Volansi NextGen Autopilot & Backplane

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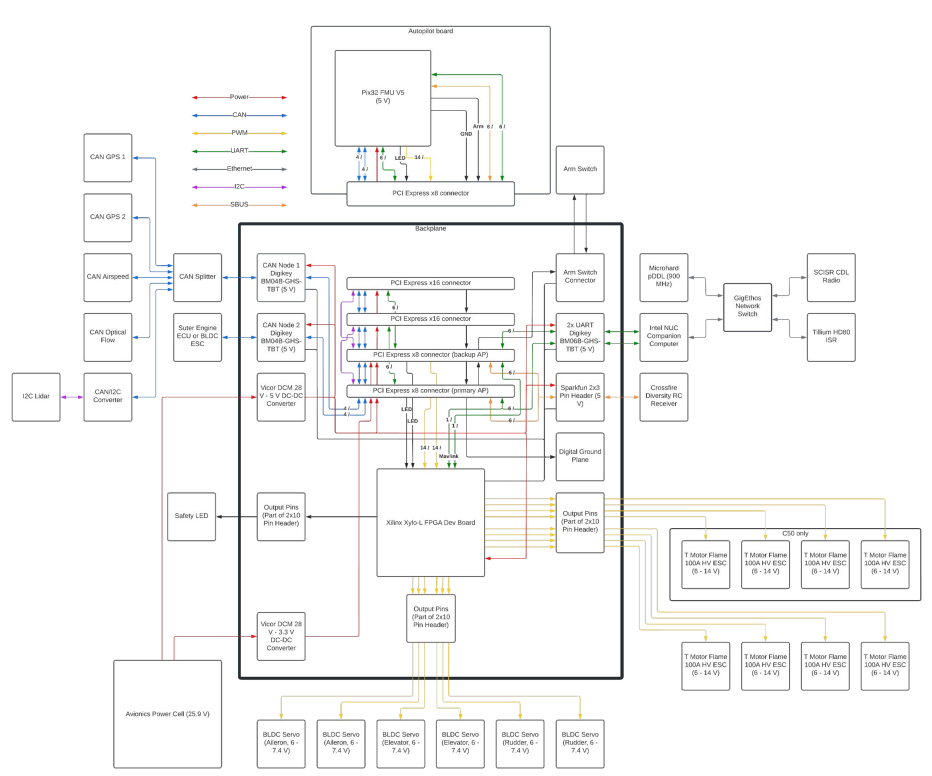
Background

- Volansi is building unmanned drones for civilian and military logistics use
- These drones come in different sizes for various applications; currently, each size has its own design and all components are hard-wired in place
- The intended use of the drones is for providing healthcare to rural areas and sites of natural disasters, but current designs are not optimized for this
- This project developed a modular backplane and autopilot design
- Design requirements were to have hardware redundancy for the autopilot, use an FPGA for signal multiplexing, and make sure components were durable

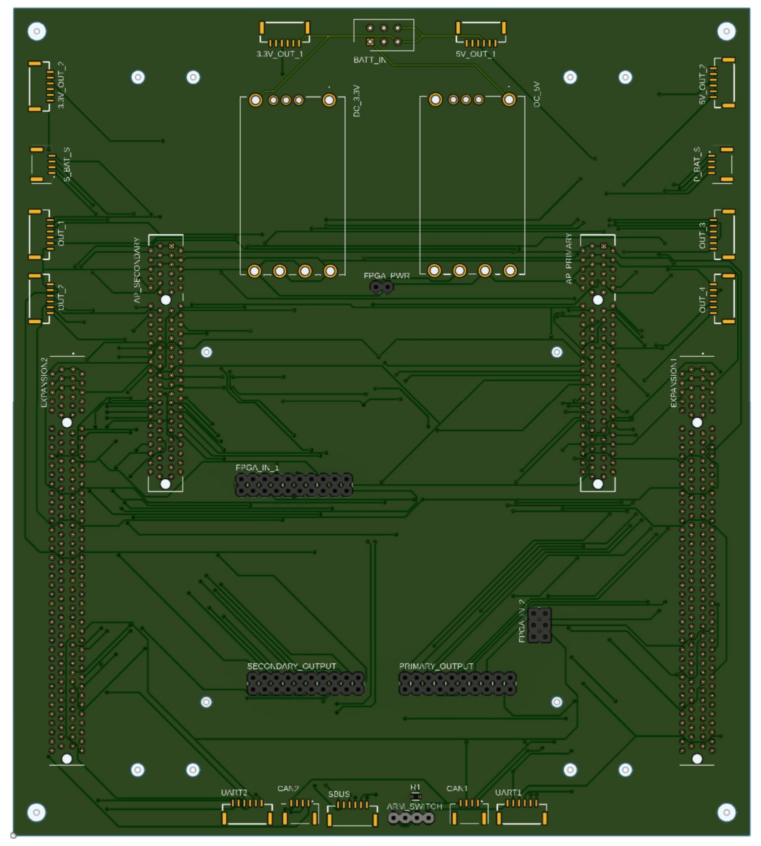
Design structure and consideration

- The overall design consists of backplane and two autopilot cards for avionics control
- The backplane routes the input signals from the drone sensors to the autopilots and switches between autopilots when a hardware failure occurs
- The autopilot cards each have a flight computer on board and run in parallel to control the drone using inputs from the backplane



