a good-enough level, both is a best-case scenario
* starlings (because they flock), zebra finch (if they flock), pigeons (talk to anthony if they flock and if they can be reused because of homing nature)
* low-res is fine
* time it needs to stay alive: not sure at all, but perhaps a day or two maximum, minimum could be a few hours (4-6?)

Companies to contact:

* Microwave Telemetry (sent)
* Wildlife Computers (sent)
* Lotek (sent)

Useful Resources:

* Pi Zero Power Use under various conditions: <https://raspi.tv/2016/raspberry-pi-zero-1-3-power-usage-with-camera>
  + ~350mA during 1080p video shooting. Using a 3.7v lithium battery (2000mAh), it should last 4-6 hours
  + <https://www.adafruit.com/product/2011?gclid=CjwKCAiAirb_BRBNEiwALHlnD-j4fvZJjO1byH6WHKvXdeBnNlJhs1M9oX5VyoTPBmBAR6_XhdghxBoCo88QAvD_BwE>
  + Super lightweight battery: <https://www.adafruit.com/product/3898?gclid=Cj0KCQiAlsv_BRDtARIsAHMGVSYx7raXZabrhWj6P_Lh8PkKgxXf8yOrZtUEhsfXMOawUirN_ZcXSNkaApVAEALw_wcB>
* Memory will not be the bottleneck. At 720p, we can record ~7h/5GB
  + Based on testing with the Pi Zero & Spy Cam

Tests & Results:

* Rpi Settings: 720p (1280,720) recording in 10min segments with a limiter of 3h (18 segments)
* Battery: *almost* fully charged [400mAh lithium ion battery](https://www.adafruit.com/product/3898) hooked up to [Powerboost 500](https://www.adafruit.com/product/1903) and then to the Pi Zero
* Results:
  + Ran for 50+ mins, recorded 5 out of the 18 segments (which is expected since the Pi pulls an estimated 350mA
  + Log shows that it began recording the 6th, but did not finish the full 10 mins
  + Unsure whether it closed due to black/brown-out or if the script accurately detected low battery and then exited
    - Need to add file-writing step to the code when it detects low battery (DONE)
  + Either way, looks like ~1hr is a reasonable estimate for the 400mAh battery, and by extension, ~1h15min will be likely for the 500mAh battery

Current priorities:

* Finalize the simple prototype:
  + Incorporate camera extender once parts arrive
  + Figure out attachment (soldering vs alternatives)
  + Figure out covering (epoxy, tape, etc. to prevent pecking/residue from birds)
  + Attachment logistics (how to attach to harness, etc.)
* Prepare more advanced prototype:
  + Order dev/evaluation boards for camera, MCU, flash memory chip
  + Order small lipo’s near the 1g level: <https://www.pdbattery.com/ultra-small-battery.html>
    - PD371520 looks particularly good: <https://docs.google.com/spreadsheets/d/1y1Z6Qv7kmgagiCsKiD3wtRDvCgFPn8NgJU1lKOL76JA/edit#gid=743502038>
  + Look into device-level requirements and arriving at estimates for minimum BOM list
    - (what is the fewest number of components we’ll need to show a proof-of-concept for this?)
    - We want a device which runs on a battery, interfaces with a cam module, stores video data, and can output data to a computer or SD card to provide the user with the data it collects
* LOOK INTO THIS BEFORE DOING ANYTHING:
  + <https://github.com/daharoni/wire-free-miniscope>
  + Questions to answer:
    - Can the current CMOS be used for our purposes as-is? (i.e. can we just put a different lens on it to allow for non-microscopy purposes)
      * If not, what alternative CMOS can be used?
      * If yes, which lens should we go with? Currently using 3mm lens doublet
        + https://www.edmundoptics.com/p/3mm-dia-x-6mm-fl-mgfsub2sub-coated-achromatic-doublet-lens/5580/
    - What's the current total weight of the assembly? If higher than we'd like, some parts can be removed (LED excitation, some areas of the PCB, etc.)
      * [This review paper](https://www.frontiersin.org/articles/10.3389/fncel.2019.00141/full#h4) says it’s 4.5g for wireless miniscope, but probably can be reduced by getting rid of the 3D printed enclosure, circuit components unnecessary to us, etc.
      * There’s also a [wireless, finch-specific device](https://iopscience.iop.org/article/10.1088/1741-2552/aa6806) inspired by the miniscope, but was also too heavy (~4g) to be used by finches. Also, the wireless device only transmitted data up to 5m away, so it somewhat limits the experiments that can be done.
    - How can we change the attachment method so that it works with our species (zeebie instead of mice) and orientation (front-facing camera instead of top-down)?

