

Performance and Design of UAVs: Test Aircraft Development

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Abstract

The student completed a ten-week project to design a radio-controlled test aircraft for laboratory exercises for MEAM 543, Performance and Design of UAVs. The resulting aircraft was handed over to the teaching assistants for the Fall 2017 iteration of the class, alongside instructional materials on the manufacture and configuration of the plane and software used, to allow for repeatability and continued development. The aircraft uses a Pixhawk flight controller and GPS module to log flight data, which can be extracted in CSV format and used in Matlab for students to analyze.

Adapting the Plane

The plane is a commercially available SuperPup RC plane, and was chosen for its quality as a “starter kit” - intended for inexperienced pilots – as well as its portable size. It was modified with the addition of an internal 3D printed brace and external wing mount for a pitot airspeed sensor. The brace holds a Pixhawk flight controller and gps module in place and accommodates the wiring necessary to connect the controller to the rest of the system.



Figure 1: SuperPup with wing-mounted pitot airspeed sensor.

Designing the Brace

The internal brace was designed to sit in the central compartment of the SuperPup and to be held in place by the wing. It needed to be light weight and hold a Pixhawk flight controller module and its accompanying GPS module.



Figure 2: The Pixhawk flight controller.

The initial prototype pictured leftmost in the Figure 3, was refined in the subsequent iteration (right) to reduce weight by removing material, whilst resisting bending stresses in the undercarriage holding the Pixhawk and GPS module through the use of supportive longitudinal and transverse beams. This technique was inspired by semi-monocoque wing designs used in aircraft manufacture. Further improvements included designated holes for wire-management.

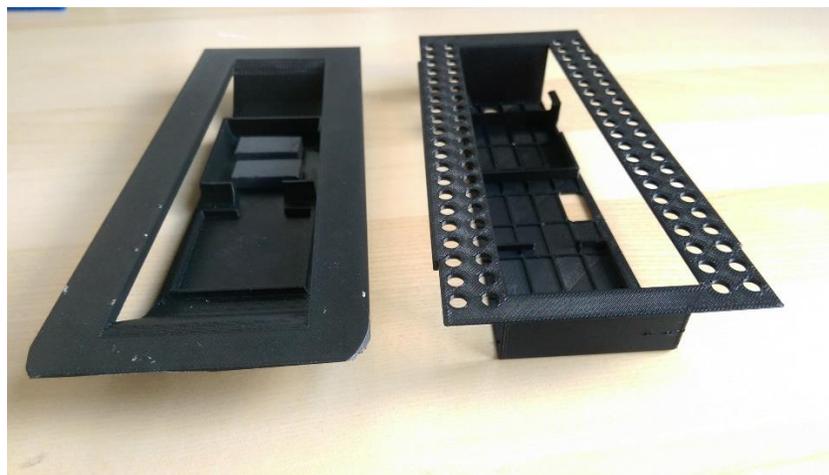


Figure 3: Initial iterations of the brace.

The final iteration of the brace included an additional downwards plate to prevent the additional wiring of the Pixhawk module from becoming entangled with and snaring the SuperPup's elevator and rudder servos, also contained within the plane's main compartment, an issue discovered in initial flight testing.



Figure 4: The final Brace iteration with vertical plate and clips for cable management.

Pitot Airspeed Sensor

The pitot airspeed sensor was designed following similar light-weighting techniques used for the brace, with the additional challenge of needing to mate with the pre-existing attachment points used for the wing's support struts. It attached directly onto the wing, though could not be removed without cutting the 3D printed piece itself once attached.



Figure 5: Pitot Airspeed Sensor mounted on wing.

Wiring

The propeller's motor controller and the servos controlling the rudder and elevator were fed into the Pixhawk RCIN port via an adapter and servo Y cables, with the GPS and airspeed cable connected directly to the Pixhawk. The Pixhawk drew power from a Pixhawk brand power module which connected the Pixhawk directly to the LiPo battery, into which two switches were spliced to allow for easy resetting of the Pixhawk module without needing to open up the main compartment.

