Precision DAQ Package for Aerospace Applications

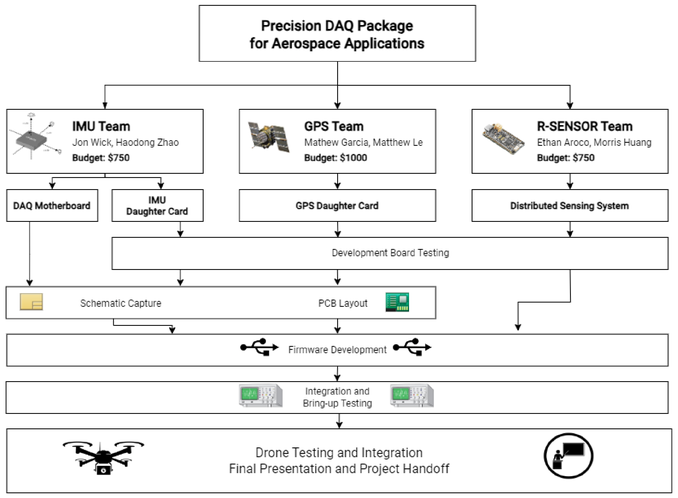
Fusion Flight

Problem Statement

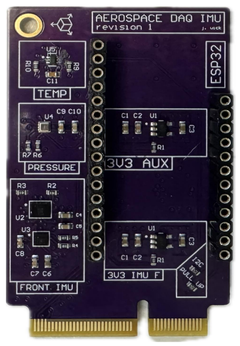
- FusionFlight has developed a set of aerospace electronics to improve the current sensing solutions for advanced unmanned aerial mobility operations
- Prioritizes real-time data acquisition, onboard storage, and wireless streaming, focusing on IMU and GPS data collection
- A variety of sensors are employed to fuse positional data into a single source
- The hardware draws less than 25W, with a BOM cost less than $1000

System Features and Requirements

- Current solutions sample GPS at 1 Hz and IMU data at 10 Hz, significantly limiting the processing potential. FusionFlight hardware can sample GPS at 10 Hz, and distributed sensing systems and inertial modules at 100 Hz.

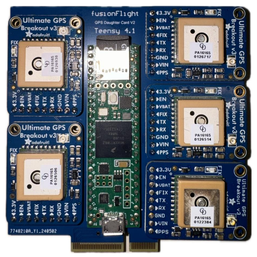


IMU – Inertial Measurement Unit



- Custom ESP32 carrier board with multiple sensors: accelerometers, magnetometers, gyroscopes, pressure and temperature sensors
- FreeRTOS based operating system allowing for deterministic and high frequency communication [2] (Up to 100 Hz sample rate on select sensors) [3]
- Adjustable full-scale measurement range, allowing for tunable accuracy across varied physical environments
- Automotive rated parts used wherever possible to ensure robust and reliable operation

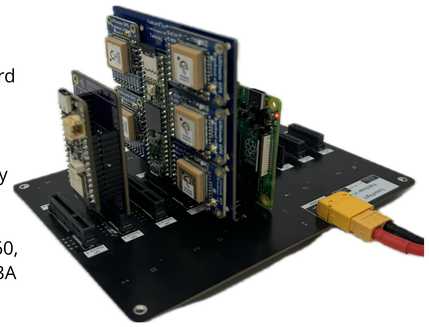
GPS



- GPS Interface Card acts as a RDC (remote data collection) to collect, process, store, and transmit data
- Collects 550 parameters in one second [1]
- Receives 5 signals from GPS satellites and decodes raw data to calculate 550 parameters per second
- Processed data is externally stored to log data on the microSD card
- Encapsulates collected data string and communicates over custom protocol compatible with industry standard Serial Peripheral Interface (SPI) [4]