Meeting with Nick on Thursday, Feb 25, 2021 to discuss options and plan:

* Bhaskar:
* Get access to firmware code (& see which parts to change/omit) (DONE)
* Order a range of batteries
* Start messing with PCB layout file to cut excess weight (DONE)
* Nick:
* Looking into optical aspect:
  + Wide/fisheye lenses possible with current coms?
  + How to mount lenses on CMOS (3d printing etc)

Mar 10, 2021

* Found a vendor that sells the CMOS sensor, trying to figure out how to get it to PCBWay for third-party manufacture
  + <https://www.hilltech.com/products/electro_optics/CCDCMOSsensorsandLineararrea.html>
* Heard from Daniel Aharoni (wire-free miniscope creator) that the wire-free PCB weighs 1.7g (without SD card, battery, lens system, etc.)
  + Now, need to figure
* For the pi zero extension system:
  + Black part of ribbon cable up on the board side
  + Metal part of ribbon cable up on the extender side

Mar 15, 2021

* Soldered powerboost to pi zero for stability
* Added complementary velcro strips to pi zero and lipo battery
* Works fine, main issue to address is:
  + When pins on pi or the battery are jiggled, brief loose connections cause system to reboot
  + **Solution: once battery is connected and attached to velcro, liberally use horizontal electrical tape to:**
    - **Secure boards and battery together tightly**
    - **Protect metal surfaces of pins from moving/being touched to prevent loose connections**

Mar 19, 2021

* Looked into lens options at [optics-online.com](http://www.optics-online.com/)
  + Emailed them for lens suggestions
* This (<https://exposuretherapy.ca/photography-guide/lens-focal-length/>) was a good resource for understanding focal lengths and FOV

Mar 26, 2021

* Wire-free CMOS PCB (without battery or sd card) = 1.7g
* Trying to estimate weight of unnecessary components:
  + Full list of removed parts:
    - LTC3218EDDB (LED driver), R7, R8, C24, C25, C26, NTK3134NT1G (MOSFET), TSOP57438TT1 (IR SENSOR)
  + IC Weight Estimates:
    - LTC3218 (10-Lead DFN)
      * Volume = 3mm x 3mm x 0.75mm = 6.75mm^3
      * [Estimate](https://www.melexis.com/-/media/files/documents/environmental/package-material/dfn-10-3x3-gr-s2-package-material-declaration-melexis.pdf?la=en): 0.02445g = ~**24mg**
    - NTK3134NT1G (SOT-723)
      * Volume = 1.2mm x 0.8mm x 0.5mm = 0.48mm^3
      * Estimate: ~**1.7mg**
    - TSOP57438TT1 (*Belobog* Package?)
      * Volume = 3.95mm x 3.95mm x 0.8mm = 12.5mm^3
      * Estimate: ~**44.4mg**
    - 0402 Resistors (x2: R7, R8)
      * [0.65mg each](https://www.mouser.ca/ProductDetail/Panasonic/ERJ-2RKF2001X?qs=H7k1u0Mp9JSbtBe1nkwQGA==)
      * Total Estimate: 0.65 x 2 = **1.3mg**
    - 0402 Capacitors (x3, C24, C25, C26)
      * [0.223mg each](http://www.calchipelectronics.com/pdf/gmc_materials_%20declaration.pdf)
      * Total Estimate: 0.223 x 3 = **0.67mg**
    - **TOTAL Mass Reduction = ~72.1mg**
      * **I.e. not significant**

Wednesday, April 14, 2021:

* Trying to get [basic device #2](https://www.adafruit.com/product/3202) working:
  + Battery:
    - Change connector on main board to female JST (DONE)
  + SD Card:
    - Acquire SD card & format it as required (DONE)
* Got basic device #2 working
  + Weight out-of-the-box (including SD but without battery) = 2.8g
* Removed long & heavy wires, used the fine wire connected to JST female = 2.8g
* Weight of ONLY the JST female connector + some length of wire = 1.1g
* Conclusion: The wires were not the biggest source of weight

Monday, April 19, 2021:

* Desoldering mic & usb port to see if that reduces weight while keeping functionality intact:
  + **Functionality works**, even without mic & usb port
  + New weight (w/SD, but without battery is still only ~2.8g), so these components didn’t affect overall weight much

Tuesday, April 20, 2021:

* **Basic prototype 2 will weight around 3.3g (device + SD + battery), which is close enough to the zebra finch weight budget**
* For hummingbird, we have to go 1 order of magnitude smaller, so a completely new system will be needed. At this point, 2 main ideas:
  1. Use the Hendrick gantry system to have only camera on the hummingbird, and have everything else off the bird via long wires that move along with the bird’s motion
  2. Use optitrack to get a high-res idea of the bird’s head movement over time and 3D space, and use that to simulate what the bird “would be seeing” using VR (maybe even show the bird the VR world as well)