Send an email to "thomas.deegan22@imperial.ac.uk"
with your github username.

Thomas will add you to the competition:
- Google Drive shared folder
- Github repository

ELEMIND

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June 26th, 2025

TOP VIEW

Volume Controls
(**NOT used for competition**)

Bone Conduction Driver
(BCD)

Fp1

Fpz

Fp2

Over-Ear
References

Adjustable Rear Strap
(Largest attached,
2 smaller sizes in box)

BOTTOM VIEW

LED Light

Action Button
(**NOT used for competition**)

USB-C Port

Action Button Tips
Double-Tap starts a pre-programmed routine, LED will glow purple for 5 seconds.
Send command "ble_therapy 0" to stop.

LED Light Tips
Blue Breathing = BLE Pairing To Phone Needed
Red+Blue Alternating = Needs Real-World Time
Green Breathing = Charging

Press any button when off charger to check charge:
Green = >70%+ Charged
Orange = 25-70% Charged
Red = = <25% Charged
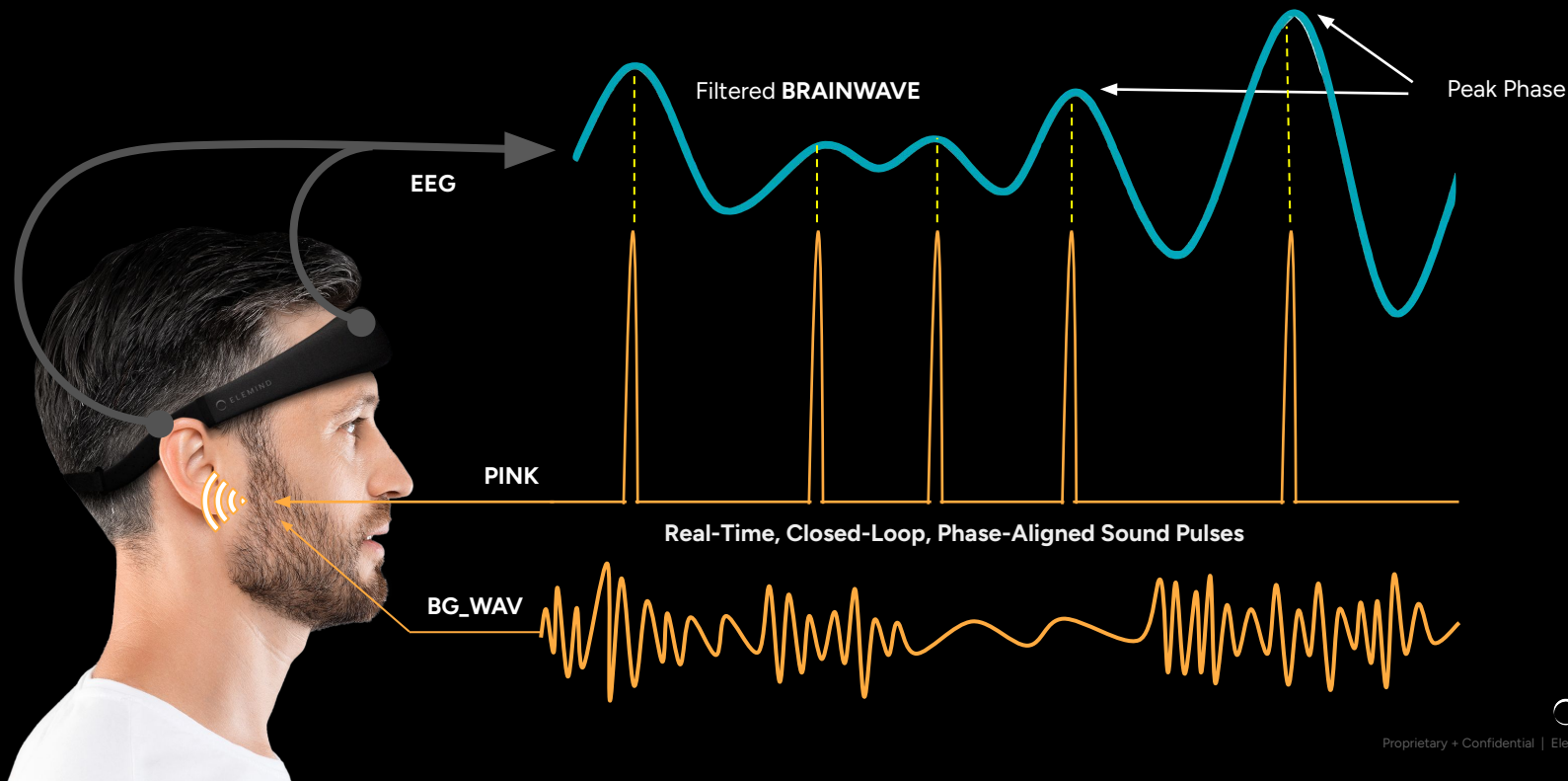
How to Wear

