IPRO 317: VTOL Aircraft for the Masses
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Final Report

Dr. Francisco Ruiz

Teodor Chankov
Edward Dalton
Brandon Honore
Chad Meyer
Adam Naselli
Mohammed Qadir
Paul Rozier
Joanna Szwajnos
Jason Tenenbaum
Anthony Ziskovsky

Here's our project

The goal of IPRO 317 is to design, construct, test, and ultimately sell a vertical takeoff and landing aircraft that, when in production, will be much more affordable and easy to fly than anything currently in the market (which is not much). Further, this semester we worked to get more public input and to find parts for new prototypes of different scale than the current one.

Things to know from the past

Our design has several traits that distinguish it from other aircraft currently in production as well as on drawing boards. At first glance, it looks like a helicopter with wings. Unlike helicopters, however, our design has dual, interlocking rotors with fixed pitch blades. This feature immediately distances it from helicopters. The dual rotor configuration perfectly balances the rotational inertia created by the spin of each rotor, thus eliminating the need for a tail rotor as seen on almost all helicopters. Also different from helicopters, this design's fixed pitch blades mean it cannot alter the angle at which the blades cut into the air in order to change direction and lift. Instead, it implements a gimbal mechanism in which the entire rotor assembly shifts front to back and side to side with 360-degree motion to direct the craft through the air. The unique rotor-gimbal design combines in several ways to make this design *much* easier to pilot than a helicopter. The last important trait is the wings, which allow it to take off vertically then transition into horizontal flight much more efficiently than helicopters. Whereas a helicopter in forward flight must create all lift *and* forward thrust with its rotor, the wings on our design pick up a majority of the lift after the craft has transitioned into forward flight. This leads to improvements in fuel economy as well as stability.

Previous semesters of IPRO 317 constructed a small-scale physical prototype featuring the rotor-gimbal design described above. They had limited successes in the testing of this prototype. One success among many setbacks in testing was achieving lift during one tethered startup. The setbacks included torn gears needed replacements ordered from Southern Asia, nuts and screws appearing on the test bed from unknown origins, and a frequent issue with the remote control losing all communication with the prototype while the engine was running.

Another positive from previous semesters are the computer models. As of the start of this semester, IPRO 317 had stable and accurate full-scale and prototype-scale computer models simulating how an aircraft showcasing our unique design features will fly.

What needed to get done

This semester the most important thing was getting the physical prototype through tests to demonstrate that our design does indeed perform as expected. In tethered tests, hover, forward/backward flight, and side to side flight would be demonstrated. Building off of the success in testing, a design team would work on identifying the parts needed to begin construction of a full-scale prototype. Parts lists and prices would be needed for any future funding proposals. Also useful for proposals would be an analysis of the social impact of vertical takeoff and landing aircraft on the public.

Sometime through the semester it became clear that our prototype, which had many problems in past semesters, was facing similar problems (and more) this semester. This changed the goal for

the design team somewhat, in that it became more important to find the parts needed for a new, more reliable scale-prototype than for a full-size prototype.

What happened

As alluded to above, this semester the IPRO was split into three teams: construction/testing, social/market research, and design.

The construction/testing team created a testing schedule which, in tethered tests, would progress from a demonstration of lift to directional control tests. To achieve this safely, they designed and constructed a test bed on which the prototype could be secured and allowed to move relatively freely in one dimension. Depending on how the prototype was secured, this could be forward and backward or side to side. Throughout the semester, numerous tests were performed using this apparatus. Early on, the prototype began giving the testing team problems, and much of their time this semester was dedicated to dealing with and overcoming these ever-growing problems. From a shredded main reduction gear which required the prototype to be disassembled in order to replace it, to nuts and bolts and mufflers flying off when the engine was started up, to an engine that just refused to continue operating for more than a few seconds, the team was always finding and creating solutions to the problems but the prototype seemed to be one step ahead. Since they faced problem after problem and many of them were similar to those of last semester, the testing team decided to create some preflight and startup procedures. These will help future teams avoid similar problems, and also keep them from spending so much of the available semester overcoming different issues to get back to where the last team left off.

The social/market research group also saw their progress come to a crawl relatively early in the semester. Within the first couple of weeks they, together with the rest of the team, had come up with a comprehensive list of issues a vehicle such as our design would bring with it if introduced to the public. With this list came walls though, as most of the questions did not seem to have answers to be found without actually having a successful VTOL aircraft available to the public (which is exactly what this project aims to achieve). For several questions concerning the specifics and performance of the aircraft, answers were guesstimated using the computer simulations, but it was found for most of them there was no concrete response. It was decided to take several of the questions (cost, safety, utility, etc.) directly to the public with the creation of a market survey. This was distributed to people of varying demographics, and the input they provided should help to guide the project to something the public will appreciate.

The final team, as mentioned earlier, had their priorities shifted fairly early in the semester as well. The design team handled the switch very well. The change to a new, smaller model meant going back to X-Plane for simulations because no suitably stable model of the size needed existed at the start of the semester. Creating this model took up a large portion of the semester, but it resulted in a very stable model *and more*. Through tinkering with the model in simulations, it was found that our original design may be able to be simplified further (simplicity is paramount in our design to keep down cost and make it more “user-friendly). It was found that the side to side motion of the gimbal could be left out of the design, as the tail-mounted rudder is sufficient to create roll and bring the aircraft through turns. With this new design in pretty colors in the simulator, the design team then set about searching for parts with which to build a new prototype based on this design. They would only find parts that were easily

purchased, and the new prototype would be powered by electric motors rather than a gas motor like in the current prototype. The size of the new prototype will make the new prototype much easier and safer to handle, and the electric motors will greatly improve the reliability during tests.

Let's wrap it up

This semester should truly be looked at as one of transition. As most of our tasks were redirected or changed altogether from those planned at the beginning of the semester, we had a much more limited chunk of time to do the work we all ended up settled on. The results each team ended with were not those sought after at the beginning of the semester, but they were important no less. Successes were limited but they will all be important to future teams.

A word to the next team

There is definitely still plenty of work left in this IPRO. The most important of course is with the construction and testing of the new prototype. Every project has to take steps backwards to go forwards at times, and it is very important that next semester we get a good start going forward again. The table is already set. This semester's construction/testing team has outlined problems to watch out for and steps to follow in order to avoid them, as well as a testing schedule and test bed to help in further tethered tests. The social/market research group has created an initial market survey that can be easily modified and added to increase our public input as well as assist in future funding proposals. Finally, the design team has the most important parts located for the construction of the new prototype that will help us go forward towards our goal of getting our design and our project off the ground.