Maseeh College of Engineering and Computer Science

PORTLAND STATE UNIVERSITY

Capstone Project Proposal

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Executive Summary

Portland State University's Department of Electrical and Computer Engineering has partnered with Galois, a leading innovation company in the field of research and development of new technologies, to model and simulate a small-scale F-16.

By June 2021, Cam Osborn, Minh Le, Qingchuan Hou, and Christopher Mersman will design a software package that runs in parallel with an advanced autopilot, stores data in real-time, and determines an accurate flight dynamics model of an RC F-16. This will be accomplished by defining flight dynamic variables necessary to model a ducted F-16 model aircraft, testing the flight dynamic model variables, creating an accurate State-Space representation of the model F-16, and finally, instrumenting the F-16 model to gather real flight data. Furthermore, the final product has stretch goals of performing real flight validation, designing an autopilot to adjust flight characteristics of the F-16 model to improve the ease of use of the RC F-16 and to perform an autonomous flight.

Product Design Specification

Concept of Operations

The main objective of this project is to design an RC F-16 fighting falcon model and perform a flight simulation. Designing and flying a drone is not as simple as people think. The speed, direction, and stability of a drone in flight can be affected by a variety of external factors. To ensure that a drone can fly at an accurate speed and direction, it requires an automatic control feedback system. This system has to analyze external factors such as air concentration, wind speed, etc. in real-time. Based on these external factors and the aerodynamic coefficient, this system will adjust the drone to make the drone fly at a controlled speed and direction.

Stakeholders

Open source: Hobbyists

Industry Sponsor: Galois, Michal Podhradsky, Matt Clark, Ethan Lew

Project Team: Cam Osborn, Minh Le, Qingchuan Hou, Christopher Mersman

Faculty Advisor: Dr. James McNames

Requirements

Should measure and calculate aerodynamic coefficients and other constraints using equations found in the textbook, "Aircraft Control and Simulation" by Brian L Stevens.

Must identify appropriate flight control variables that need to be observed and recorded during simulation and real flight.

Must develop a test plan that describes how to excite the system such that the variables of interest can be observed.

Must use the supplied Pixhawk software stack and identify where the particular input variables within the stack can be processed and logged.

Must flight test the model F-16 with trained personnel to gather data with the addition of the Pixhawk sensors and hardware.

Must validate governing system equations and variables through the use of data gathered from flight tests with trained personnel.

Must compare scaled-down F-16 model with a real flight test to quantify the accuracy of the model.

May use a system identification approach instead of the aerodynamic equations found in the textbook, "Aircraft Control and Simulation" by Brian L Stevens.

May perform real flight validation to compare to simulated flight data.

May design an autopilot to adjust flight characteristics of the model to assist in real flight.

May perform an autonomous flight with the model.

Specifications

Deliverables

Project Proposal

Weekly progress reports

Final report

ECE Capstone Poster

A Test plan that establishes a successful flight / pass of simulated flight

A working simulation of the F16 model

A model F-16 fitted with instruments to record flight data

Our Github documents including a report on our development process for the model

Initial Product Design

What are you proposing to make?

We are proposing to design a mathematical model of a model F-16 for simulation and to fit a model F-16 with instrumentation to gather inflight data to compare against and use in our mathematical model.

How are you going to make it?

We will make this by first understanding the equations involved and then creating state space models that will be used to describe the model F-16 in simulated flight.

What are the big risks? How are you going to answer them quickly?

Deeply understanding the way the state space models are working individually and as a whole to create a realistic model of the F-16. Also correctly accounting for all the variables involved in the mathematical model to reflect flight. These will be mitigated through our test plans and associated readings on how to model flight.

What are the questions you have still need to be answered?

TBD - ask group for input.

How much of this do you think you can get done in 5 months?

I believe the creation of the simulation model up to the verification and gathering of the flight data are very achievable in 5 months. I also believe that the stretch goal of assisted autonomous flight is also achievable in that timeline if the project runs “smoothly”.

Things to include here:

Hardware architecture - Model F-16, associated flight data instrumentation using the Pixhawk system

Block diagrams (L0, L1, maybe even L2) - insert picture of model and associated inputs for pixhawk system

Software architecture - Pixhawk system and developed model.

