DIY HUD Development & Install in my RV8 or Your Aircraft

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HUD Project Presentation Summary

1. **What is a HUD?**
2. **Short HUD History**
3. **Why have a HUD in a Experimental Aircraft**
4. **Design Goals**
5. **Current Operational Experimental HUD's**
6. **FlyOnSpeed.org HUD Project Goals**
7. **System Overview & Supported Hardware**
8. **Software System Design**

What is a HUD?

- A **head-up display** (or **heads-up display)**, also known as a **HUD** is any transparent display that allows the pilot to look outside the aircraft while also viewing critical aircraft data without requiring the pilot to also look inside the aircraft.

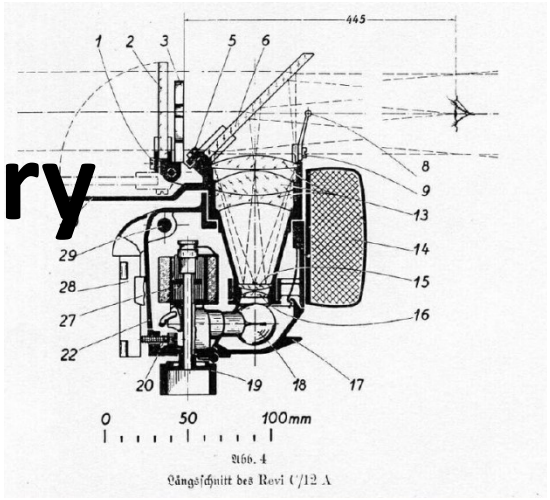
Elbit Systems Skylens

F-18

C-130J

F-35 HMD

Modern HUD Design History



- 1 - Use CRT to generate a green phosphor image on a combining glass
- **2 - Use (LED) light source, modulated by LCD screen (or DLP) to project image on a combining glass**
- 3 - Use optical waveguides to produce images directly in the combiner.
- 4th Gen—Use a scanning laser to display images and even video imagery on a clear transparent medium.

Why have a HUD in a Experimental Aircraft?

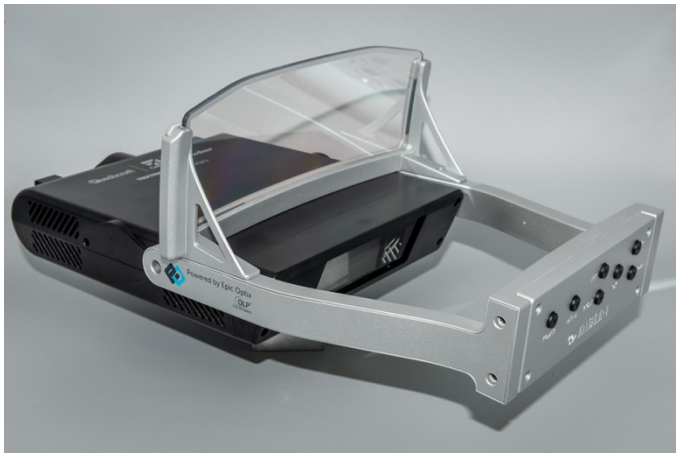
- HUDs enhance safety by providing critical flight information in the visual (Heads-Up Outside the Aircraft) Pilot Environment.

- Typical aircraft HUDs display ➡ Airspeed, **Altitude, Attitude (pitch/roll),** a **Horizon Line, Heading, Vertical Velocity, AOA &/**or ("α“ #), and **Slip/Skid** indicator.
- **Boresight/waterline** symbol,
- **Flight Path Vector** (FPV) or Velocity Vector
- **G’s, QNH, Wind Dir/Speed,** & **OAT**.
- Critical Traffic Data (TD Box -Target Designate)
- Navigation/Comm Data —(For Enroute, approach and landing)
- Critical Aircraft/Engine Data (+ Other information)

Generic HUD Design Goals

- **Focus** – The HUD display should be focused to Infinity
- **Eyebox** – The fixed HUD produces an image inside a three-dimensional area called the eyebox. Head movement too far up/down left/right will cause the display to vanish off the edge of the HUD.
- **Luminance/contrast** – HUD should have luminance/contrast adjustments to account for Sun/Clouds/Night/etc.
- **Boresight** – Aircraft HUD symbology should be aligned with the aircraft's three axes, so that displayed data conforms to reality (typically ±7.0 milliradians), but may vary across the HUD's FOV.
- **Scaling** – The displayed HUD image (flight path, pitch & yaw), should be scaled so picture overlays outside world in an exact 1:1 relationship. Example; object 3 degrees below horizon should appear at the −3 degree index on the HUD.

Available (Economical?) Experimental & TSO'd HUD's



Epic OPTIX Eagle 2 (HDMI Video Input)
$1.5K (Made for Aircraft ⟹ Infinity)
Daylight usable 20K Nits, Night Compatible

DUAL HUD Display (Interfaces with STRATUX/ADSB via WIFI/BT) $549 (DUAL/ACS/Sportys

(Made for Cars ⟹ 2 Meters)

MGF SKYDISPLAY (HUDLY v2 ?) ~$23-25K TSO

(Interfaces with TSO'd Avionics)

(Made for Cars/Aircraft ⟹ 2 Meters?)

GRT Hudly Classic HUD (HDMI Video Input) (In Production but Not Available from HUDLY?)

(Made for Cars ⟹ 2 Meters)

HUDWAY Drive HUD (Comp Video/Tablet Mode) ~ $275 (HUDWAY.com)

(Made for Cars ⟹ 2 Meters)

Why use the Epic Optix HUD?

- The most important innovation in bringing a HUD to GA is to be able to produce a quality but affordable product.
- Epic Optix achieved this by:
  - Designing a HUD that's bright enough for full Sunlight readability (in Full Color using LED/DLP technology)
  - HUD Focuses to Infinity
  - Its designed to fit in the most GA/Experimental aircraft as possible
  - It is affordable at $1500, by commercial HUD standards this price is a rounding error

