FINAL REPORT

I. Project Title

Flight Test Instrumentation for Drag Measurement Using IoT Devices

II. Project Completion Date

January 15, 2020

III. Student(s), Department(s), and Major(s)

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IV. Faculty Advisor and Department

Dr. Paulo Iscold, Aerospace Engineering

V. Cooperating Industry, Agency, Non-Profit, or University Organization(s)

Cal Poly Aerospace Engineering Department, Cal Poly Machine Shops, Akaflieg SLO

VI. Executive Summary

A wing drag measuring device known as a drag rake was conceived, built, and tested to support the flight test of the Nixus Sailplane project. This device improved upon existing drag rake designs by incorporating a self-contained microcontroller that logged drag rake data and broadcast that data wirelessly to a WiFi equipped smart device in real time. By being entirely wireless, the drag rake can be quickly mounted to any aircraft and does not have any wires that must run long distance to the cockpit affecting the aircraft's aerodynamics.

Design work started by looking for a suitable microcontroller that could communicate wirelessly with a smart device such as a smartphone. After testing multiple microcontrollers, we selected the Adafruit Feather M0 WiFi ATWINC1500. The drag rake body, which samples the wing's wake at specific points was then designed based on D. Althaus's proven design with modifications for manufacturability. Sensitivity analysis was performed to select highly accurate pressure sensors needed for measuring the small variations in drag. Finally, sturdy mounting hardware and a PCB for connecting all the components physically and electrically were designed.

Prototypes of the electrical system, mounting hardware, and rake body were created and tested. Notably, the rake body was tested in the Cal Poly Low Speed Wind Tunnel. The rake was mounted to a symmetrical airfoil wing section in the tunnel, and pressure, both freestream and in the wing's wake, was measured from the pitot tubes. Different speeds and angles of attack were tested to ensure readouts were correct and followed the expected aerodynamic trends. During the testing of the first prototype, some concerns were raised with the length of the freestream pitot tubes and the possibility of the rake body leaking. After this first part of testing, a new rake with slight design changes was created to address these concerns. Testing continued on the second prototype and it was confirmed the issues were resolved and readouts were correct.

Component and system designs were then completed for mass manufacturing and parts for building multiple drag rakes were ordered.

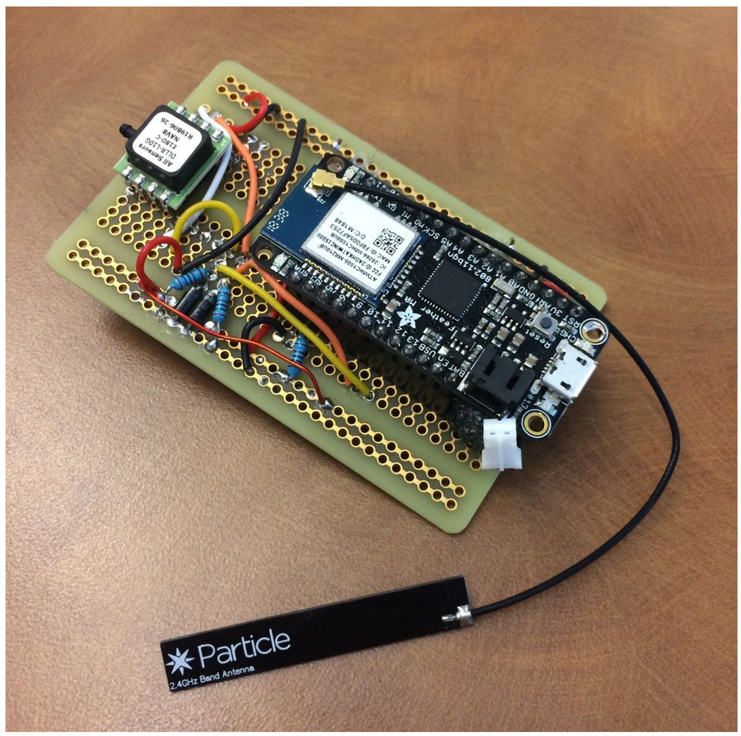
After the end date of the grant, the completed drag rakes will be used for flight testing on the Nixus Sailplane and will be available for testing wing drag on other aircraft. Akaflieg SLO members will gain real-world experience with flight test and flight test instrumentation. Code for the microcontroller as well as design documentation will also be finalized and published as an open-source project for groups interested in building their own drag rake.

