Custom Dev Board Ideas

Sensor Suite

Barometer – BMP390

- MS5611 is great but more expensive and has had supply shortages recently
- Provides pressure and temperature readings, altitude can be derived

IMU – LSM6DSO32

- Great performance for the cost
- Have previous experience with it

Magnetometer – *TBD*

- Adds additional degrees of freedom when fused with the 6DoF IMU for more accurate orientation

Ambient or Infrared Light Sensor (analog)

- Cheap, small, and easy to use
- Included "because why not" given the low cost and easy integration

Proximity Sensor

- Enables some interesting functionalities I've wanted to experiment with
- Some ICs bundle an ALS, which could make the previous discrete ALS unneeded

Humidity Sensor *(optional)*

- Useful for collecting environmental data

Power Supply

Linear Regulator (LDO)

- Simple and reliable
- Very low output noise, great for an AVDD rail
- Inefficient and limited VIN range on small boards without sufficient thermal management

Buck / Buck-Boost SMPS

- Higher efficiency
- Wide VIN range and maintains efficiency when stepping down from higher voltages

- More complex layout with additional external components
- Requires careful layout to minimize switching noise

Planned Scheme

- **SMPS** supplies the main 3.3 V rail and feeds the LDO.
- **LDO** powers the 3.3 V analog rail (MCU AVDD and sensitive analog sensors).
- Considering adding an SMPS-bypass jumper so the LDO can act as the sole regulator for ultra-quiet operation.

Power Source

Primary Source: USB-C

- When connected to a computer or in locations where outlets are available
- 500mA max at nominal 5V

Secondary Source: Battery
- When portability or higher current capabilities are needed
- Max supply current and voltage are battery and regulator dependent

Power Management & Protection

- 1S / 2S / 3S Li-Po charger IC + battery monitor
- Considering a shunt resistor for current monitoring
- Protections: reverse-polarity, over-current, over-voltage, under-voltage, etc.
- Considering a load switch for integrated peripherals supply rail

External Storage / Memory

QSPI NOR Flash

- Solid-state data and file storage
- Allows multiple firmware images
- QSPI offers quad-bit transfer vs single-bit SPI for higher bandwidth

microSD Card Slot

- Allows optional mass storage
- Easy capacity upgrades

PSRAM (Octal)

- Greatly expands available RAM for demanding tasks such as an Extended Kalman Filter

Microcontroller

Primary MCU – ESP32-S3

- Similar to the C3 I've used, but with more GPIO, USB OTG/MSC, greater processing power, and other useful features
- Excellent community support and documentation
- Works with the Arduino IDE, great for people new to microcontrollers and writing writing embedded firmware
- PlatformIO + VS Code development stack allows for lower level board control and a more capable workflow (Arduino Framework to easily switch from Arduino IDE and ESP-IDF for maximum control and performance)

Secondary MCU *(maybe)*

- A companion (e.g., STM32) could off-load dedicated workloads and free up GPIO for the sensor suite
- Can be function without it preserving ease of use for beginners

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Communication Interfaces

Internal Buses

- **SPI** for high-speed sensors (IMU)
- **I^{2}C** for lower-speed sensors (optionally the IMU via jumper)
- TBD bus for chip-to-chip comms (relevant for a dual-MCU design)

External / User IO

- **UART** for debugging and redundant flashing
- **SPI / I^{2}C** broken out to headers for external peripherals
- **USB 2.0 FS (CDC)** for primary programming, boot-loading, and serial monitoring
- **USB MSC** to expose SPI-flash or SD-card partitions as a mass-storage drive
- **Wi-Fi** for OTA firmware updates and general wireless comms
- **BLE** for low-power, lower-throughput wireless links
- **GPIO** pins broken out to side pins for the standard Arduino/breadboard experience

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Other Functionality

- Reset and boot buttons (plus spare user buttons)
- Status LEDs
- Microphone *(maybe)*
- Piezo buzzer *(maybe)*

- ESC or H-bridge for motor control *(maybe)*
- Dedicated servo channels *(maybe)*
- Footprint / connector for optional LoRa or GNSS modules *(maybe)*