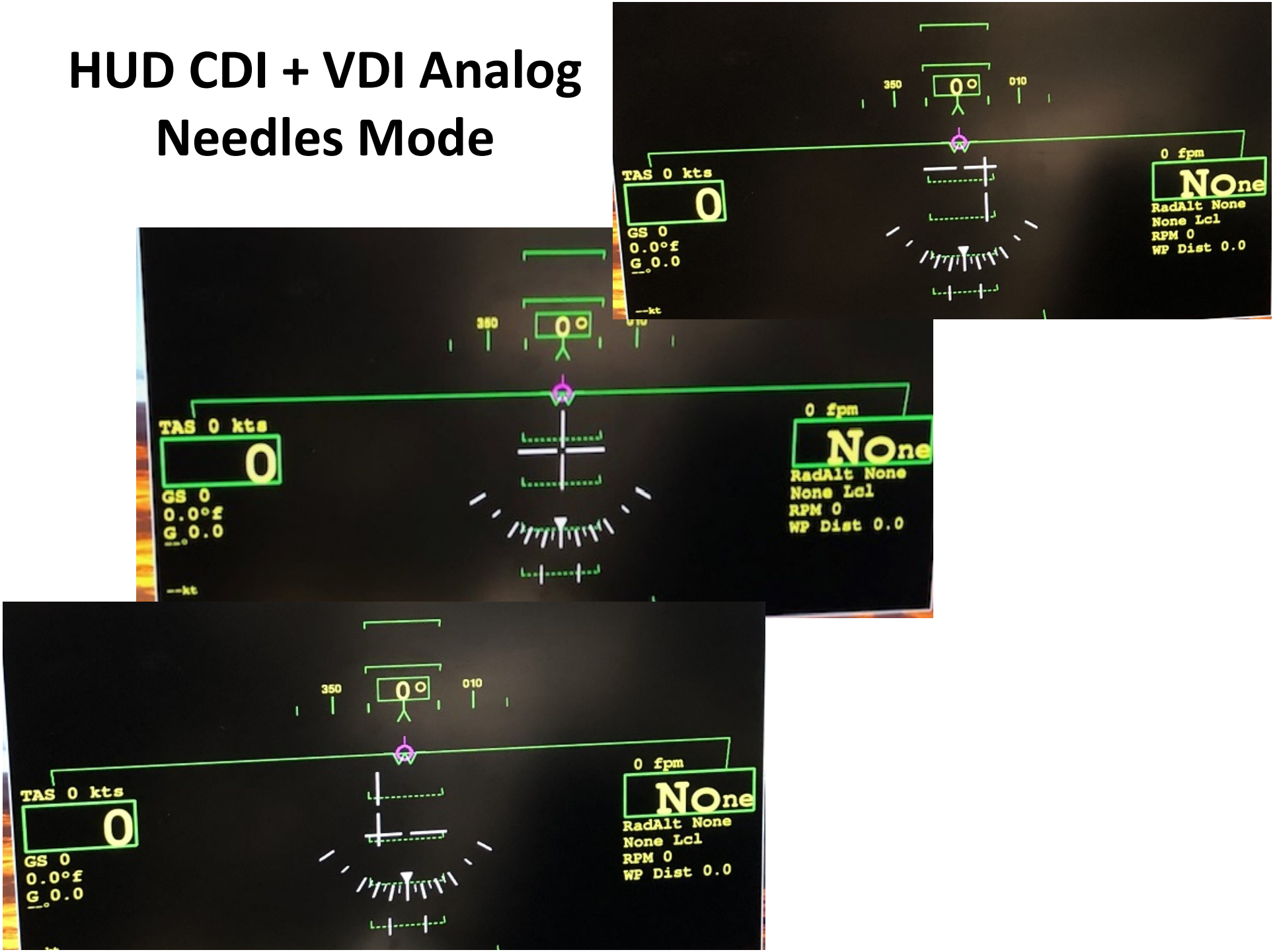
FlyOnSpeed.ORG HUD Project Goals

- Enhance Flight Safety
- Use affordable technology and open source (Free) HUD software
- Make it to be easily integrated with current Experimental EFIS Systems.
- Use a quality HUD that can be installed in many experimental aircraft.
- Use a capable Micro-Computer. Currently a RASPBERRY PI 4B+ ~ $80
- Do the research and development to provide a baseline HUD design
- As much as possible make the system pilot/user friendly
- Allow users so inclined to also modify or create their own HUD designs
- Provide a path for an optional 2nd A/C display (HDMI Video), or display the HUD Camera view via the Camera or DVR outputs.

Basic OnSpeed HUD Design Info


06/16/2023 13:51:33
N95CH
163°
TAS 126 kts
120
GS 132
78.0°f
G 1.1
-388 fpm
3093
RadAlt 3028
9:47:58 Lcl
RPM 2329
WP Dist 11.2
Rng:1800ft
06/16/2023 13:57:48
N95CH
88°
74
GS 73
87.0°f
G 1.0
-455 fpm
337
RadAlt 124
9:54:13 Lcl
RPM 1309
WP Dist 0.4
Rng:3500ft