VII. Major Accomplishments

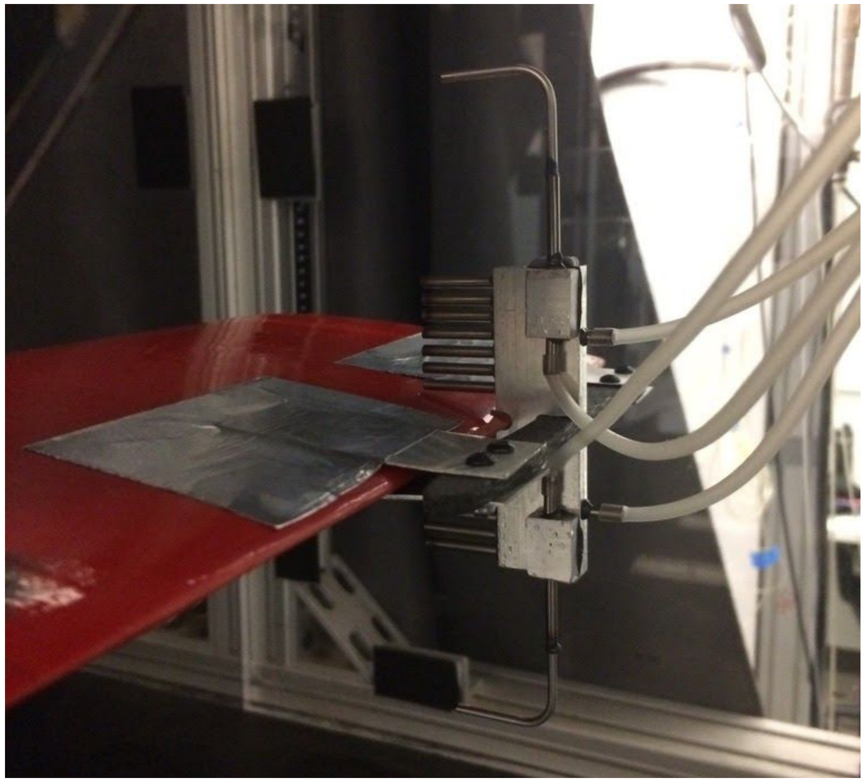
(1) Created wireless architecture for displaying data in real time to any WiFi-equipped device with an internet browser. Selected the Adafruit Feather M0 WiFi ATWINC1500 microcontroller because of its good performance, small size, powerful WiFi capabilities, and support for the widely used and well-supported Arduino codebase. This microcontroller creates its own WiFi network and hosts a webpage that displays the real-time data from the drag rake sensors.

(2) Selected highly accurate pressure sensors based on a sensitivity analysis.

(3) Created prototypes of the electronics, mounting hardware and rake body.