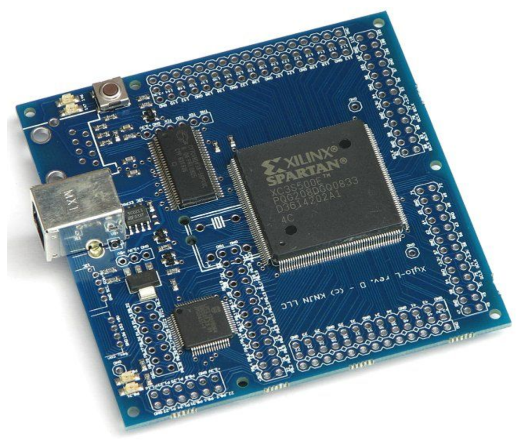
Backplane

- The backplane is the main focus of the project, and provides the main connections between all of the avionics components.
- The backplane houses connections for two autopilot PCI-e cards (a primary card and a secondary card), which output their signals through the PCI-e slot, to the FPGA.
- The FPGA uses a watchdog timer and a "heartbeat" signal from the AP boards to determine if the main board is functioning properly, if not, it will switch control to the secondary autopilot card.
- All flight sensor devices (LidAR, Airspeed, Optical Flow, GPS) connect to the backplane through a CAN bus
- All Servos and ESC motors are controlled through PWM output ports.



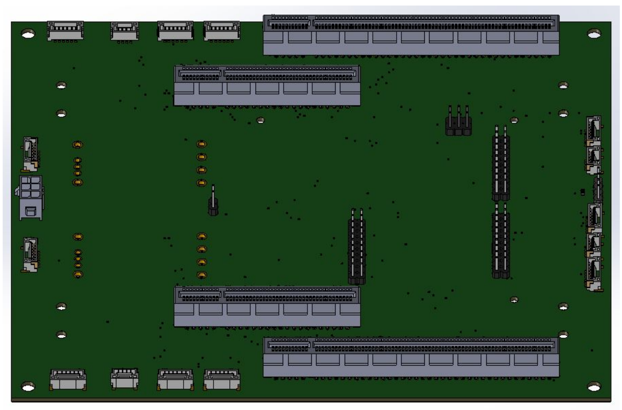
Power and FPGA

- The Board is powered by the onboard avionics battery, which provides 26V DC to the board through the main battery connector. This voltage is then stepped down to 5V and 3.3V through two DC-DC converter modules. The FPGA and autopilot cards run on these power rails
- There are power ports available for powering any external devices.
- The FPGA is a Xilinx Spartan 3E on a Xylo-L dev board. Its purpose is to take the control signals from the two autopilot cards, including a watchdog signal, and multiplex the signals and output the right signals to control the motors and aero surfaces on the drone.