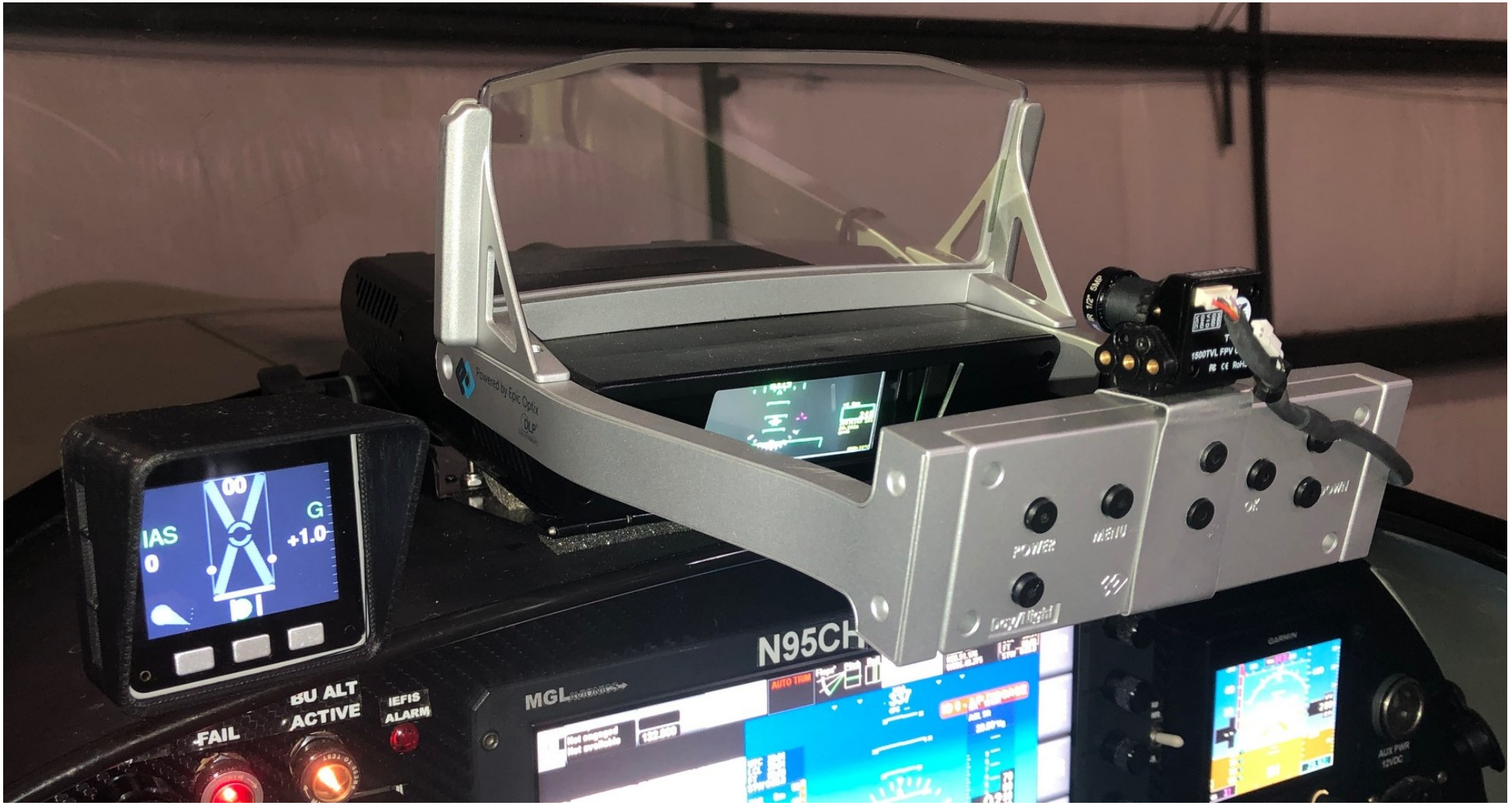
HUD CDI + VDI Analog Needles Mode



BFM Video

Oshkosh_HUD Video_2023.mp4

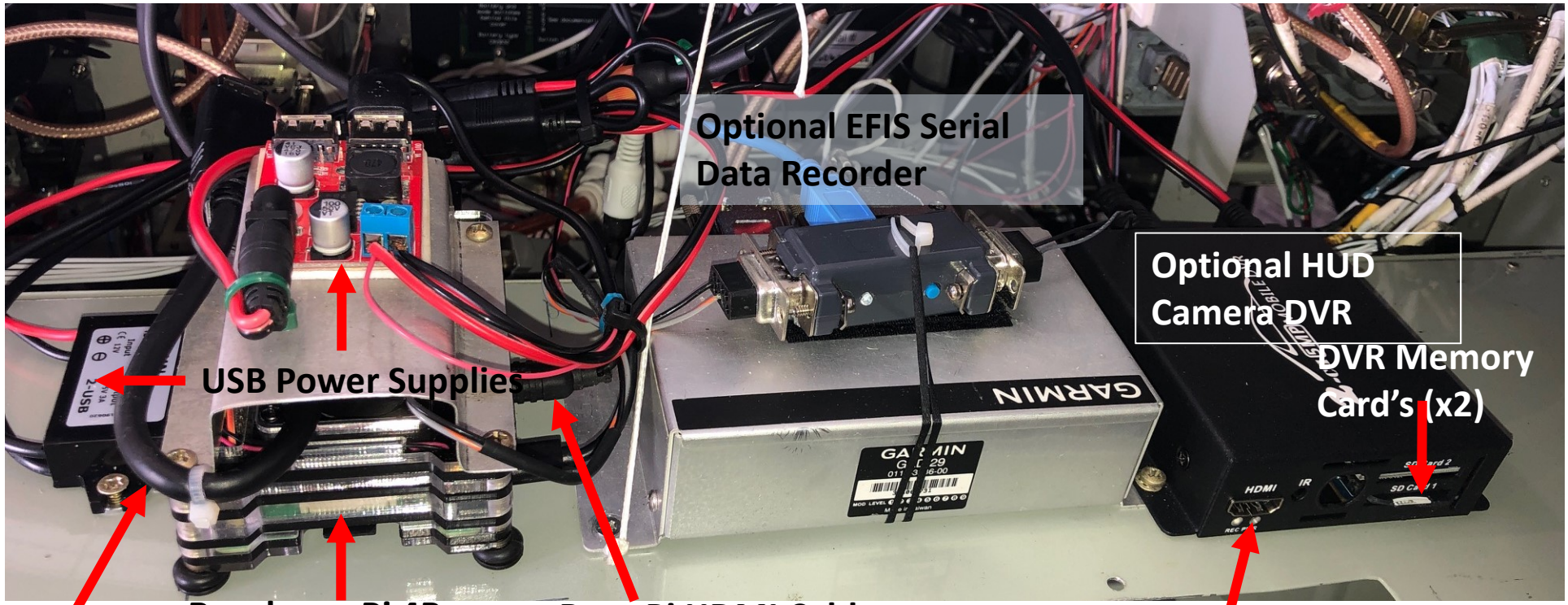
My RV8 HUD Install
Larger Tinted Non-Vans Canopy



Determine Head position / Line of Sight for HUD position.

Next determine how the HUD should be installed.

Locate where to install your HUD Support Electronics (Required and Optional)



