CAL POLY

Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment *for Student Success*

Proposal Cover Page

Title of Project: FLIGHT TEST INSTRUMENTATION FOR DRAG MEASUREMENT USING IoT DEVICES

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Signature (Optional): Will. Bergm

Signature provides permission to check financial aid eligibility.

Previous Baker/Koob Endowment funding? (circle one): Yes [✓ No]

Is this request to support a Senior Project or thesis? (circle one): Yes [✓ No]

Team Member(s)	Signature	Cal Poly Email	Department
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Anticipated Start Date: 12/2018 **Anticipated End Date:** 12/2019

Total Funds Requested: $ 4850

Faculty Advisor: PAULO H. ISCOLD **Department:** AEROSPACE.

Faculty Advisor email: piscold@calpoly.edu **Telephone:** 209 4189760.

Signature of Faculty Advisor: **Date:** 11/4/18

I. Project Title

Flight Test Instrumentation for Drag Measurement using IoT Devices

II. Abstract

Measuring the drag produced by a wing during flight is a useful method for understanding the aerodynamic characteristics and performance of an airplane. This measurement is particularly important when dealing with sailplanes because the contribution of the wing drag to the overall vehicle drag is especially significant. The Robert D. Koob Endowment will enable Akaflieg SLO - a group of Cal Poly students interested in sailplane design and development - to fund the development of an agnostic drag measurement device that can be applied to measure drag for a variety of flight test projects. The proposed instrument, known as a drag rake, is based on a proven hardware platform developed by D. Althaus [1]. Akaflieg SLO aims to improve this design by utilizing wireless data transfer over the internet of things (IoT) network, state-of-the-art digital pressure sensors, and modern microcontrollers. This multidisciplinary project will require hands-on integration of software and hardware components drawing from the fields of aerodynamics, microelectronics fabrication, and computer science. Akaflieg SLO is involved with multiple engineering projects including the manufacturing of the Nixus Project under the supervision Dr. Paulo Iscold, a Cal Poly aerospace engineering professor. The Nixus Project is a high aspect ratio, fly-by-wire sailplane with a wingspan of 28 meters. This one-of-a-kind, open-class sailplane aims to test new high-performance technologies and will serve as the first in-flight testbed for the drag rake.

III. Objective(s)

By taking a proven approach to hardware development outlined in the D. Althaus paper [1], our primary objective is to build a cost-effective drag measurement rake that can be adapted to a variety of aerodynamic environments. We will then improve upon the original hardware by integrating modern, state-of-the-art pressure sensors to a digital microcontroller rather than a traditional analog signal analyzer. The microcontroller will allow data to be transmitted wirelessly over the Internet of Things (IoT) network to portable devices such as smartphones and tablets. Modern sensors and digital data transmission will also allow for minimal invasiveness of the instrument in the airflow, and therefore augment its precision. With this approach, we hope to complete the following primary objectives:

1. Design and build a modern version of the drag measuring device by D. Althaus [1]
2. Test and calibrate this device using the university wind tunnel and other campus facilities such as the temperature chamber
3. Use the calibrated rake to measure performance of the Nixus Project
4. Create documentation on how to operate the drag measurement system so that students can continue to apply this device to future projects

IV. Methodology

The device proposed by D. Althaus [1] is a drag rake that can be connected on the trailing edge of a wing. The drag rake integrates the total pressure distribution inside the boundary layer of the upper and lower parts of the wings as illustrated in figure 1. These values are compared to the readings of a separate pitot tube that measures the undisturbed total pressure. The drag from that portion of the wing will be proportional to the difference of the integrated total pressure inside the boundary layer and the total pressure in the undisturbed flow.

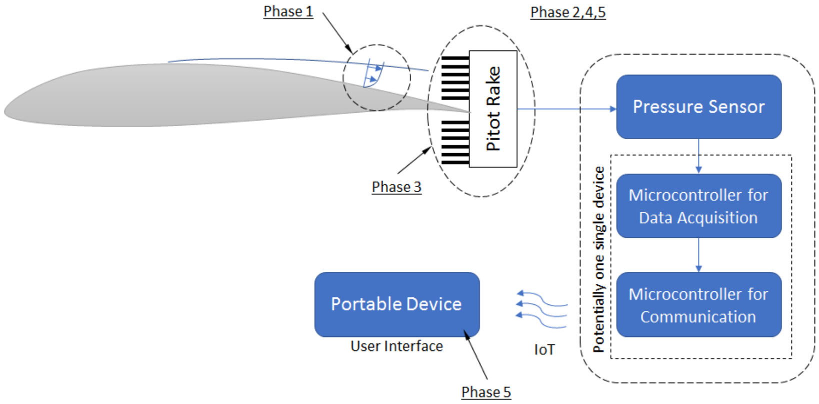

Figure 1 - General schematic and phases of the project

The first phase of the project will be a study of the different potential use cases for the drag rake. A primary design characteristic for the instrument is for it to be applicable to as many future projects as possible. Therefore, a broad spectrum of potential test cases will be taken into consideration during this phase to ensure that the endowment award is used in the most economical way. An intensive study of airfoil boundary layer characteristics for typical sailplane and light airplane applications will be conducted using the Xfoil software. Then the results will be analyzed to specify the optimal pressure sensors for the drag rake.