Tips:
- Wipe forehead and over ears with napkin to remove oils.
- Does not need to be tight. Just not shifting if you shake your head.
- For long hair:
  - Set adjustable strap to largest size.
  - Slip over hair down to neck.
  - Bring headband up to the forehead, under hair.
  - Tighten strap as need.
- Once on the head:
  - Clear hair from between references and ear.
  - Pull down on the adjustable strap to ensure references are well-seated on the ears.
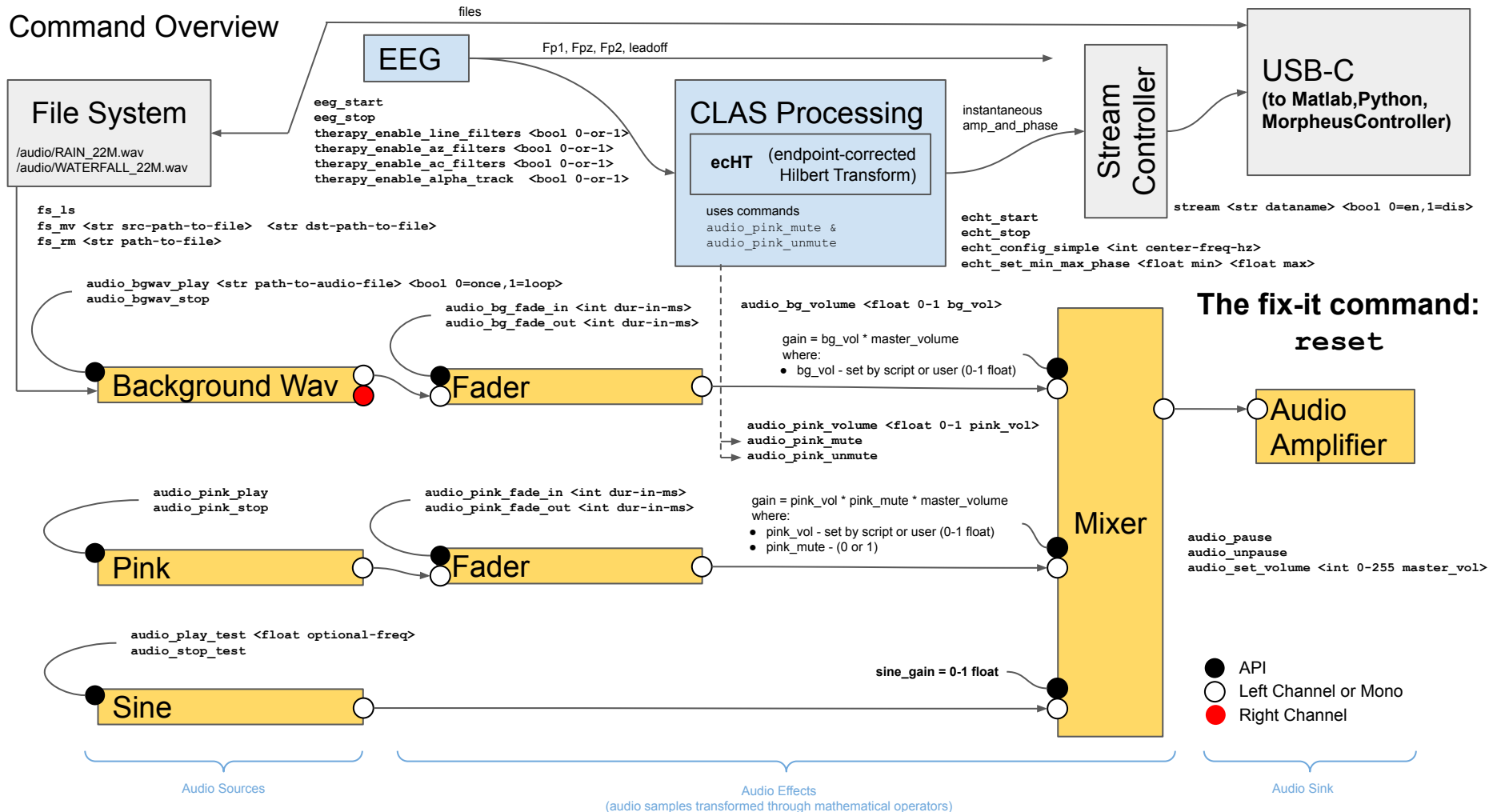
Hardware Specs