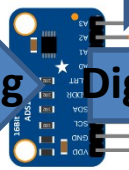
HUD Interconnections

EFIS/NAV

Serial

ADSB-WIFI/Serial

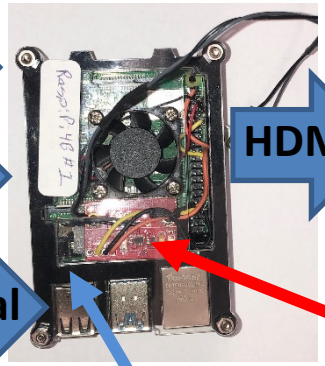
+Analog Digital



ADC1115

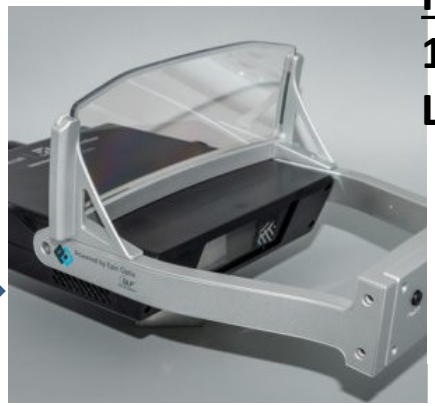
HDMI

Raspberry Pi 4B+ CPU
64GB Data Recorder



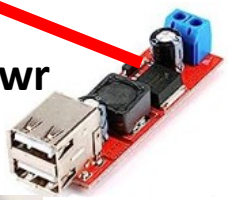
HDMI

Epic OPTIX HUD



HUD

USB-Pwr



USB-Pwr

FPV HUD CAMERA
16-25MM Zoom
Lens & 32 ND Filter

1080P AHD
Video Out

USB

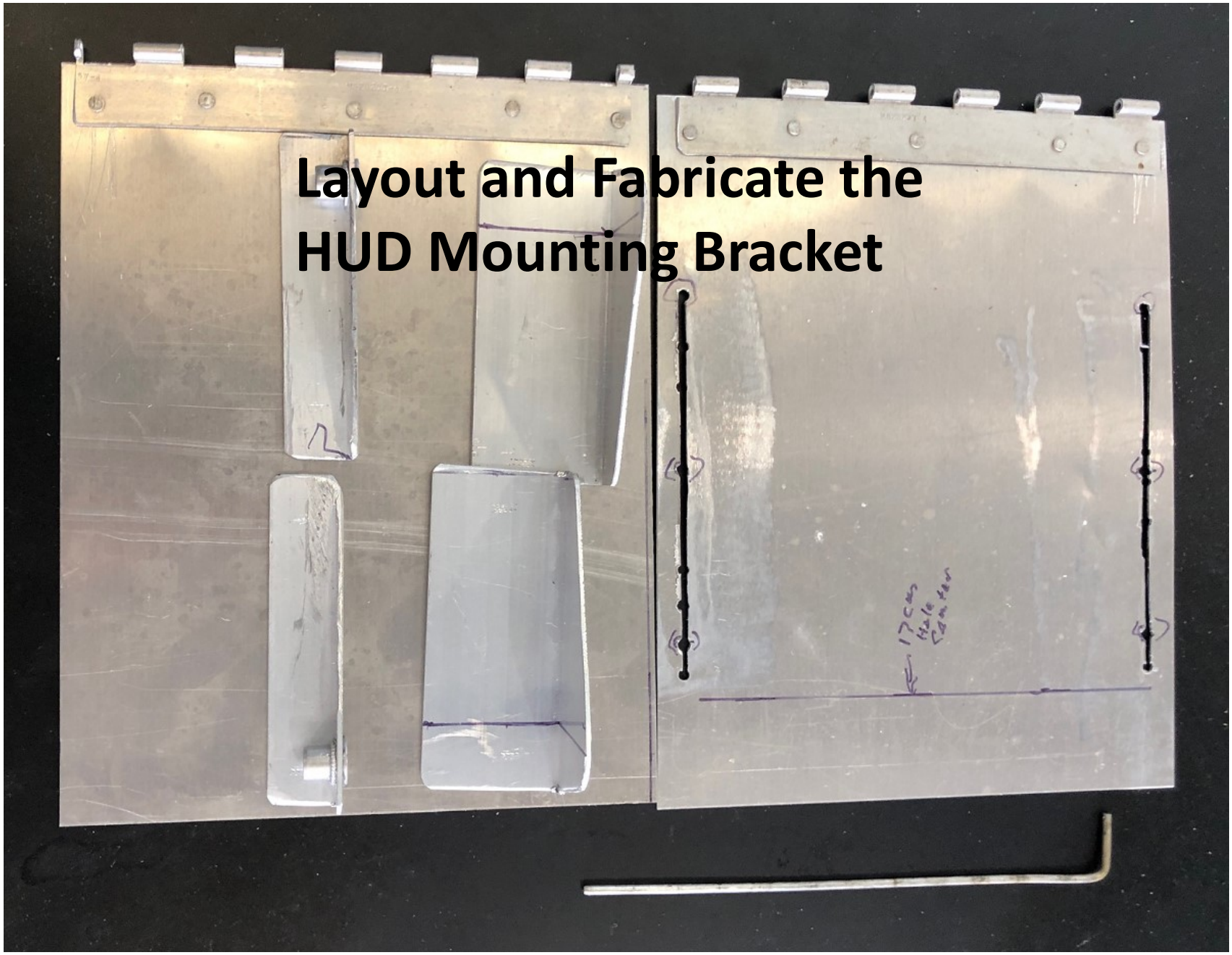
Key Pad Ctrl

1-Start Data Rec
2- Stop Data Rec
3- Tfc Display Cycle
4/5 Drop Buoy Tgts
6- Clear Buoy
7- Data Debug
8- LCOS Ctrl
9- FPM/Ctrl
10- TD Box/ILS

