What to do with an army of interns
by Hannah Dromiack

Throughout history the same question has been asked by many mentors, from blacksmiths and cobblers to engineers and scientists. Now, at NASA Ames Research Center, it has been answered once again. Over the summer of 2018, the aeromechanics branch at NASA Ames Research Center was overrun by 53 Interns with backgrounds ranging from physics and engineering to education, from high school students to graduate students, causing this branch's population to grow by 50 percent. The Aeromechanics Office at NASA Ames Research Center is responsible for aeromechanics research activities that directly support the civil competiveness of the U.S. helicopter industry and the vertical lift requirements of the Department of Defense. The interns were set off to assist with work related to vertical take-off and landing (VTOL) technology and vertiport counterparts, computational fluid dynamics (CFD), 3D modeling (CAD), and projects that may even escape this world to Earth's neighbors Mars and Venus. More than 20,000 man-hours were dedicated to completing over 41 projects.

VTOL

Vertical take-off and landing (VTOL) aircraft have the capabilities of both rotorcraft and airplanes. They can hover, take off and land vertically and perform forward flight. This reinvigorated field has the intention of developing new forms of urban transportation that will reduce travel time and environmental damage caused by current means of travel. In the pursuit of this goal, both NASA and Uber have designed concept ideas for potential VTOL aircraft with capacities that range from one to 14 passengers and are fully electric or hybrid fuel users.

NASA reference models. Left to right: NASA reference model 3 (14 passenger TiltWing), NASA reference model 2 (six passenger side-by-side), NASA reference 1 (personal quadrotor).

Ethan Krings, Yeray Pabón González, and Makynzie Zimmer modeled the NASA concept designs and other common reference models with CAD modeling software programs such as Solidworks and Rhino. This allowed each of the models to be analyzed in RotCFD, a program designed to simulate rotorcraft fluid dynamics, to determine if the design was feasible for its intended use. Models were then 3D printed. RotCFD is an unsteady compressible flow solver that uses Reynolds-Averaged Navier-Stokes equations to model flight characteristics such as lift, drag, power, torque and thrust for flight regimes including takeoff, hover, cruise and landing at different velocities, angles and altitudes. Interns Ali Fares, Curtis Zicker, and Lauren Wagner were instrumental in the computational modeling of the models produced over the summer.

Fares completed computational analysis of a single-passenger, fully electric quadrotor. The simulations analyzed for the quadrotor were done at various atmospheric conditions and angles of attack to determine the overall cruise efficiency of the vehicle.

Zicker performed an analysis on a common reference concept model that was fully electric and determined that under the conditions in his study, the cruise configuration would have to maintain a relatively high angle of to generate slightly more lift than was needed to get the vehicle off the ground. This reference model shows promise as a base for future eVTOL aircraft, but would require modifications to be capable of performing the task efficiently.

Wagner assessed the capabilities of the fully electric NASA reference model 2 (the side-by-side), and determined, under varying atmospheric conditions, angles of attack, and maneuvers, that the vehicle is capable of producing significant thrust in flight and all but on configuration, meeting the minimum performance requirements to complete the maneuver. The side-by-side shows great potential as a VTOL aircraft.

The computational modeling done by interns over this summer, as well as past interns, provides a current outlook on the capabilities and feasibility of ideas being produced within the VTOL community, opening the door to further analysis of the future of the field.

VTOL Vertiports

The next step in VTOL technology is an investigation of the infrastructure needed for efficient and convenient use. These new ports would likely accommodate 2,500 vertical takeoffs and landings every hour regardless of most weather conditions.

In 2018, UBER Elevate held a summit to present vertiport designs that could accommodate the needs of the industry. Of the six proposed concepts, interns chose to analyze the UBER Hover Design from Humphreys and Partners Architects.

Humphreys and Partners Architects veriport concept design

Katie Adams, Jacob Kowalski, and Michael Swafford used the designs supplied by UBER Elevate to create reference models for RotCFD analysis and construction of physical models for testing in the wind tunnel. The computational analysis showed that the presence of the vertiport did not significantly alter the torque or roll moment exerted by the rotors on the center of gravity. However, the pitch moment was changed significantly, with the direction of change being positive in a crosswind and negative in a rear wind. This means that in changing wind conditions, pilot input would be required to ensure safe landings and takeoffs. Future research for this project will include wind tunnel testing a NASA Ames Research Center, allowing for analysis comparisons of computer simulations with real data.