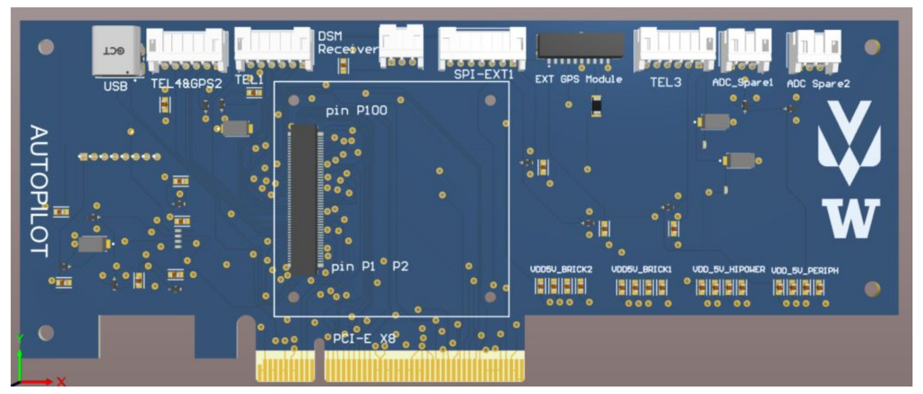
Data transfer and I/Os

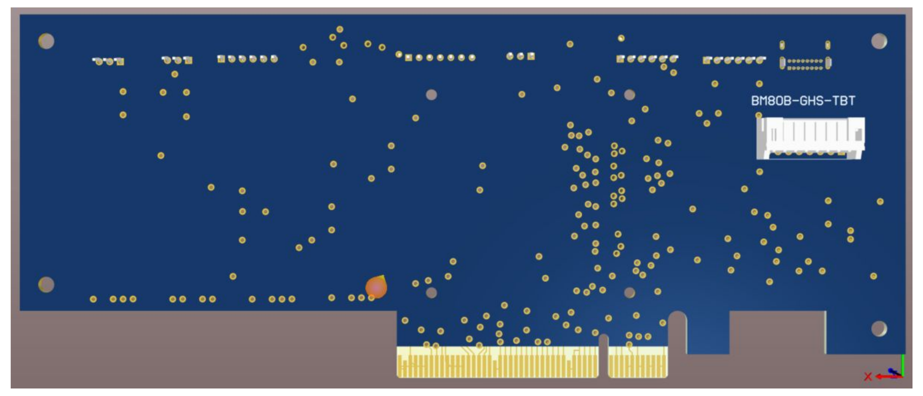
- The Autopilot board is contained with all different specs of JST-GH connectors for different sensors, and for power connections. Ready for peripheral sensors and GPS modules to plug and play.
- The Autopilot board is USB type C ready. flight data setting would also simple and easy.
- This board connects to the backplane via the PCI-e x8 connectors, and each autopilot card can connect to one expansion card through the larger corresponding PCI-e x16 slot.



Autopilot Board

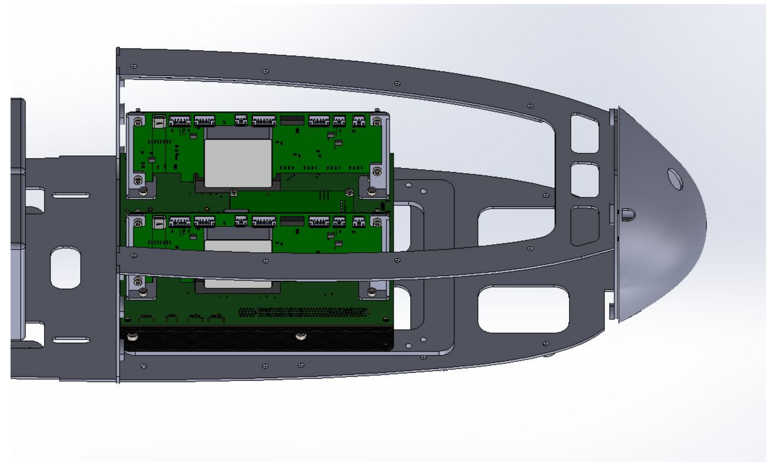
- The Autopilot Board is the hub, linking the flight control units on backplane and the peripheral sensors to the computation module on the center box.
- Considering its requirement on quick swap and high dataflow, we made it as a Modular PCI-E card. The maintaining process would be as easy as handling a desktop graphics card.
- All the functions on Pix32 calculation module is kept and capable for all sensors.
- USB type-C connector ready. instantaneous firmware tweak and shortened turn-around time due to software settings

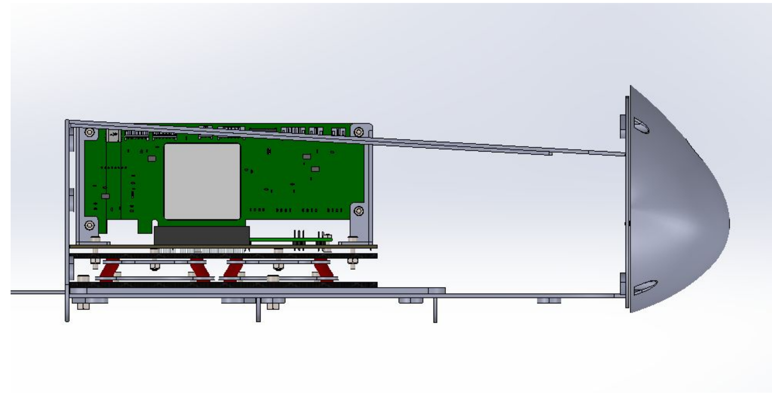




Mechanical aspect

- The base bracket is designed to hold the backplane and autopilot cards in the fuselage to withstand force, vibration and thermal impact.
- The isolators are placed between upper and lower carbon fibre plate which dampens the vibrations passing from the frame of the drone to the backplane.
- Isolators have silicon rubber dampers placed on all four corners on which the backplane is placed.
- The vertical mounts placed on the backplane are designed to hold the autopilot cards from shaking during the flight.





Results

- The Backplane and Autopilot cards were designed with the IPC-2221 PCB design standards. This permits 0.1mm clearance between traces, and this was used in the DRC check for both boards, which pass this requirement.
- The virtual assembly of all parts (Backplane, AP boards, FPGA, Pix32V5, brackets) was successfully completed in Solidworks with 3D CAD models of all components.

Future Work, References, and Acknowledgments

- The next steps for this project is to take the designs to the manufacturing phase, manufacture the Printed Circuit Boards, and build and assemble the final redesigned avionics bay.
- The physical hardware also needs to be tested once built to ensure design is practically sound, and will not fault under actual flight conditions.
- An additional improvement would be to integrate the FPGA with the backplane instead of using the Xylo-L dev board

References:
- Altium Designer PCB Design Resource
https://resources.altium.com/
- Electronic Component Search Engine
https://componentsearchengine.com/
- DigiKey
https://www.digikey.com/
- PX4 Autopilot User Guide
https://docs.px4.io/master/en/

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