Assessing Propeller Stability Effects in Small Electronic Aircraft

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Abstract

P-factor is an aerodynamic phenomenon experienced by ascending, single propeller aircraft. An angle between the blade of a rotating propeller and the airstream causes thrust generation to change at different angular positions of the blade. The result is asymmetric thrust production and the induction of a negative (counterclockwise) torque about the yaw axis. In order to explore more efficient propellers and higher power motors on smaller 0.5-1.5 m wide airframes, we want to understand and characterize this phenomenon. Using a combination of wind tunnel and field tests, we plan to characterize the p-factor related torque experienced at a variety of angles of attack, freestream velocities, and different rotational velocities.

Introduction

The goal of this project is to design systems to take tests to characterize the P-Factor phenomenon. By characterizing the forces and torques imparted on the propeller in a wind tunnel the torque induced by a specific electric motor-propeller configuration can be analyzed. If a wind tunnel is not available gyroscope and accelerometer measurements can be taken in the field to estimate the maximum

Field Test System

- Test system design
  - Modify existing airplane, designed by flitetest
  - Update planform and tail configuration
  - Add an oversized propeller and motor
  - add data logging system
- Data Logging
  - Acceleration
  - gyroscope
  - air velocity

Wind Tunnel Test system

- Test system design
  - Force dynamometer
  - 4 strain gauge torque sensor
  - Handheld taachometer
  - analog pitot tube
  - TracerDaq readout system
- Electronics setup
  - 3 x 5000 mAh batteries
  - Power meter
  - Handheld transmitter
  - FrSky X4R receiver
  - Lumenier 35A ESC
  - Cobra motors
  - APC propellers

Figure 7: The Union College Wind Tunnel (picture from Union.edu)

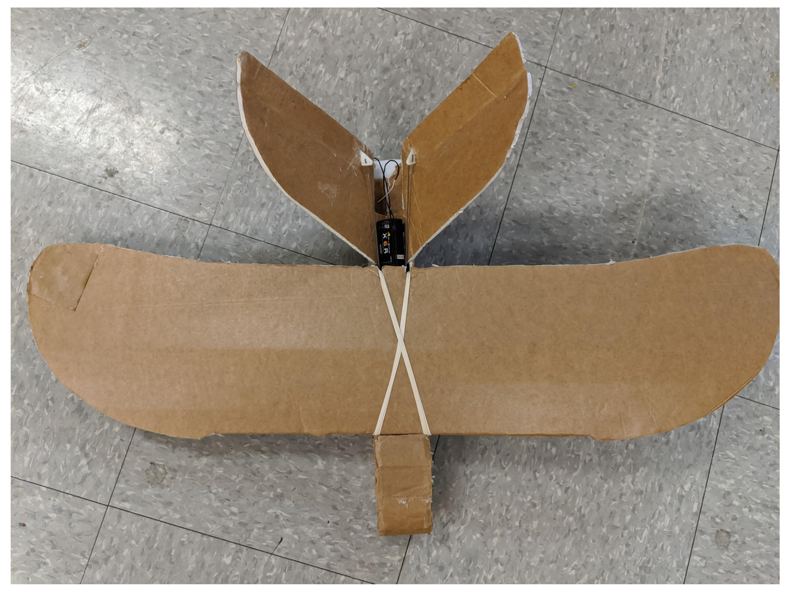

Figure 3: Fully constructed FliteTest Sparrow, the design that our field test system is based on. Uses ruddervators instead of standard control surfaces.