Languages and development environments - Python and Matlab

Data flow diagrams

User interface / experience - output data from model must be presentable / code well documented

User stories of how the end-user actually uses your product

Other considerations:
Security (physical, electronic, and software)

Regulatory compliance - look up drone regulations, we also have a licensed pilot

Back up plans:
What if things go wrong? What can you fall back on? -

Verification Plans

The test plan for the model F-16 is a milestone in our capstone project and will not be fully developed until later in the project after developing a deeper understanding of the model. A high-level view of what a successful test plan should look like for our project would start with a test of our mathematical model in simulated flight, these would be designed to test extremes of our model along with several normal maneuvers that we could expect our F-16 to do in real flight. The next part would be to perform tests on the flight recording instruments pre-flight to verify if they are functioning correctly and the Pixhawk system is recording the data accurately. If stretch goals are met, we can further develop the test plan to include verification of autonomous flight both for complete flight control and user assistance.

Project Management Plan

Timeline

Start	Jan 4, '21	Write Project Proposal
		Review Project Proposal with Industry Sponsor
		Approve Project Proposal
		Design Mathematical Model
		Develop Equation For Small Scale F16
	Feb 15, '21	Approve Model Design
	Feb 16, '21	Design Software
		Develop Test Plan
	Mar 26, '21	Approve S/W Design
	Mar 29, '21	Simulate F16 Model with Pixhawk 4
		HITL + Collect Data
		SITL + Collect Data
		Revise Design
		Final Testing
	May 10, '21	Approve Model
	May 11, '21	Real Flight with Small Scale F16
		Final Report
		ECE Capstone
End	May 31, '21	Presentation

Table 1: Major Tasks

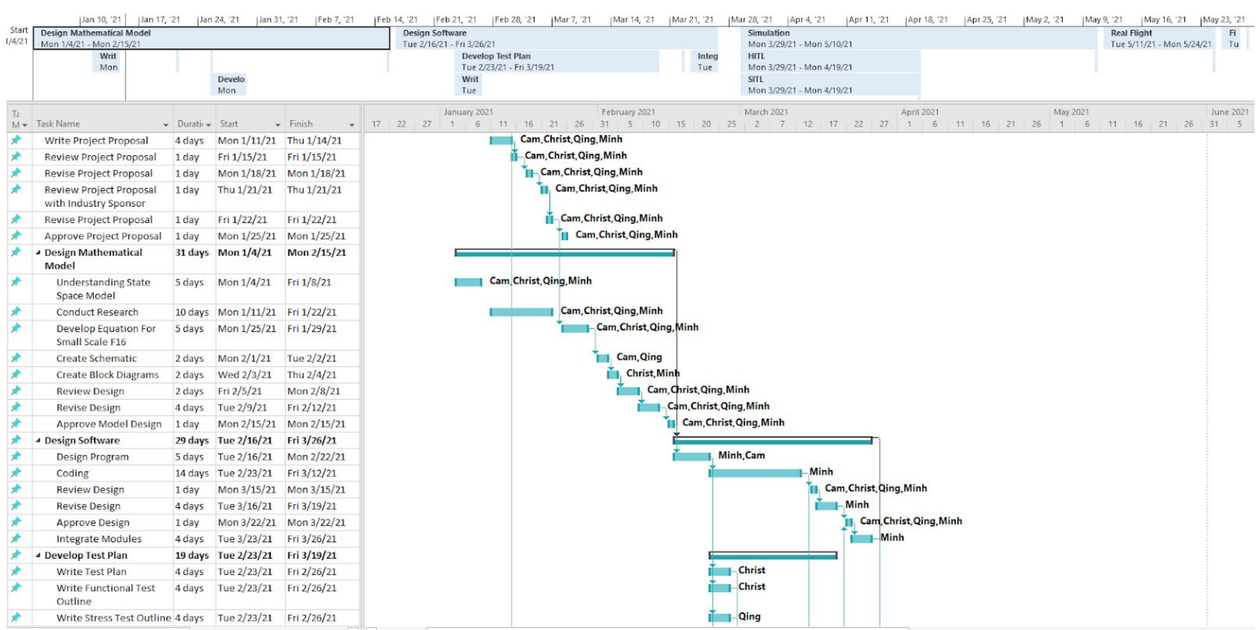

Figure 1: Detailed Timeline in MS Project

Budget and Resources

Hardware resource industry sponsor provides:

- F-16 Thunderbirds 70mm EDF BNF Basic with AS3X and SAFE Select: $299.99
- Pixhawk 4 flight controller with HITL

Open-source flight simulator:

- Development Environment: Ubuntu LTS
- FlightGear, JSBSim, jMAVSim with SITL

Team and Development Process

What are each of the team members going to do? You might not know yet, of course.

- Assigned in project schedule

Who is going to be the point person to be communicating with your industry sponsor and faculty advisor?

- Everyone takes turns

Is there a team leader for your group? Who is that?

- no? Cam? Christ? Qing? anyone?

What collaboration tools are you going to use?

- Project management: github, trello, google drive
- Communication & meeting: gmail, zoom, discord