DVR

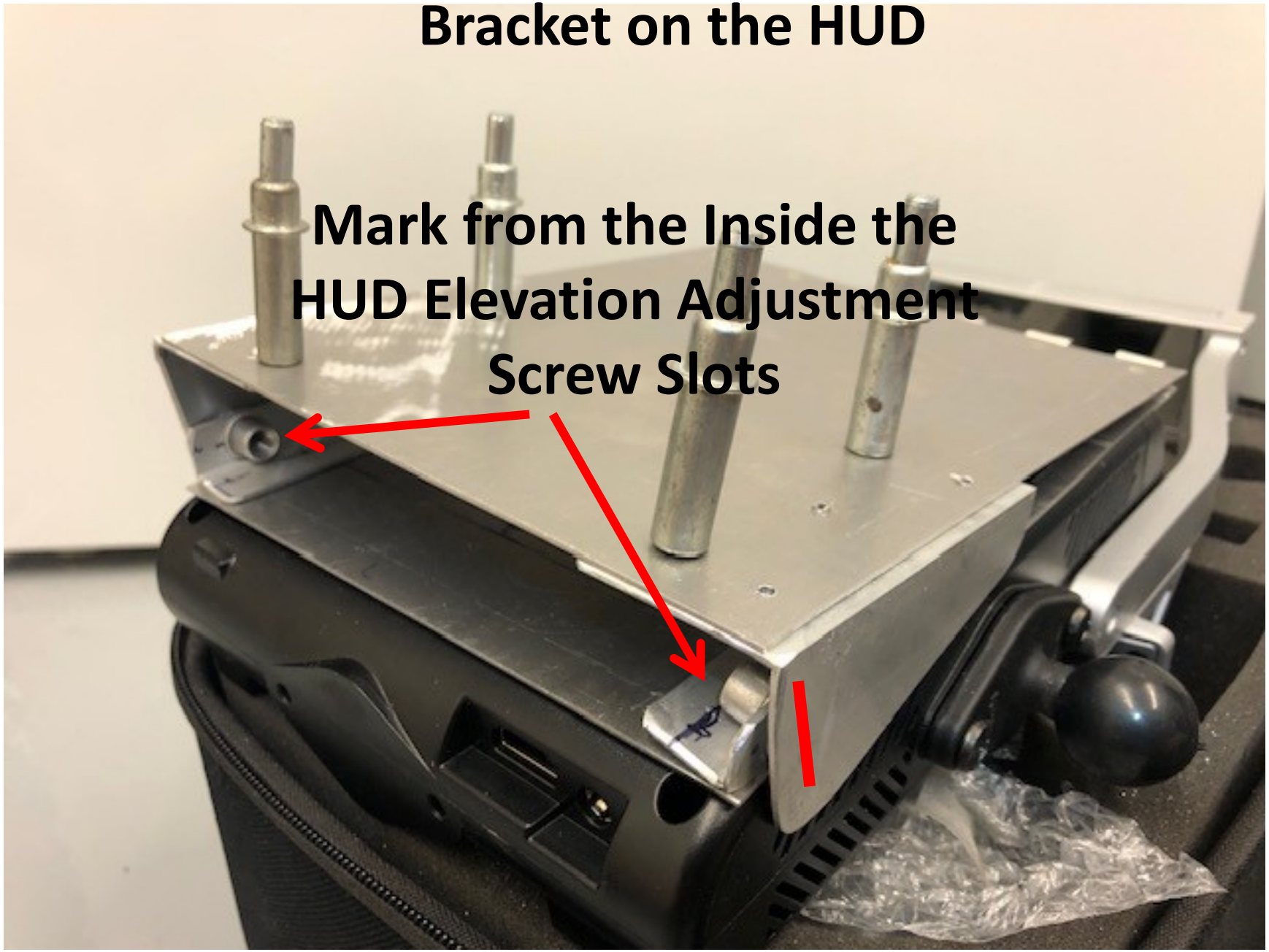
12VDC

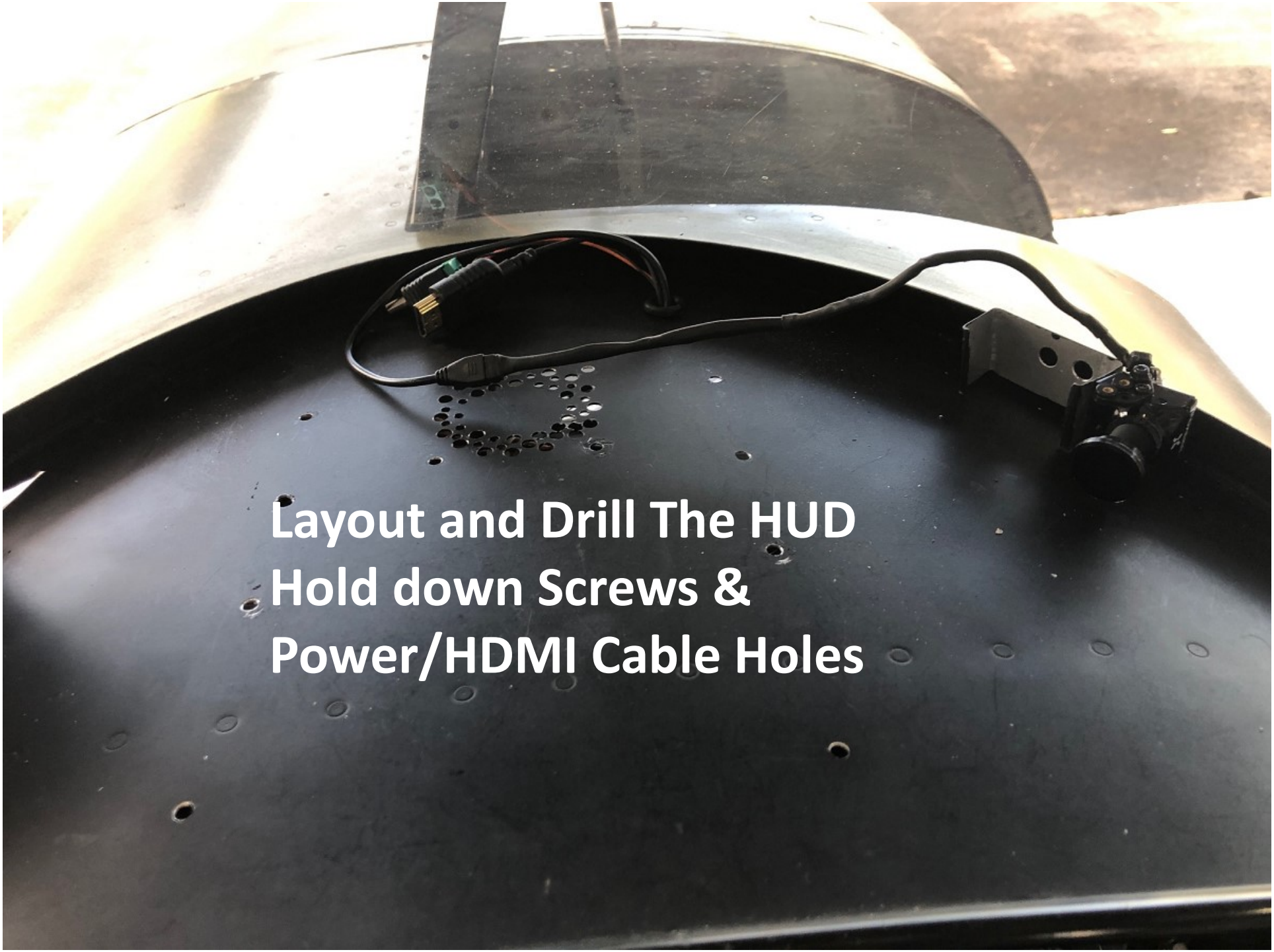
128GB SD Memory Card


Layout and Fabricate the
HUD Mounting Bracket

Assemble the HUD Mounting Bracket

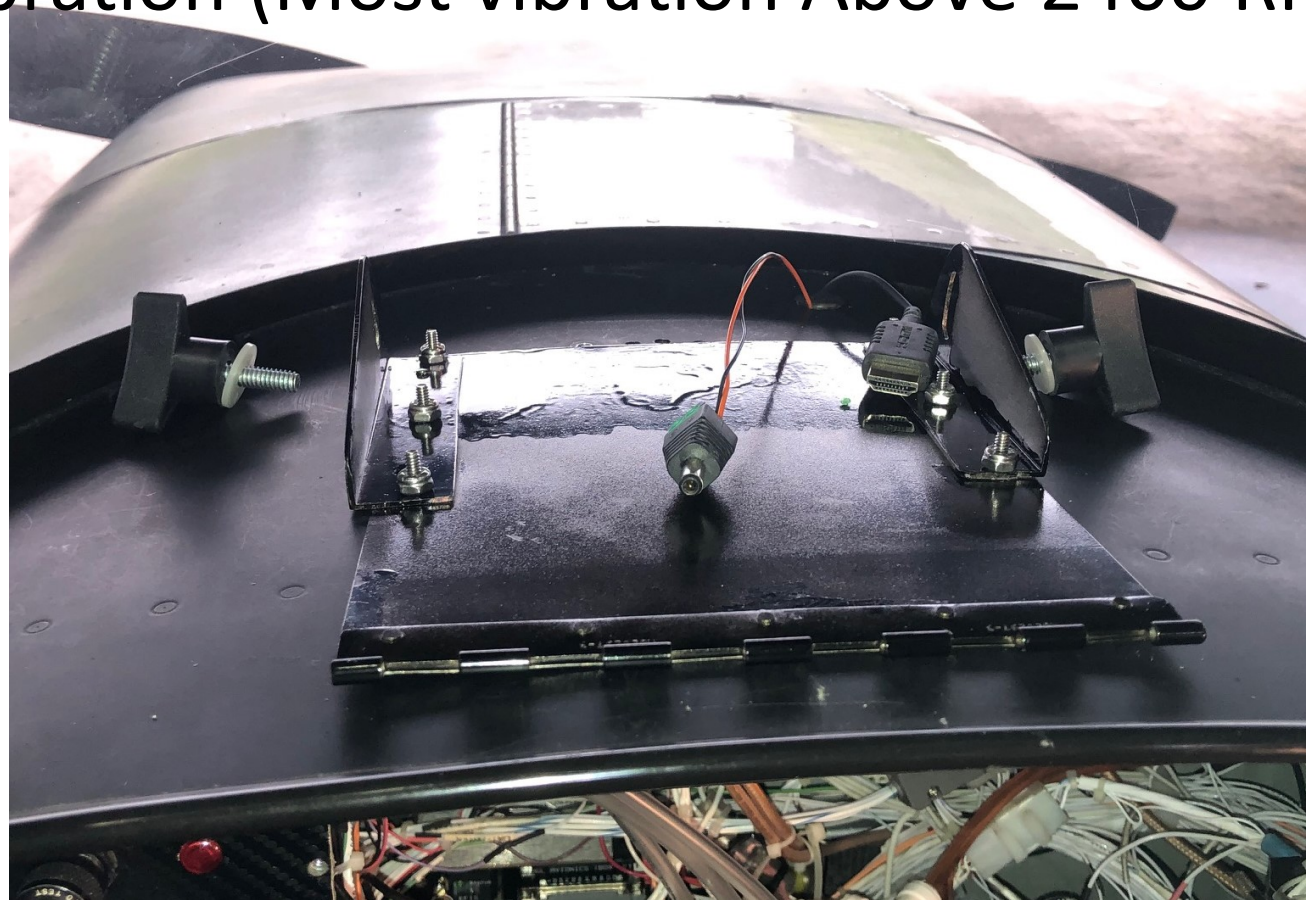
Fit Check HUD Mounting Bracket on the HUD