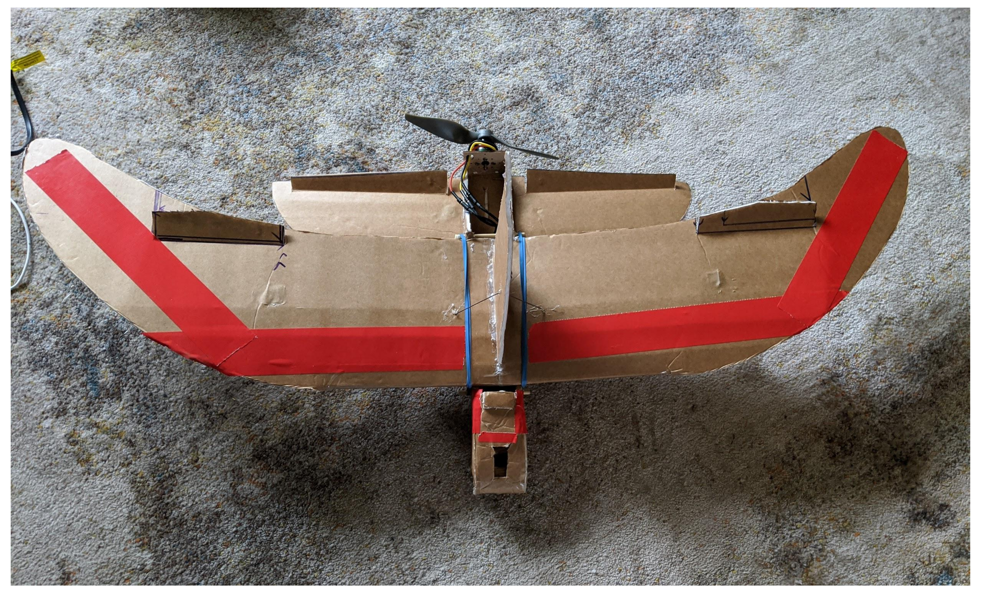

Figure 4: Modified flight test system with expanded wings, modified tail, ports and slots in fuselage for electronics organization, and standard control surfaces.

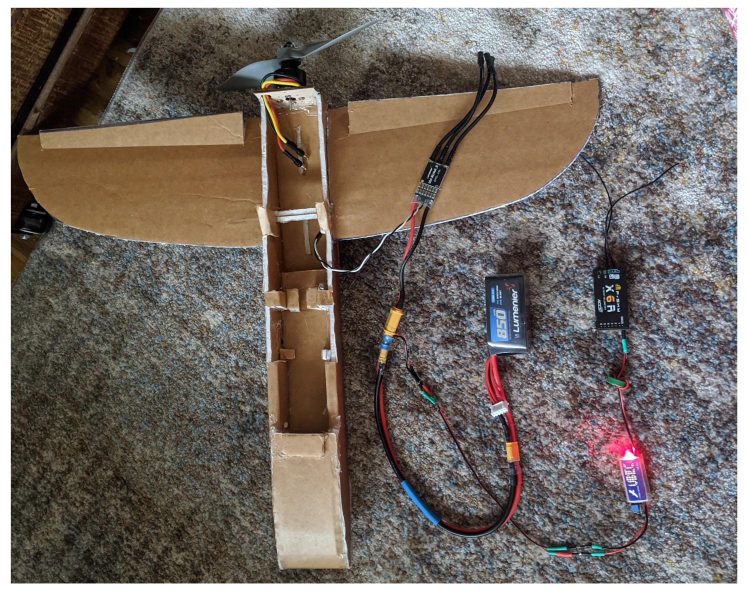

Figure 5: Field Test electronics system including battery eliminator circuit (BEC), electronic speed controller (ESC), X6R Reciever, 14.4 V 850 mAh battery, and Cobra Motor.

Figure 6: A pixhawk PX4 flight controller. Data collection system for analog pitot tube readings, gyro sensor, and accelerometer readings.