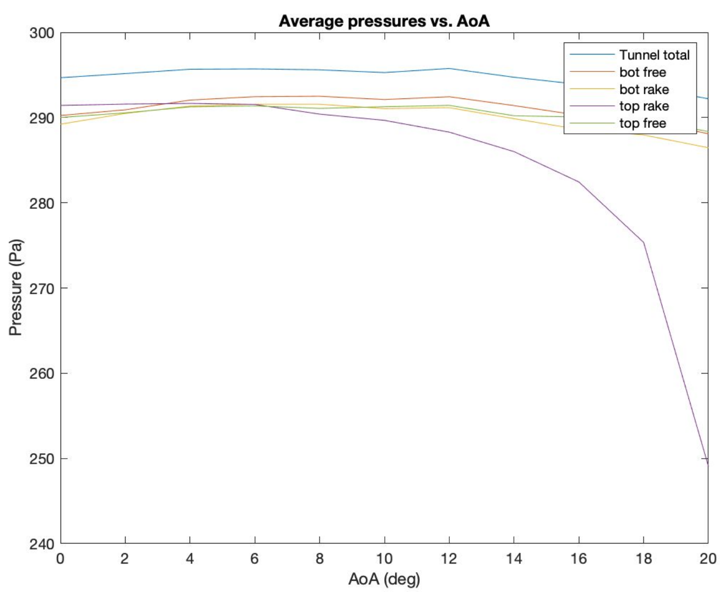


Electronics prototype.



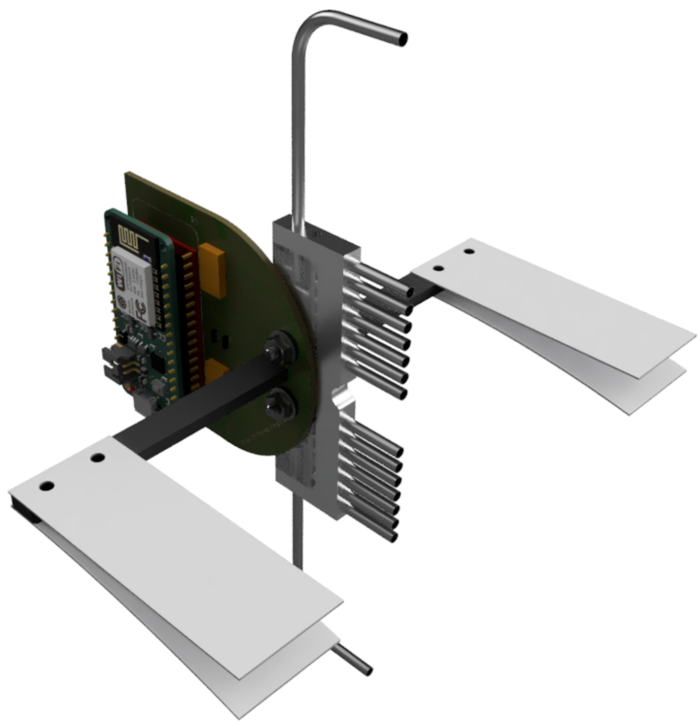
The first drag rake prototype and mount prototype in the wind tunnel.

(4) Conducted wind tunnel testing of the prototype rake body. Created a final redesigned rake body based on previous testing data and analysis.



Pressure data collected from the drag rake prototype during wind tunnel testing. The trend of decreasing pressure with increased AoA (angle of attack) is apparent and expected.

(4) Created a final complete design for the entire drag rake system. Ordered parts for building a 7 batch set which will be built in late January 2020.



A render of the finalized design.

VIII. Expenditure of Funds

Funds allotted to this project were used for both buying components and materials needed to build multiple drag rakes and for buying key manufacturing and test equipment including a soldering iron and oscilloscope.

IX. Impact on Student Learning

This interdisciplinary project proved to be a great experience in systems engineering as aerodynamic, structural, and electrical systems had to be seamlessly integrated. Members of this project gained knowledge and experience in disciplines outside of their major (i.e. our biomedical engineering major learned how to design PCBs, normally an electrical engineering task).

This project also provided great project management experience. An entire “product” had to be developed from requirements all the way to final manufacturable design according to the intended user’s needs. Documentation was created for all the drag rake systems to describe the architecture of each system as well as how each system interfaced with the other systems.

Testing of the rake also provided valuable hands-on experience with operating the wind tunnel, not only with collecting and processing data in the tunnel, but with troubleshooting common issues that arise when testing. This testing also provided an opportunity for students that might not have used the wing tunnel in a lab class to be exposed to how it operates and learn more about aerodynamics. The creation of a second prototype to resolve issues with the first helped to provide experience operating in the engineering design cycle, by having a design change based on data from previous testing and analysis.

Manufacturing of the prototypes also allowed students to gain experience machining parts and using the various tools of the machine shops on campus.