Layout and Drill The HUD
Hold down Screws &
Power/HDMI Cable Holes

Install the HUD Bracket

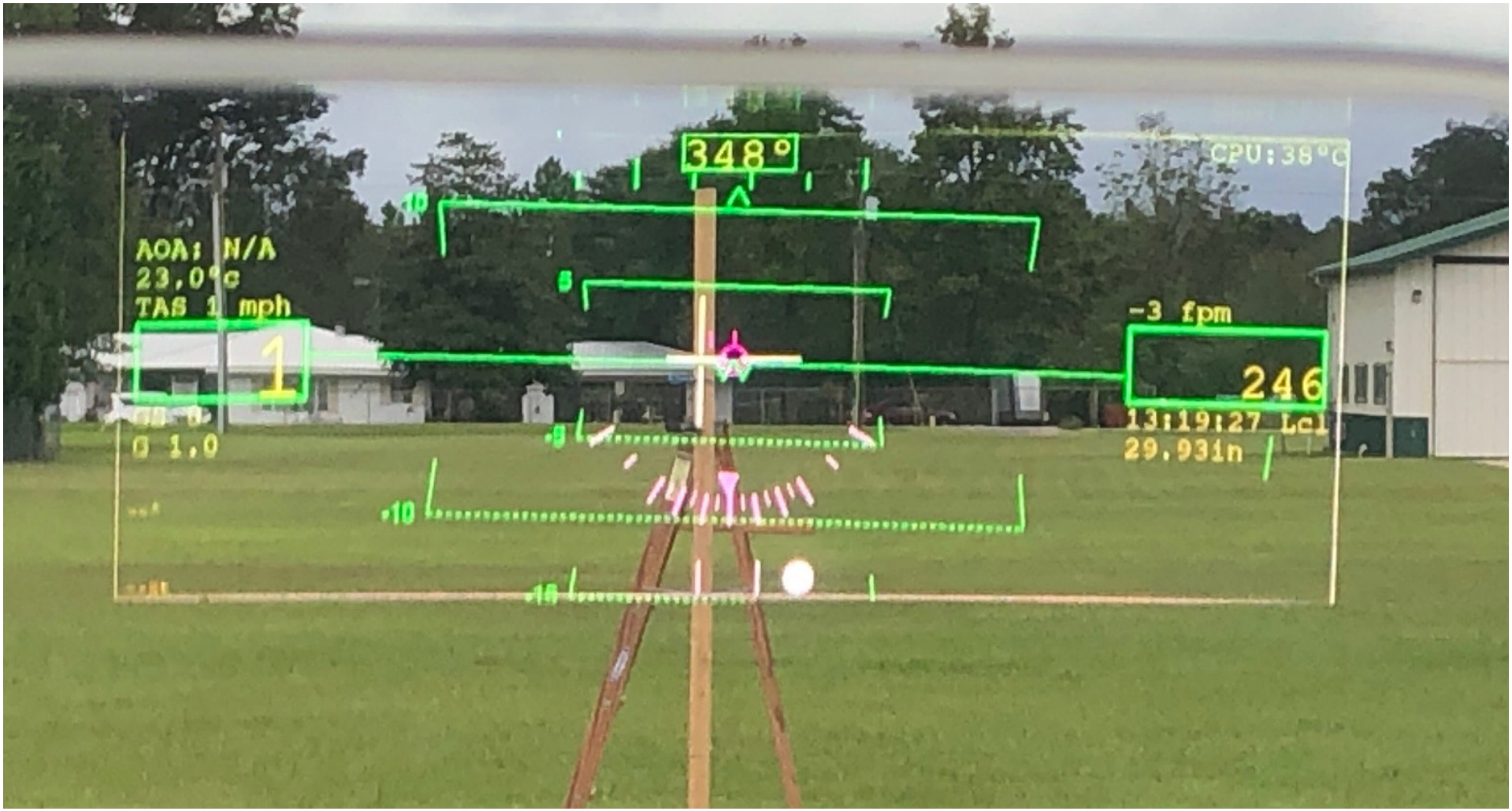
- Screws Allow Elevation Adjustment
- Piano Hinge Gives Bracket Rigidity
- Recommend to Balance Prop to reduce HUD Vibration (Most vibration Above 2400 RPM)



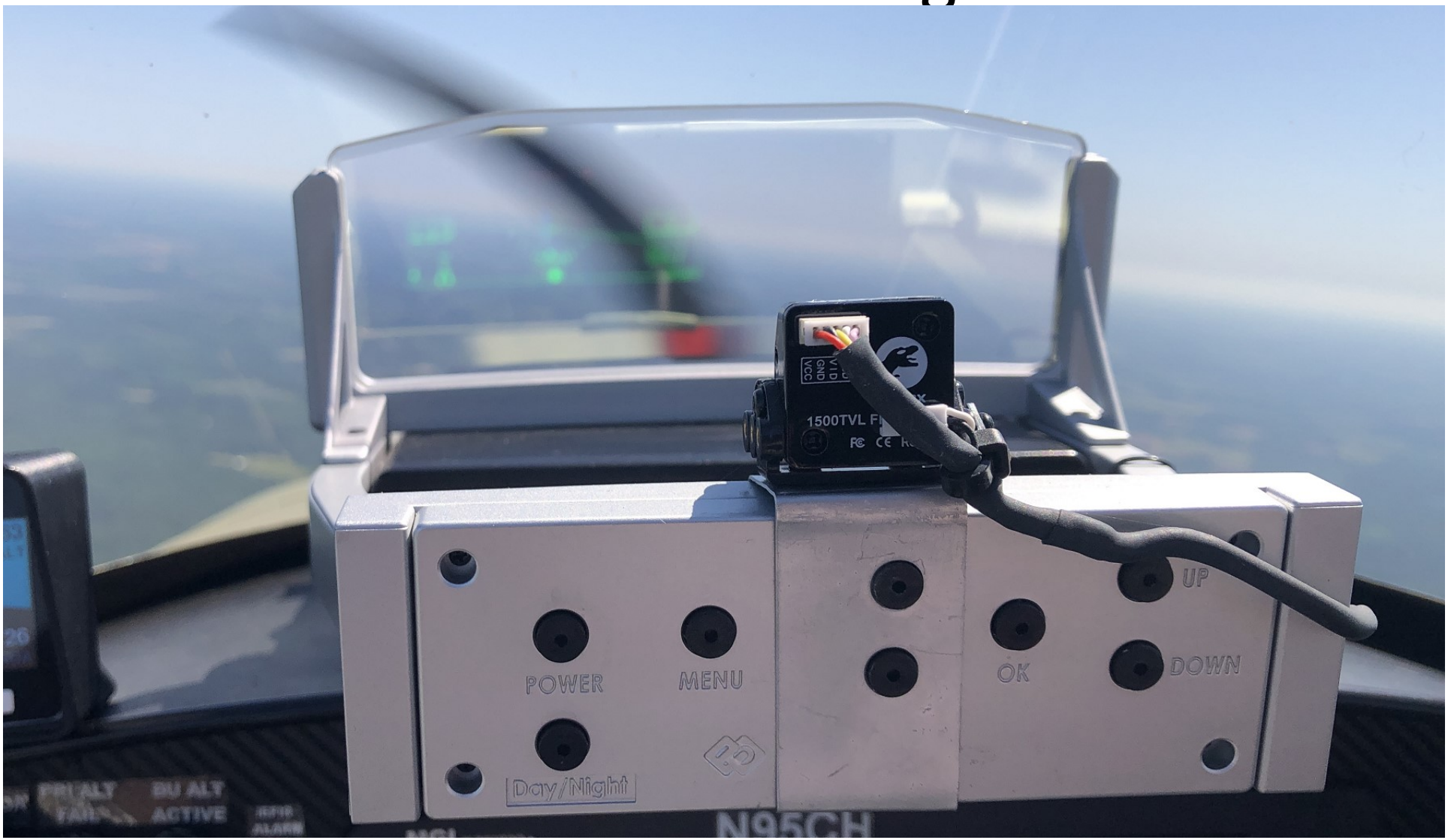
Aligning the HUD Boresight

Azimuth Gnd Install Alignment is Critical

1. **HUD Bracket Azimuth is Fixed - Elevation is Adjustable**
2. **Minor adjustments can be done in software config file**