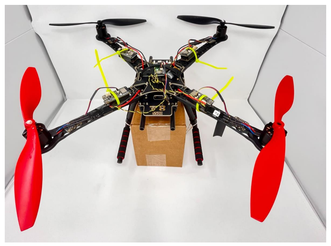
Data Acquisition Motherboard

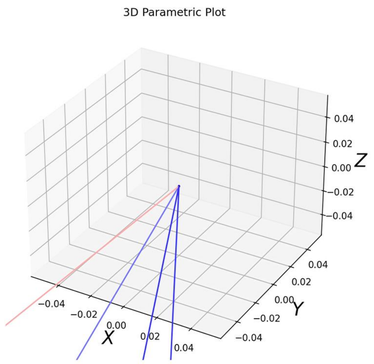
- The motherboard serves as the central hub, it distributes power and data busses for all 8 possible daughter cards
- Standard pinout for maximum daughter card customizability
- Facilitates data transmission through 2 SPI channels and 1 I2C channel into a Raspberry Pi 5 for further analysis by FusionFlight
- Powered by a 3S drone battery through XT60, the motherboard efficiently distributes 5V/3A (15W) to daughter cards using automotive rated buck converters [5]



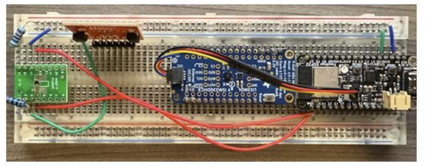
R-Sensors

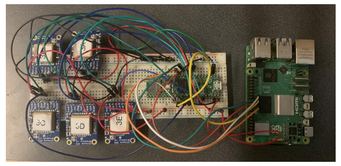
- Distributed inertial and environmental sensing network
- One “pod” measures magnetic field and acceleration (position)
- 5 pods work in tandem to collect, store, and visualize data in real-time 3D



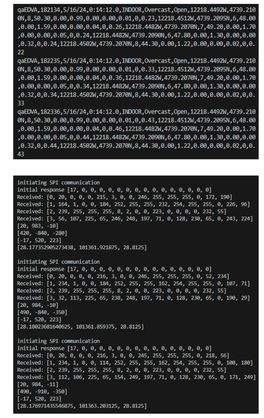


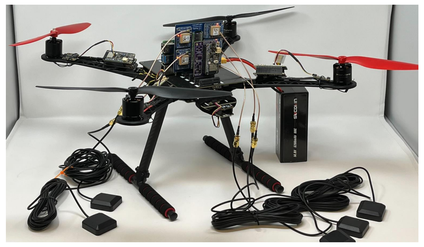
Testing and Results





- Daughter cards were tested on breadboards with off the shelf development boards to begin firmware
- GPS functionality tested and verified under varied natural environments (inclement weather, clouds, etc.)
- Static acceleration rig to calibrate accelerometers at a standard 1 m/s² acceleration
- R-Sensors experimentation was done on separate rig to independently verify its measurements for each pod
- All daughter cards can successfully communicate and are powered by the motherboard





Future Work and References

- Perform rigorous flight testing and collect datasets from differing flight conditions
- Fuse all sensor data together with FusionFlight ML algorithm for real time positioning
- Use NEO-M8N GPS Modules as a cheaper, lower power consumption, and higher precision alternative for commercial use
- Refine 3D data plotting by using MATLAB or optimizing Python; develop R-sensor daughter card

[1] Adafruit Industries, "Adafruit_GPS," *GitHub*. [Online]. Available: https://github.com/adafruit/Adafruit_GPS. [Accessed: 15-May-2024].
{2} Hideaki Tai, "ESP32SPISlave," *GitHub*. [Online]. Available: https://github.com/hideakitai/ESP32SPISlave. [Accessed: 15-May-2024].
[3] STMicroelectronics, "ASM330LHH," *GitHub*. [Online]. Available: https://github.com/stm32duino/ASM330LHH. [Accessed: 15-May-2024].
[4] PJRC, "Teensy 4.1 SPI Slave," *Forum*. [Online]. Available: https://forum.pjrc.com/index.php?threads/teensy-4-1-spi-slave-here-it-is.72792/. [Accessed: 15-May-2024].
[5] Texas Instruments, "LM22670-Q1," *TI Product Listing*. [Online]. Available: https://www.ti.com/product/LM22670-Q1/part-details/LM22670QMRE-5.0/NOPB. [Accessed: 15-May-2024].

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SPONSOR: GOKUL NATHAN, FusionFlight