- **Dry EEG Sensors:** 3-channels (FP1, FP2, FPZ), 2 reference electrodes

    (Bandwidth: 0.5-35Hz, Sample Rate: 250 Hz)

- **3-axis Accelerometer** (+/-2Gs, Sample Rate: 25 Hz)

- **Stimulation:** Phase-locked acoustic stimulation via bone conduction

    transducer

- **Real-time phase computation, stimulation, and ML sleep-staging (on-device)**

- **Phase Stimulation Accuracy:** 90-98% PLV (from peer-reviewed study)

- **Phase Stimulation Error:** 4-15 degrees (from peer-reviewed study)

- **EEG-based sleep tracking accuracy:** 83%

- **Weight:** 60g

- **Battery Life:** >3hr w/ stim, >24 hrs recording, 48hr standby time

- **Battery Charge Time:** ~3 hrs

- **Connectivity:** Bluetooth Connectivity, USB-C

- **Automatic Data Transfer:** Lossy or Lossless sensor data transferred over BLE

    to App to Cloud.

○ E L E M I N D

① TOP VIEW

⑧ ⑦ ⑥ ③ ② ③ ③ ④ ④ ⑤ BOTTOM VIEW

① Volume Controls
② Bone Conduction Speaker
③ Forehead EEG Sensor
④ Ear Sensor
⑤ Adjustable Rear Strap
⑥ USB-C Port
⑦ LED Light
⑧ Action Button

Closed Loop Audio Stimulation (CLAS)

Filtered **BRAINWAVE**

Peak Phase

EEG

PINK

Real-Time, Closed-Loop, Phase-Aligned Sound Pulses

BG_WAV

Command Overview

File System

/audio/RAIN_22M.wav
/audio/WATERFALL_22M.wav

EEG

files

Fp1, Fpz, Fp2, leadoff

USB-C
(to Matlab,Python,
MorpheusController)

Stream Controller

CLAS Processing

ecHT (endpoint-corrected Hilbert Transform)

uses commands
`audio_pink_mute &`
`audio_pink_unmute`

```
eeg_start
eeg_stop
therapy_enable_line_filters <bool 0-or-1>
therapy_enable_az_filters <bool 0-or-1>
therapy_enable_ac_filters <bool 0-or-1>
therapy_enable_alpha_track  <bool 0-or-1>
```

instantaneous
amp_and_phase

`stream <str dataname> <bool 0=en,1=dis>`

```
echt_start
echt_stop
echt_config_simple <int center-freq-hz>
echt_set_min_max_phase <float min> <float max>
```

```
fs_ls
fs_mv <str src-path-to-file>  <str dst-path-to-file>
fs_rm <str path-to-file>
```

```
audio_bgwav_play <str path-to-audio-file> <bool 0=once,1=loop>
audio_bgwav_stop
```

```
audio_bg_fade_in <int dur-in-ms>
audio_bg_fade_out <int dur-in-ms>
```

