

What Else to Do with an Army of Interns

NASA Ames Research Center (ARC) Aeromechanics Branch hosted more than 60 interns this summer and focused their energies on studying the future of vertical flight. This is the second of two reports from this past year's summer interns.

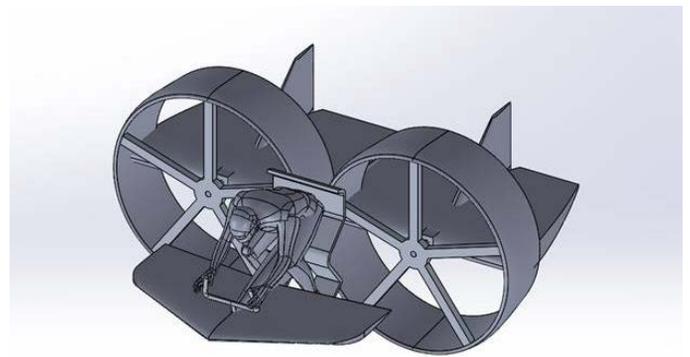
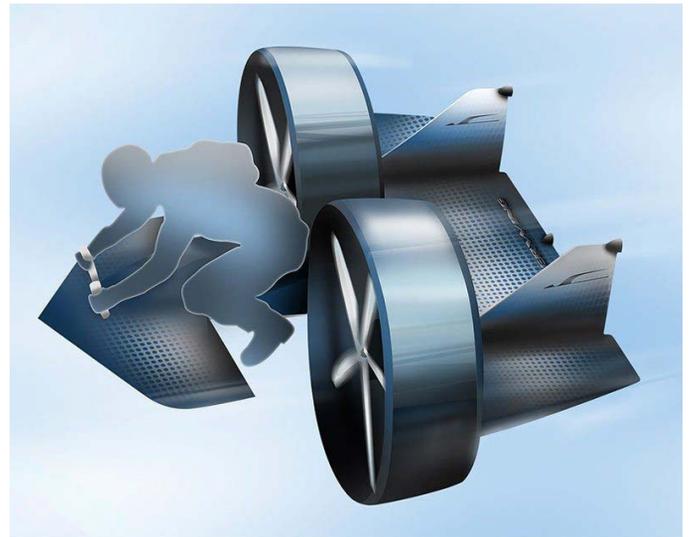
By Nicholas Peters

During my ten-week NASA Aeromechanics Branch internship, I focused on what is considered by some as the most ambitious and ground-breaking new market of the modern aviation industry: urban air mobility (UAM). Even before *The Jetsons'* first appearance on TV in the early 1960s, the world has hungered for a possible future of commuting to work by sky. Yet, what started out as a fantasy has slowly turned into an increasingly urgent need. The world traffic issues faced in megacities is one that results in the loss of billions of dollars a year of productivity and one that only continues to worsen with time (see for instance, "Traffic Congestion Costs Americans \$124 Billion A Year, Report Says," *Forbes*, Jan. 25, 2015).

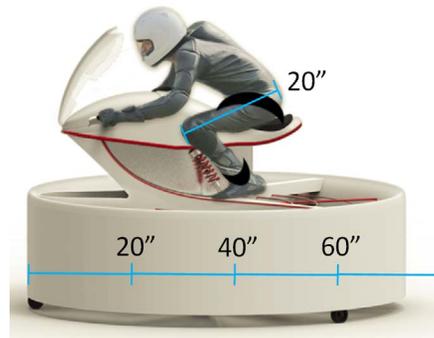
It is this impending megacity gridlock that has led to the business case for not only the UAM field but an overarching goal across the industry to establish alternative forms of transportation for the modern urban environment. Yet, with each of these plans, there are selective enabling technologies that act as limiters to their mass market application, and the UAM market is no different. Currently, eVTOL.news — the VFS website on electric vertical takeoff and landing (eVTOL) aircraft — lists more than 125 proposed UAM-styled aircraft established by companies ranging from startups to the largest players of aviation (e.g. Airbus, Bell, Boeing and Embraer). Nearly all of these concepts propose using enabling technologies such as fly-by-wire-based control laws, electric or hybrid propulsion, and advanced structures and manufacturing techniques.

With a large array of technologies still needing to be studied, there is a clear need for a financial incentive to speed the practical application of these technologies. Here is where the GoFly Prize enters the UAM field. The GoFly competition requires that selected teams design and fly minimally-small "personal flying devices" that can incorporate VTOL technologies into their design (see "GoFly Enters Phase II," *Vertiflite*, July/Aug 2018 or www.goflyprize.com). While each team is competing for \$2M in prizes and the hopes of developing a marketable product, the collective information provided by the teams will form the foundation on which a future UAM market for individual transportation could grow.

To date, the competition has completed its first phase and has selected 10 winners. It is clear that these teams were selected



Top: Artistic rendering of the Silverwing team's S1. Bottom: Ethen Krings' resized version of the S1.



Example of image with pilot used scaling. Here Makynzie Zimmer used an average sized femur to scale Georgia Tech's Hummingbuzz aircraft.