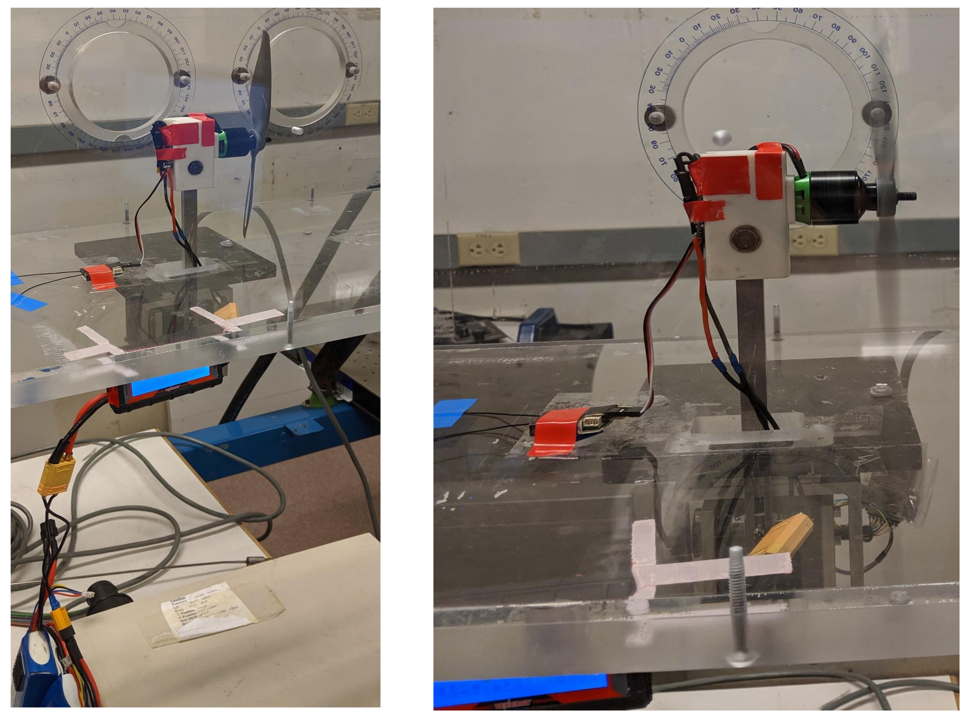

Figure 1: Wind tunnel test setup. Full static system (left), active test (right). The system is controlled with a transmitter paired with the receiver, pictured taped to the bottom of the wind channel. Power metrics are monitored on a power meter below.

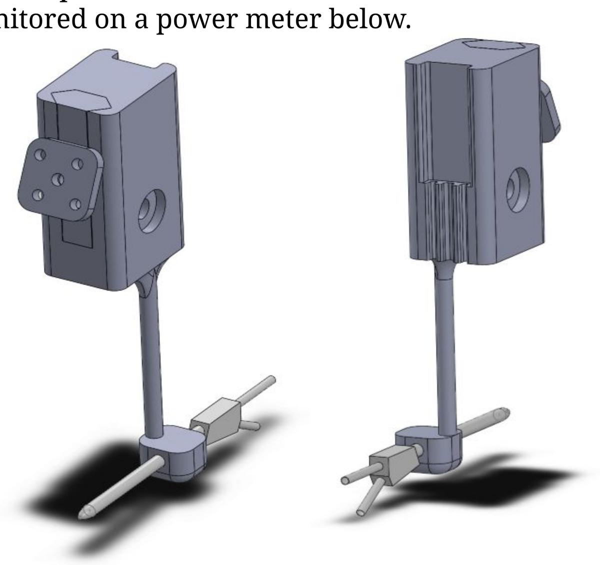

Figure 2: Updated designs for the wind tunnel test system. Motor mount plates can be printed at a variety of angles to generate a

Conclusions

More work needs to be done to take this project to the point of developing a conclusive dataset. But the two test systems that have been developed and tested can be used to collect the data as soon as access and time permit. That being said, there are now two well developed test systems that can characterize this problem in different and important ways.

Future Work

Work will be conducted over the summer with the field test system to characterize a design space for propeller diameter to wingspan ratio as well as collect a set of informative data on small electronic aircraft for future use in Union College Aeronautics.

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