`audio_bg_volume <float 0-1 bg_vol>`

The fix-it command:
`reset`

gain = bg_vol * master_volume
where:
- bg_vol - set by script or user (0-1 float)

Background Wav

Fader

```
audio_pink_volume <float 0-1 pink_vol>
audio_pink_mute
audio_pink_unmute
```

```
audio_pink_play
audio_pink_stop
```

```
audio_pink_fade_in <int dur-in-ms>
audio_pink_fade_out <int dur-in-ms>
```

gain = pink_vol * pink_mute * master_volume
where:
- pink_vol - set by script or user (0-1 float)
- pink_mute - (0 or 1)

Pink

Fader

Mixer

Audio Amplifier

```
audio_pause
audio_unpause
audio_set_volume <int 0-255 master_vol>
```

```
audio_play_test <float optional-freq>
audio_stop_test
```

Sine

`sine_gain = 0-1 float`

● API
○ Left Channel or Mono
● Right Channel

Audio Sources

Audio Effects
(audio samples transformed through mathematical operators)

Audio Sink
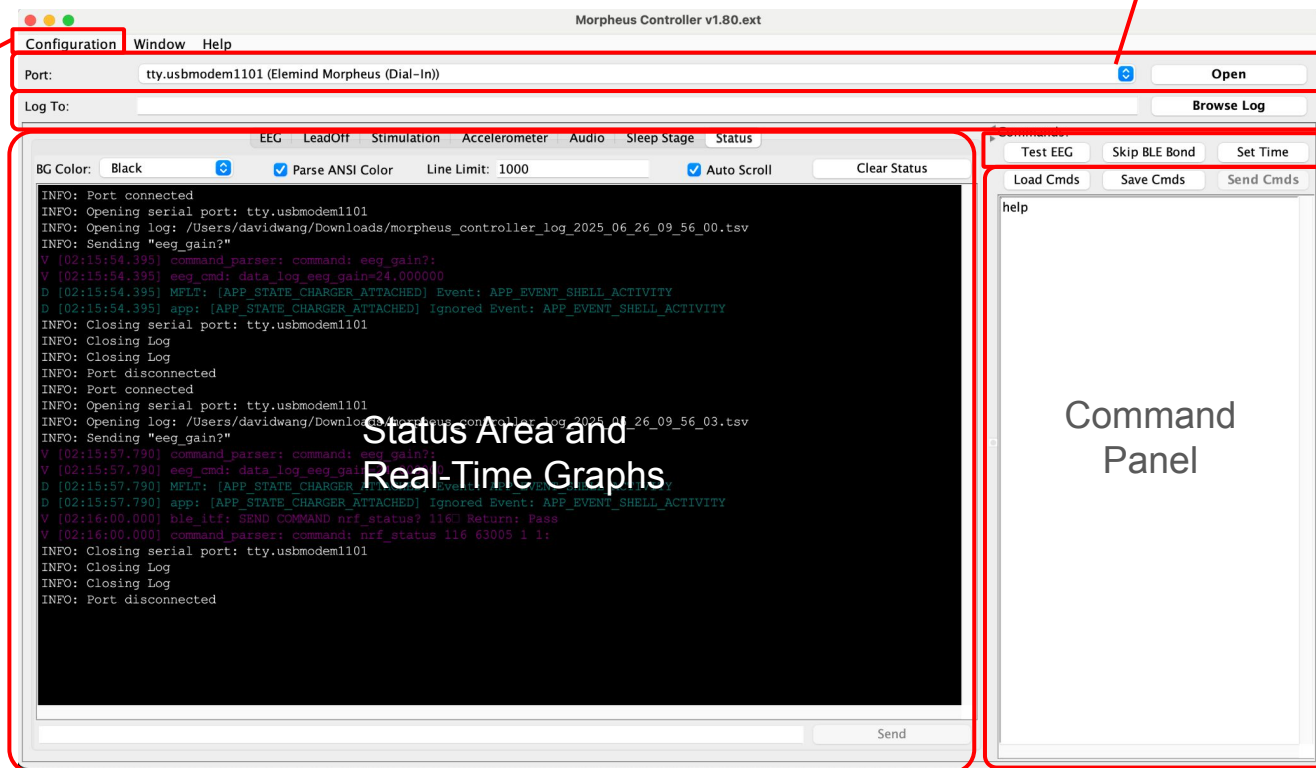
Morpheus Controller
(A Java GUI for Testing)