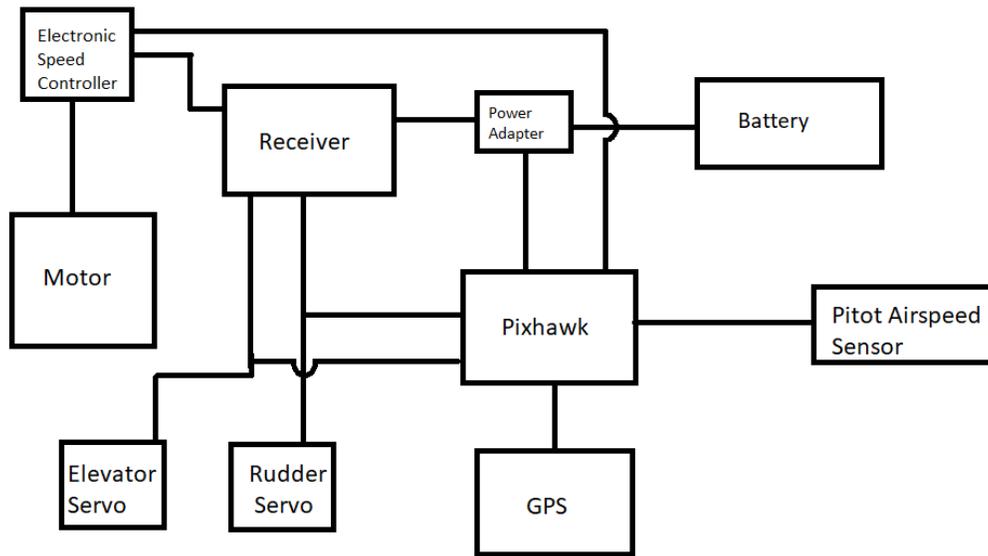


Figure 6: Wiring Overview.

Finally, additional wiring extensions were added and run out of the plane's main housing to the pitot speed sensor.

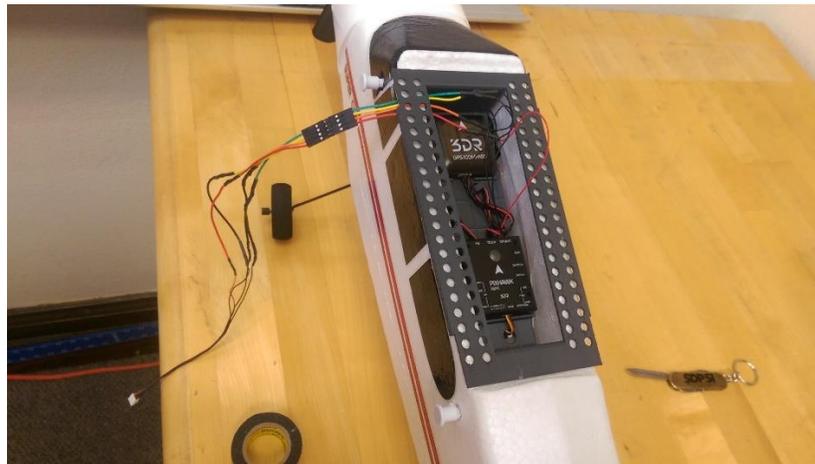


Figure 7: Brace and fully wired Pixhawk and GPS module.

Data Collection and Processing

Using these inputs and its own onboard sensors, the Pixhawk records a huge breadth of data, only some of which is useful. Of most interest to the project are the accelerometer, gyroscope, gps, and airspeed data logs produced. The Pixhawk is configured to begin recording data from startup to shut down and produces a single .ulog file for each time switched on. To split the file into usable data the python NUMPY library was downloaded and used to install a Pixhawk script library called pyulog from Github. This library splits ulog files into many excel spreadsheets (.csv files) which can be read by Matlab.

Conclusion

The project overall made strong progress towards a fully functional test aircraft. The adapted SuperPup flew in several test flights and recorded data successfully which could be used in Matlab. A step by step manufacturing process guide, configuration guide and the CAD files necessary for 3D printing the brace and pitot sensor mount were provided to the teaching assistants for the Fall 2017 iteration of Performance and Design of UAVS. Future steps to continue development of this project should include an emphasis on using the data collected to validate student developed flight models, as well as further refinement and redesign to increase ease of use and crash resistance.