HUD Complete install with Camera and Mounting Bracket



HUD Picture at Infinity
(HUD Graphics fills screen from Pilot View Box)

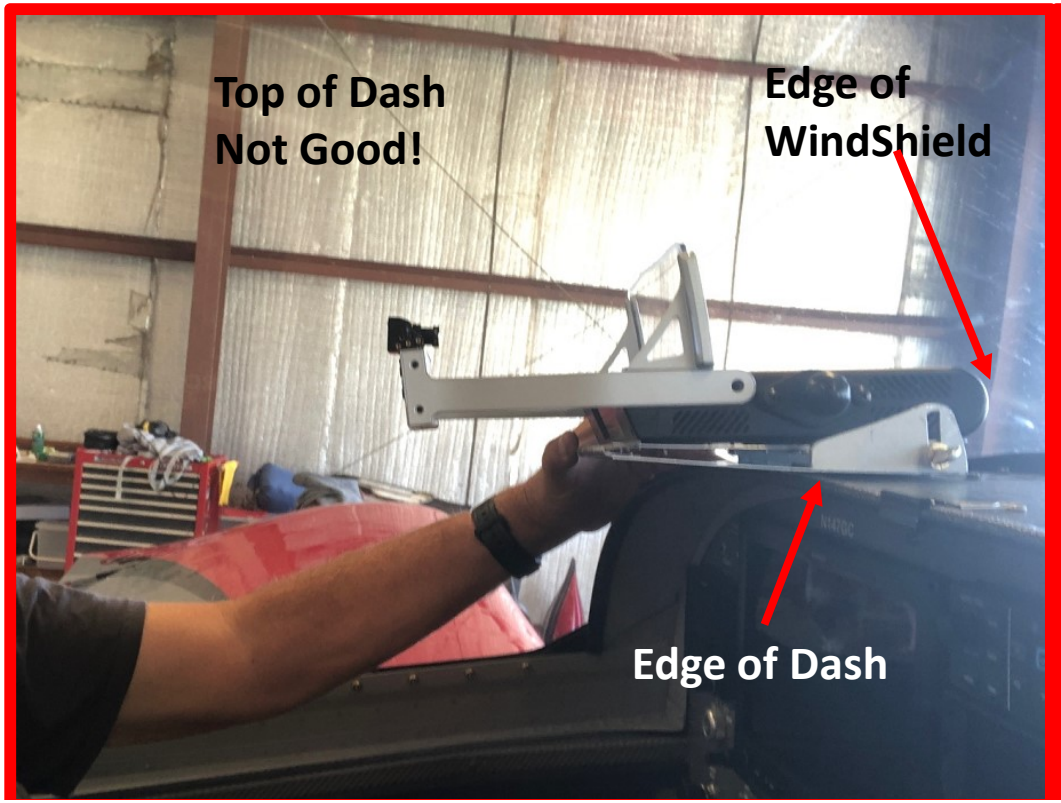
HUD Install in RV8 with Vans Standard Windshield

RV8 HUD Install in - side profile

(Vans Standard Windshield)

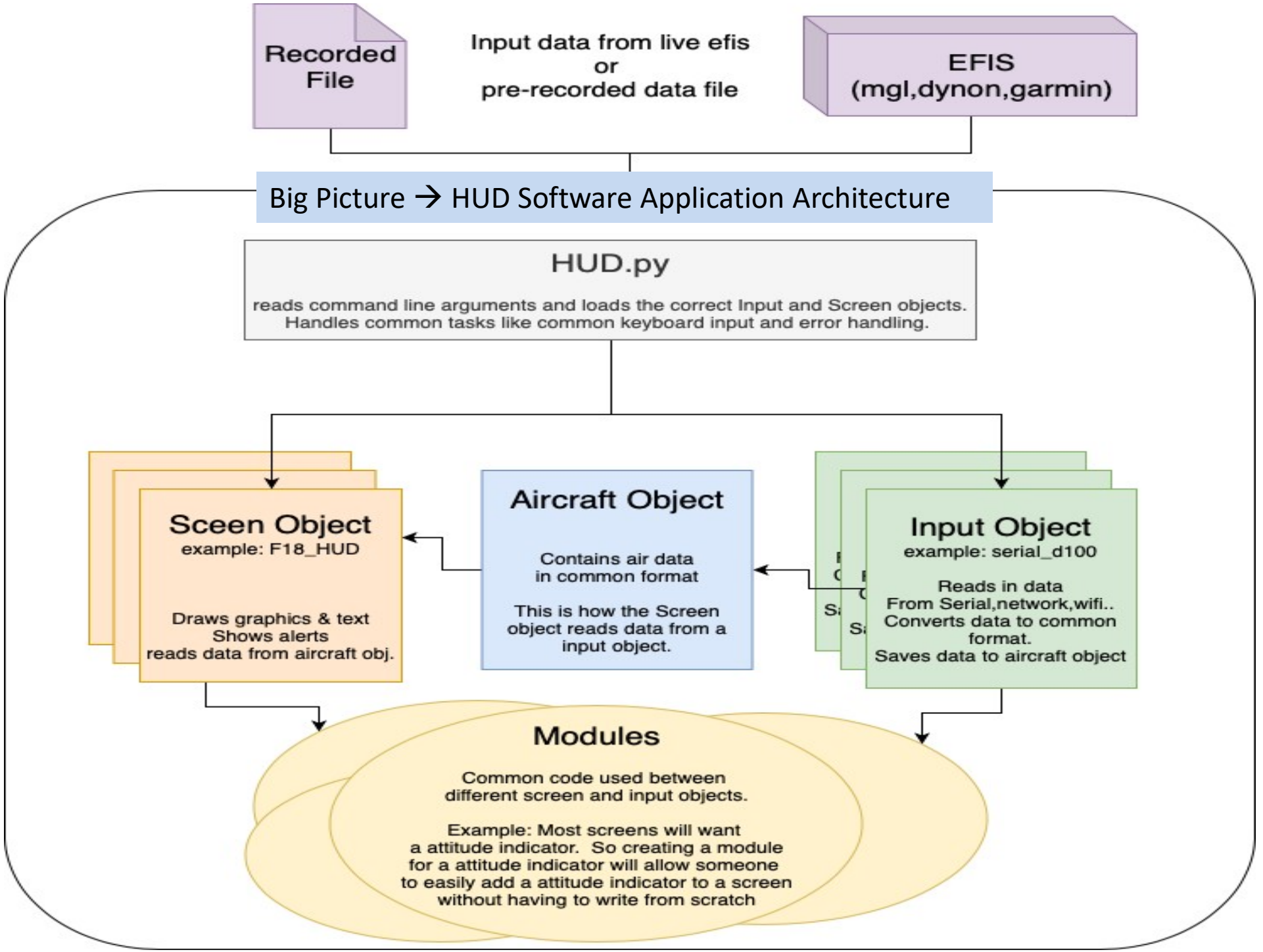
HUD Test Fit in RV14

To Cut and fit HUD under Dash & windshield would likely put HUD "EYEBOX" to low for normal use?