Connect to Headband

Local Logging
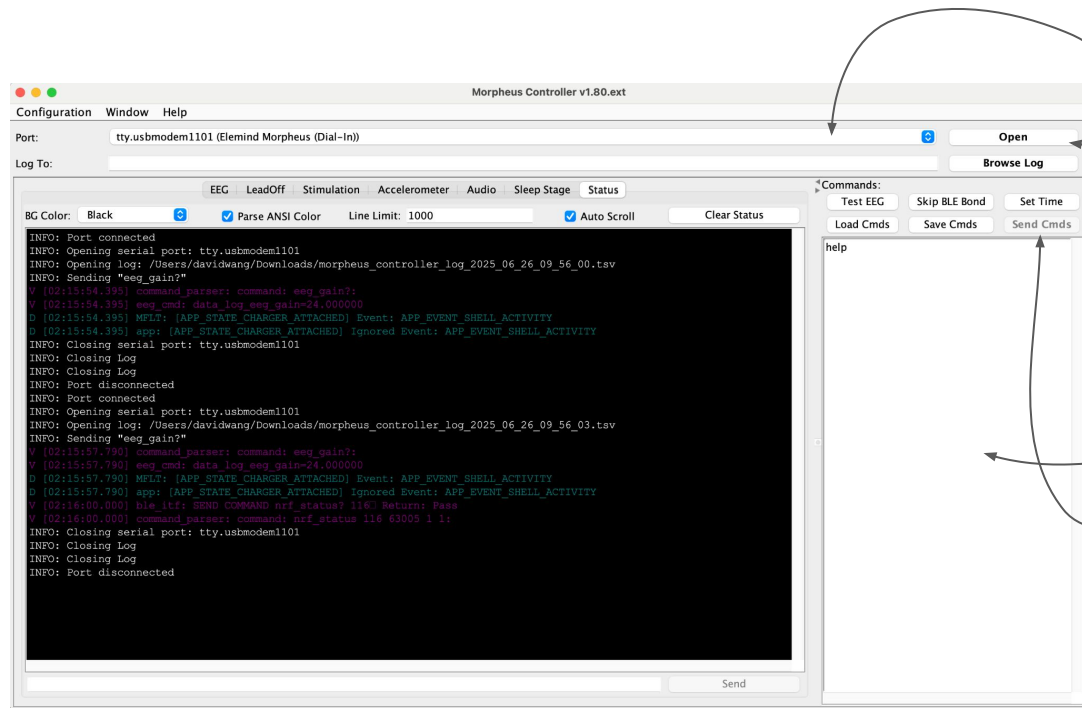(Status text saved to Downloads folder automatically)

File Upload/ Download Menu

One-Click Convenience Commands

Command Panel

Status Area and Real-Time Graphs

Morpheus Controller v1.80.ext

Configuration   Window   Help

Port: tty.usbmodem1101 (Elemind Morpheus (Dial-In))   Open

Log To: Browse Log

EEG   LeadOff   Stimulation   Accelerometer   Audio   Sleep Stage   Status

BG Color: Black   Parse ANSI Color   Line Limit: 1000   Auto Scroll   Clear Status