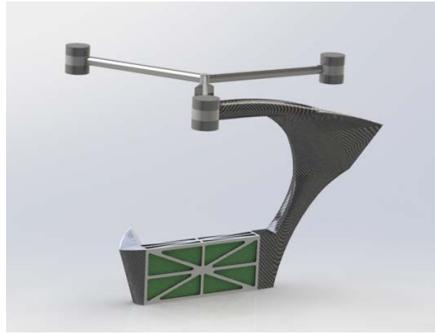
Final rendering of the Hummingbuzz as constructed by Makynzie Zimmer.

both because their proposed aircraft represented a practical demonstrator and because they appeared capable of seeing their project to completion. However, what may not be so clear is the feasibility of each aircraft selected. With new proposals for eVTOL aircraft being posted on the eVTOL.news directory on almost a daily basis, the rotorcraft community has the opportunity to consider the feasibility of these aircraft. In his Sept/Oct *Vertiflite* Commentary, “Beware the Hyper-Hype Cycle,” VFS Executive Director Mike Hirschberg warned of over-expectation: “While a few early entrants — most notably Ehang, Joby Aviation, Kitty Hawk, Opener and Volocopter — have conducted robust flight testing, including manned flights, the vast majority of innovators are still discovering the unique challenges of vertical flight.” A lack of analysis into potentially unrealistic claims made by emerging manufacturers could possibly lead to an over-expectation of where the UAM field currently is. This could potentially lead to a hindrance of the market in the long run. As such, the internship directors decided that it would be worthwhile to dedicate a significant portion of the summer program for my peers and me to conduct feasibility analyses of each of the Phase I winning aircraft for the GoFly competition.

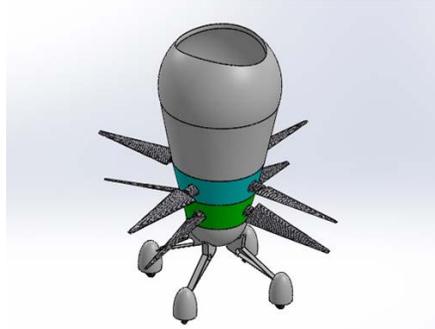
Before feasibility could be considered, the team of interns first had to accurately model each of the ten winners. These reconstructed models for the aircraft were based on images open to the public. In attempting to properly scale these models, the teams positioned 3-D computer models of pilots based on average-sized adults into the aircraft for use as a reference. It should be noted that many of the images initially used as the templates were designed with more emphasis on artistic rendering than on practical engineering (for competitive reasons the teams weren’t required to provide accurate images). Given this, it was evident that some of the components of the aircraft would need to be sized through computational analysis. As such, a low-fidelity conceptual design process was undertaken that would provide the team with power and fuel requirements for the aircraft based off a simple mission with a one-minute hover and 20 minutes of cruise. The basic objective of this step was to complete an energy balance by first finding the power required for each flight condition and then, with power and time, determining the energy required for the total mission.

However, before a conceptual mission analysis could be completed, the team first needed an initial estimate of weights to start their energy balance. This initial guess was completed by applying materials to the computer-aided design (CAD) solid models in Dassault Systèmes Solidworks and finding material weights. After the mission analysis was completed, the team took its findings for fuel weights and power requirements, and resized its aircraft with the necessary volume for both the properly-sized motors and fuel. This iterative process was repeated until the change in volumes were small enough to be considered converged.

At the conclusion of this analysis, there were no red flags raised warning against feasibility for any of the ten aircraft. However, there was much that was not considered by this simple energy-based weight balance that still needed to be considered. There was minimal consideration of component sizing, structures, safety margins, rotor-to-rotor interactions, controllability, etc. In short, only the bare minimum was considered and as such it became evident that a much deeper analysis was needed in order to validate the feasibility for these aircraft with more certainty. To this end, the NASA Design and Analysis of Rotorcraft (NDARC) conceptual design software was employed.



Final rendering of the Blue Sparrow as constructed by Mireille Fehler.



Final rendering of the Harmony as constructed by Michaela Sorrentino.

By the end of the ten-week internship, all 10 aircraft had NDARC files constructed with estimated weights and sizes. To maintain the integrity of the competition, the specific numerical results from this investigation for each of the competitors will not be published. However, what can be shared is that the findings of this secondary investigation did show that all the aircraft in fact should be able to complete their specified missions with at most minor alterations. What this study suggests is that all ten teams have the potential for viable demonstrators that can push the limits of modern VTOL engineering.

But what is possibly more important is the impact each of these teams will have on the UAM market as a whole. It’s true that the construction of these small personal flying devices will not result in the immediate future an eVTOL aircraft capable of carrying multiple passengers around megacities. Yet, what’s also true is that the work that the teams are doing will lay the foundation so that the eventual future of the UAM market will be possible. 

About the Author

Nicholas Peters is a first semester PhD student at Embry-Riddle Aeronautical University in Daytona Beach, Florida. During his internship with NASA Ames, Nick worked under Chris Silva while employing the conceptual design software NDARC to undergo a feasibility analysis of several UAM concepts. He hopes to continue working within the emerging UAM field as it continues to grow.

I would like to recognize the modeling group whose work allowed for the feasibility analysis of all 10 aircraft. Their hard work also helped me to obtain as accurate as possible geometric inputs for the NDARC software without having to obtain the actual CAD models from each GoFly team. These team members were Makynzie Zimmer, Ethan Krings, Michaela Sorrentino, James Gayton, Lauren Wagner, Hannah Dromiack and Mireille Fehler. As part of a summer high school program, two high school interns also help contributed to the project: Bianca Ortiz-Larios and Courtney Young.