Other uses for VTOL Aircraft

While urban transportation will be the largest industry using VTOL technology, some interns explored alternate uses for UAV technology. Collin Krawczyk, Nathan Mann, and Ryan Vedros designed a system to obtain usable food donations from restaurants and grocery stores for transport to food banks and homeless shelters. This project was dubbed ALFRED (Automated Leftover Food Recovery for Extended Distribution). ALFRED's mission is to reduce the amount of food wasted from restaurants or retail stores by facilitating food donations.

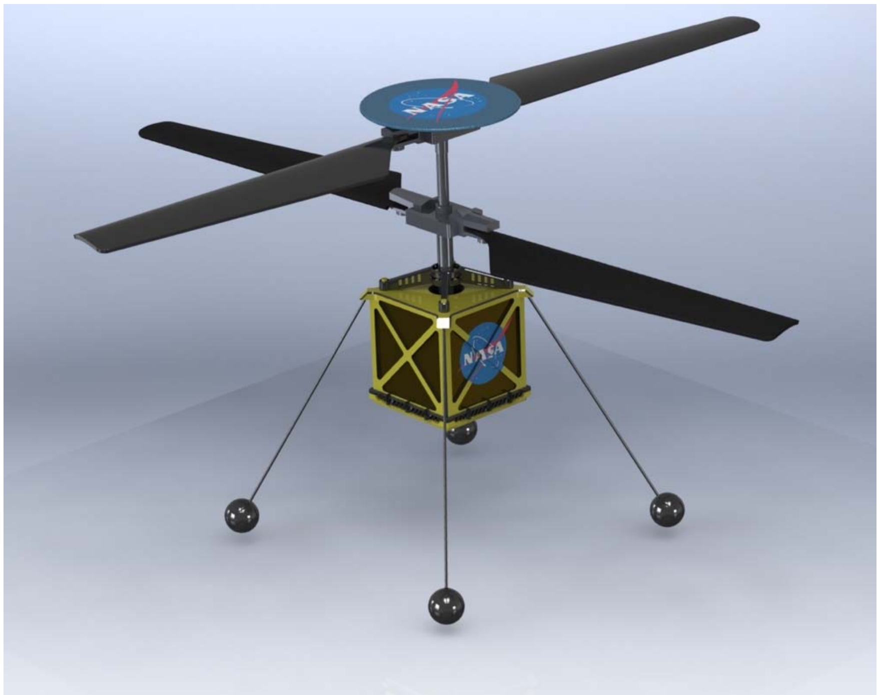
ALFRED: first concept rendering

The interns conceptualized, designed and analyzed the capabilities of this UAV. Their process included three different design, test and evaluation tasks throughout the development of vehicle: two regarding the method of securing and carrying the load and one regarding the aerodynamics of the fuselage. Flight capability was analyzed in ROTCFD and the project determined feasible. Future development should include CFD analysis, as well as acoustics analysis since it will be used in an urban environment.

Mars Helicopter

As we explore and discover new ways of traveling on our own planet, new doors have opened to expand discovery and exploration on other planets. Mars has captured minds of many humans since its discovery. Mars is our closest neighbor and the planet most like Earth, making it of keen interest. On the upcoming Mars 2020 mission, in addition to sending another nuclear-powered rover similar to Curiosity, the very first Martian Rotorcraft will be deployed. In the past, interns have performed CFD analysis to determine the flight capability of the Mars Helicopter in the Martian atmosphere. This summer significant contributions were made by Natalia Perez, Nathan Jensen, Chris Byron and Dorsa Shirazi in the analysis of the helicopter's aerodynamics within the Planetary Aeolian Laboratory Martian Wind Tunnel. Tests performed included running the rotors at a variety of RPMs over different pressures ranging from one atmosphere down to Martian conditions. This data was then used to characterize the rotors' behavior in Martian conditions.

Interns also designed their own Mars Helicopter to be used for educational purposes. Two kits were designed for elementary and high school students, allowing them to build their own working model of the Mars Helicopter. The first designed for younger students was made from Legos which has a working set of rotors but won't leave the ground. The second kit designed for more advanced students allows them to build a fully functioning Mars Helicopter. This kit has 3D printed parts for the body, an onboard computer, and a full assembly of electronics to control the vehicle. This gives students a taste of how engineering is done and what goes into the building of the next generation of exploratory vehicles.



Solidworks model of Mars Helicopter advanced student kit

The effects of an army

"Do the difficult things while they are easy and do the great things while they are small. A journey of a thousand miles must begin with a single step." --Lao Tzu. This quote represents the efforts of the summer 2018 interns. Many of the projects they worked on are ideas and concepts in their infancy, yet to be tested in the real world. These efforts have led to a better understanding of this growing field, and how it will inevitability change the world. So what do you do with an army of interns? You march them down a path that could change the world.