For the second phase, the team will research and select hardware components based on their aptitude to meet the requirements specified by our use-case study. Pressure sensors will be chosen based on their range, precision, sample rate and communication protocol. The microcontroller will be selected based on its communication protocols, computational capabilities, input/output options, size, and power consumption.

The third phase will be to build the drag rake device as described by D. Althaus [1]. This will require the use of on-campus machine shops and labs. The rake is made up of an aluminum block with tubes protruding out of the block and is simple and easy to manufacture. Along with the manufacturing of the rake, a universal mounting system shall be designed and manufactured out of 3D printed materials. This system will allow the rake to be mounted on the trailing edge of multiple types of aircraft.

The fourth phase will be done in parallel with the third phase and consists of the design and manufacturing of the embedded electronics. The electronic systems will consist of the microcontroller, multiple pressure transducers, and an IoT device. The initial prototype will be built with the separate components, but the project will also aim to design an integrated board in order to reduce power consumption, size, and weight.

The fifth phase will be to program both the embedded system and the smart device. The software will be coded with help from both Professor Iscold and students in the Computer Engineering and Computer Science Departments.

The sixth phase of this project will be testing and calibration of the finished device using Cal Poly's low-speed wind tunnel because it provides a controlled environment that will allow for calibration to a high degree of accuracy. A well-documented airfoil will be used specifically for calibration at multiple specified speeds and flight regimes.

The final phase of the project will be to implement the drag rake on new aircraft to characterize flight performance. The instrument will enable measurement of drag polars and other essential aircraft metrics such as glide ratio, best glide speed, and minimum sink speed. These metrics are critical to understanding the actual performance of new aircraft in real-world environments. The Nixus Project will be the first flying test-bed for this device.

V. Timeline

Design studies will commence immediately after receiving funding in early December 2018, and hardware specifications will be completed by the start of the middle of Winter Quarter 2019. The bulk of machining the drag rake body can be completed in parallel with the design of the data transmission pipeline throughout Spring Quarter, 2019. The hardware and software components will be integrated over Summer 2019, with **the finalized instrument ready for wind tunnel testing and calibration by the end of Fall Quarter 2019.** Once the wind tunnel testing and calibration is finished, the primary objectives will be complete. Once the project is finished testing, we will commence testing on the Nixus Project around Winter Quarter of 2020.

VI. Final Products and Dissemination

The primary final product will be the drag rake and associated embedded electronic system. Akaflieg SLO will also create instructions on how to build and calibrate the system in order to allow other entities to build and use a drag rake for flight test projects. In addition, the development of the new probe and the results from wind tunnel tests will be published as a scientific paper to be submitted to the Technical Soaring Magazine.

VII. Budget Justification

Most of the budget will be spent on hardware components for the drag rake listed the following table and they total to $2850. The other anticipated expenses for this project are software and fabrication services that will be required for aspects of the drag rake that go beyond the technical capabilities of the university. These include circuit board printing (2 x $300 = $600), 3D printing (3 x $200 = $600), and software consultation (2 x $400 = $800), for a total of $2000. Together, the total requested budget amounts to $2850 + $2000 = **$4850.**

Description	**Qtd**	**Unit Price**	**Total Price**	**Justification**
IoT Microcontrollers	6	$50	$300	The brains of the instrument. 6 required in case of damage or design changes
General electronic components	2	$100	$200	General electronic components like resistors and capacitors.
Electronic connectors	4	$45	$180	Connectors for electronic integration
Electronic fabrication tools	1	$250	$250	Tools for electronic fabrication, like soldering iron, micro drill, and others
Portable oscilloscope	1	$575	$575	For in-field data measurements
Pressure sensors	20	$40	$800	The central sensor for the project. Spares requested in case of damage.
Material for fabrication	1	$250	$250	Aluminum block, and tube stock for the rake body
Machining tools	5	$35	$175	Tools necessary for the machining of the rake
Batteries	4	$30	$120	Batteries for electrical power

References: [1] Althaus, D., “An Instrument for Drag Measurement In Flight - Optimization of Flap Settings”, *XIII OSTIV Congress,* Borlange, Sweden, 1993.

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PROPOSAL BUDGET

Student Applicant(s):	Will Bergman, Bennett Diamond, Wyll Soll (on behalf of Akaflieg SLO)
Faculty Advisor:	Dr. Paulo Iscold
Project Title: Flight Test Instrumentation for Drag Measurement using IoT Devices	**Requested Endowment Funding**
Travel *subtotal*	**$**
Travel: In-state	**$**
Travel: Out-of-state	**$**
Travel: International	**$**
Operating Expenses *subtotal*	**$ 2850**
Non-computer Supplies & Materials	**$ 2850**
Computer Supplies & Materials	**$**
Software/Software Licenses	**$**
Printing/Duplication	**$**
Postage/Shipping	**$**
Registration	**$**
Membership Dues & Subscriptions	**$**
Multimedia Services	**$**
Advertising	**$**
Journal Publication Costs	**$**
Contractual Services *subtotal*	**$ 2000**
Contracted Services	**$ 2000**
Equipment Rental/Lease Agreements	**$**
Service/Maintenance Agreements	**$**
TOTAL	**$ 4850**