Commands:
Test EEG   Skip BLE Bond   Set Time
Load Cmds   Save Cmds   Send Cmds

help

```
INFO: Port connected
INFO: Opening serial port: tty.usbmodem1101
INFO: Opening log: /Users/davidwang/Downloads/morpheus_controller_log_2025_06_26_09_56_00.tsv
INFO: Sending "eeg_gain?"
V [02:15:54.395] command_parser: command: eeg_gain?:
V [02:15:54.395] eeg_cmd: data_log_eeg_gain=24.000000
D [02:15:54.395] MFLT: [APP_STATE_CHARGER_ATTACHED] Event: APP_EVENT_SHELL_ACTIVITY
D [02:15:54.395] app: [APP_STATE_CHARGER_ATTACHED] Ignored Event: APP_EVENT_SHELL_ACTIVITY
INFO: Closing serial port: tty.usbmodem1101
INFO: Closing Log
INFO: Closing Log
INFO: Port disconnected
INFO: Port connected
INFO: Opening serial port: tty.usbmodem1101
INFO: Opening log: /Users/davidwang/Downloads/morpheus_controller_log_2025_06_26_09_56_03.tsv
INFO: Sending "eeg_gain?"
V [02:15:57.790] command_parser: command: eeg_gain?:
V [02:15:57.790] eeg_cmd: data_log_eeg_gain=24.000000
D [02:15:57.790] MFLT: [APP_STATE_CHARGER_ATTACHED] Event: APP_EVENT_SHELL_ACTIVITY
D [02:15:57.790] app: [APP_STATE_CHARGER_ATTACHED] Ignored Event: APP_EVENT_SHELL_ACTIVITY
V [02:16:00.000] ble_itf: SEND COMMAND nrf_status? 116 Return: Pass
V [02:16:00.000] command_parser: command: nrf_status 116 63005 1 1:
INFO: Closing serial port: tty.usbmodem1101
INFO: Closing Log
INFO: Closing Log
INFO: Port disconnected
```

Send

Morpheus Controller
(A Java GUI for Testing)

1. Select the port
   Look for "Elemind Morpheus".
   On Mac use either cu.usbmodem or tty.usbmodem.

2. Click Open

3. Type Commands (1 command per line)

4. Click "Send Cmds"

Morpheus Controller - Impedance Check

1. Select the port
   Look for "Elemind Morpheus".
   On Mac use either cu.usbmodem or tty.usbmodem.

2. Click Open

3. Click "Test EEG"

4. Click LeadOff Tab

Leadoff values range from 0~22000
A value below 16000 is okay.
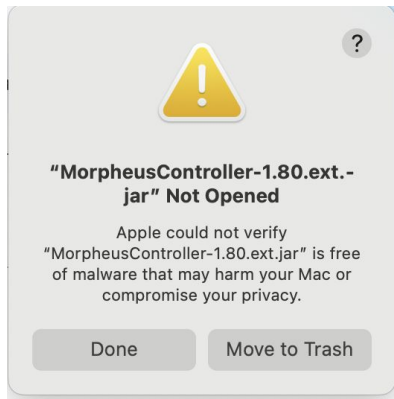
Morpheus Controller Setup

First Time Setup
- Install Java Development Kit (JDK) 24 from Oracle
  (https://www.oracle.com/uk/java/technologies/downloads/)
 It has better USB compatibility and streams data faster.

- Mac Security:
  - The first time you run Morpheus Controller, you will see this. See next slide for fix.

"MorpheusController-1.80.ext.-jar" Not Opened

Apple could not verify "MorpheusController-1.80.ext.jar" is free of malware that may harm your Mac or compromise your privacy.

Done   Move to Trash

Morpheus Controller Setup

- Mac Security (Continued):
  - To Allow, Navigate to: Apple Icon (Upper Left) -> System Settings -> Security & Privacy
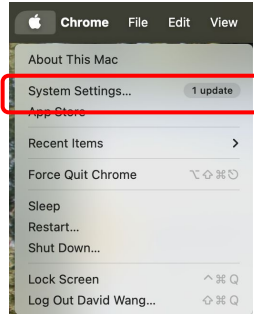
  - Scroll Down and click "Open Anyway"