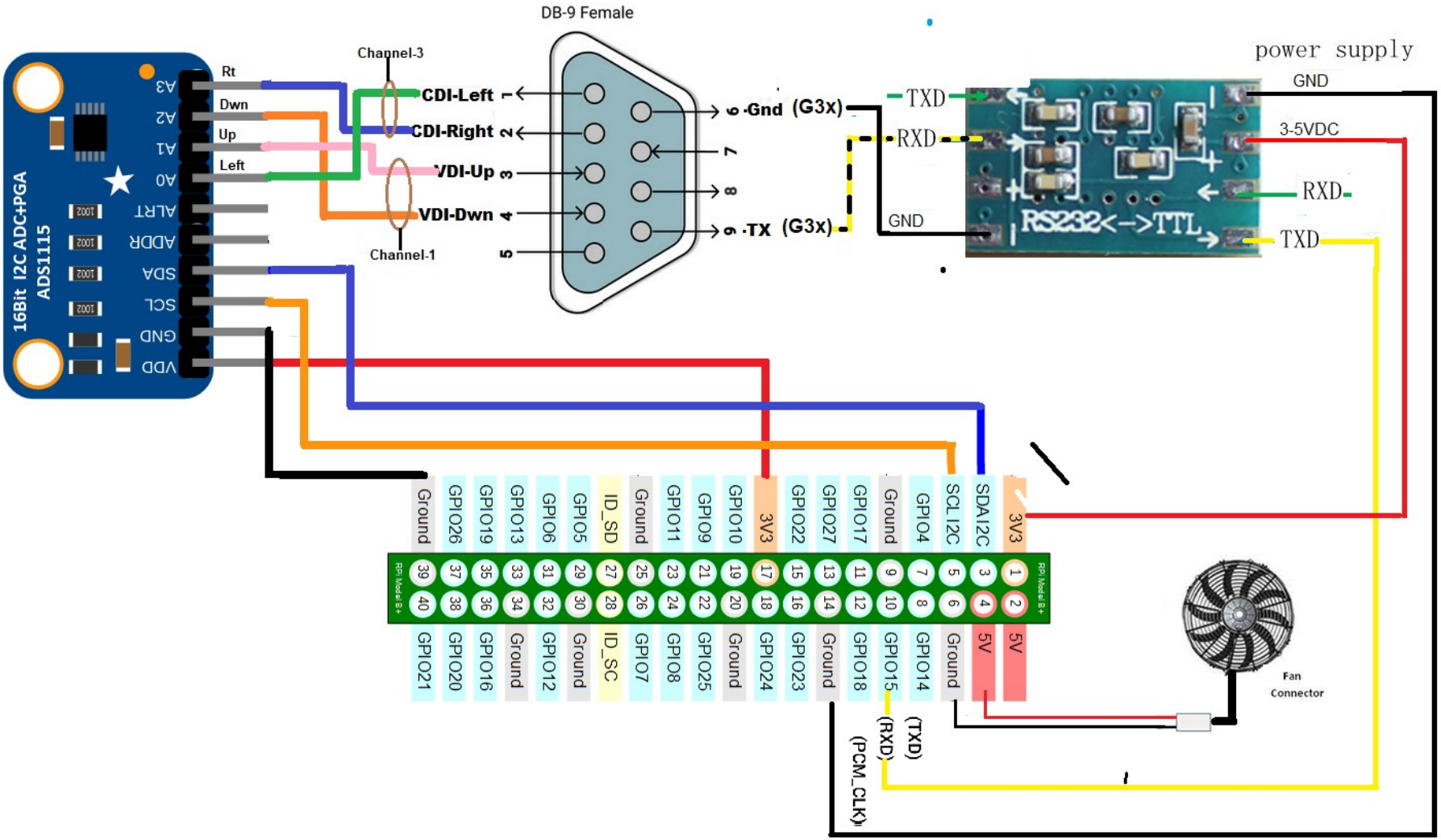


FlyOnSpeed AOA Raspberry Pi Software Features Include:

- Supports serial from MGL, Garmin G3x, Dynon Skyview & D100 (GRT Next?)
- Supports wifi from Stratux, iLevil BOM, iLevil 3, uAvionix Echo UAT, Dual XGPS190, Dynon ADSB wifi, etc.
- Software and instructions available for Free on Github
- Users can use provided HUD screens or build custom EFIS or HUD screens
- Record flight log to and Playback from external USB drive (fast forward playback avail)
- All screens look and work the same for all supported data input.
- All display screen sizes and ratios supported. (set through config)
- Touch screen support
- 14-20 + FPS on Raspberry Pi 4B+ (Frame rate impacted by Data and Graphics)
- Remote keypad / user input support. (USB 10-key number pad works good)
- Display flight data in Knots, Standard, Metric, F or C (set in config)
- Designed for Raspberry Pi but also runs on Mac OSx, Windows, and other linux systems.
- Can display CDI needles for NAV and approaches. (With Analog→Digital Chip & CDI Needles Input) or direct NAV Data
- Use multiple data sources (IE. Serial, Wifi, Analog inputs at the same time)
- Shows traffic as scope display, or target flags (When ADSB traffic source input available)
- User dropped buoy targets for virtual dogfighting
- Has BFM mode (Basic Fighter Maneuvers) for 1v1 with cooperative wingmen
- Has HUD color Camera & DVR for post flight debriefs
- Text Debug mode (Helpful to see the actual raw data values during playback)
- Now updated to Python 3!


Recorded File
Input data from live efis or pre-recorded data file
EFIS (mgl,dynon,garmin)
Big Picture → HUD Software Application Architecture
HUD.py
reads command line arguments and loads the correct Input and Screen objects. Handles common tasks like common keyboard input and error handling.
Sceen Object
example: F18_HUD
Draws graphics & text
Shows alerts
reads data from aircraft obj.
Aircraft Object
Contains air data in common format
This is how the Screen object reads data from a input object.
Input Object
example: serial_d100
Reads in data From Serial,network,wifi..
Converts data to common format.
Saves data to aircraft object
Modules
Common code used between different screen and input objects.
Example: Most screens will want a attitude indicator. So creating a module for a attitude indicator will allow someone to easily add a attitude indicator to a screen without having to write from scratch

Raspberry Pi connected to ADC1115 + RS232 connected → EFIS (+ ADSB via WIFI)



FlyONSPEED Head Up Display Project

*Featuring the most cost effective & Highest

Quality Gen Aviation HUD Available Today*

The Epic Optix EAGLE 2 HUD

Note: Any HDMI or NTSC/PAL compatible HUD/VIDEO Display can be used.

Why have a HUD in an Experimental Aircraft?

How to get the Software

1. Create a GitHub account (Free)
2. Sign into https://github.com/flyonspeed/efis_to_hud
3. Download instructions for setting up Rasp-PI
4. Perform a “git pull” to download current HUD programs
5. Select HUD program to use (test with sample HUD Data)
6. If ready to help program coordinate with Chris and myself.

QUESTIONS??