

AC 2007-1534: DESIGN, FABRICATION AND TESTING OF A NOVEL UAV: CAPSTONE PROJECT

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Design, Fabrication and Testing of a Novel UAV as a Multi-Year Capstone Project

Abstract

This paper describes one recent multi-year Capstone project in the Mechanical & Manufacturing Engineering Technology (MMET) Department at Arizona State University Polytechnic. Specifically, the project involves the design, development, construction, and testing of a prototype Unmanned Aerial Vehicle (UAV). After either an air or ground launch, this UAV will fly as a fixed wing aircraft, but it is also capable of transforming to autogyro mode in flight for slower flight or for near vertical landing. Students from the department's Mechanical, Aeronautical and Manufacturing programs are participating in the project, conducted over three years. The project is funded by an entrepreneurial engineer with the intent of attracting funding and support from industry or the military. The project has required students to perform a broad range of engineering activities, and to document their work well enough for succeeding classes to continue the work, and it has served as the core of a faculty sponsored grant proposal to the Air Force.

Introduction

A multi-year effort to develop a prototype unmanned aerial vehicle (UAV), through the efforts of undergraduate Capstone engineering technology students, is described in this paper. The UAV is a prototype that can switch from fixed wing to auto-gyro flight modes, while in flight. The project is sponsored by a professional UAV design engineer and entrepreneur. The context of the project is described in the introduction, followed by a discussion of the specifics of the vehicle and the class project.

Hands-on engineering education is what sets Engineering Technology programs apart from traditional engineering programs. The students get introduced to the engineering concepts first in carefully designed courses that have a good mix of theoretical development and problem solving techniques. Then they apply the concepts to solve practical problems and test the concepts in well designed experiments carried out in appropriate facilities. This paper is related to this hands-on learning aspect of the engineering technology program delivered in the Mechanical & Manufacturing Engineering Technology (MMET) Department at Arizona State University Polytechnic. Specifically, the paper describes a design project done by the students of the department as part of their capstone classes MET460 and MET461. The main focus of this project is the design, development, analysis, fabrication and testing of an Unmanned Aerial Vehicle (UAV). The UAV will be capable of taking off from short fields under its own power or could be launched from an airborne platform such as a helicopter. It flies as a powered fixed wing aircraft for most of its mission and can land as an autogyro by transforming its wing into a rotor. Students from the department's Mechanical, Aeronautical and Manufacturing programs participate in the project. The funding for this project is obtained from external sources with the expectation that the prototype will attract funding and support for formal development from industry or the military. The design and fabrication process requires the coupling of key disciplines in

engineering technology, including the aeronautical, mechanical and manufacturing engineering technologies which form the focus areas of MMET Department.

Engineering Technology programs focus on delivering a hands-on based engineering education in which particular emphasis is placed on the application of the theoretically developed engineering concepts to solve practical problems. Thus the students are able to test the concepts in carefully designed application oriented problems and projects. This in turn helps the students achieve a level of skills that will be of immediate utility when they join the industry workforce. Adequate engineering and experimental facilities are provided to test and verify basic concepts so that the learning experience for the student leads to a good foundation on which to build a successful engineering career. There are many areas of engineering to which the student is introduced in the engineering technology curriculum, each of which involving unique problems and the methods to solve them. To evaluate the overall merits of the program, careful consideration should be given to test the students in all the relevant areas of engineering technology and the capstone classes help to achieve this. Here the students get the opportunity to demonstrate the scientific and technical skills they have acquired during the course of their engineering education program via projects that utilize those skills. The overall design process is emphasized in which the student is expected to address all aspects of design such as conceptual, preliminary and detailed designs, configuration layouts, loads, stability, performance and cost analyses. Project planning is an integral aspect of this process which the student is expected to address. Effective communication of ideas and dissemination of technical information via comprehensive technical reports are also addressed.

The present paper describes one such capstone project undertaken by the students in the Mechanical and Manufacturing Engineering Technology (MMET) department of Arizona State University (ASU) Polytechnic in which the major disciplines such as mechanical, aeronautical and manufacturing engineering technology are addressed. The MMET department offers two ABET accredited degrees at the baccalaureate level: Manufacturing Engineering Technology and Mechanical Engineering Technology. The four concentration areas within the Mechanical Engineering Technology curriculum are aeronautical, automation, automotive and mechanical. For all the concentrations, the curriculum includes a two-semester capstone course. The course outcomes include the following:

Students will:

1. Complete an engineering project of sufficient quality and importance to be included on their resume.
2. Develop their ability to synthesize knowledge from prior courses and from self-study to creatively and effectively solve engineering and design problems.
3. Develop practical project management skills, including the ability to deliver quality engineering work on schedule.
4. Develop practical skill with selected engineering and fabrication techniques.
5. Improve their ability to work effectively in teams.
6. Improve their ability to communicate effectively.
7. Demonstrate an understanding of and respect for the professional, ethical, and social implications of their project.
8. Improve their good judgment in engineering and its appropriate application.

The MMET Capstone class is a two-semester affair. Students are expected to address all necessary aspects of a project, such as project management, conceptual design, layouts, detail design, engineering and cost analyses, construction, testing, documentation, and communication with the sponsor. The emphasis, however, is on delivering a quality engineering solution to a customer, so selected engineering tasks not central to the project are deemphasized. However, almost all aspects of engineering and product development have been required for the UAV project. Effective communication of ideas and dissemination of technical information via comprehensive technical reports has also been necessary to ensure continuity from year to year. The MMET Capstone teams have access to all MMET shops and labs, including a Haas CNC technical center, a Miller equipped welding technical center, a manual machine shop, additive equipment, a composites shop, and a materials and metrology lab. Facilities are available during normal business hours, and evenings and weekends with prior notice. Teams make frequent use of labs after hours because many MMET students are working as well as attending school. Students can engage the assistance of any faculty member regarding Capstone work, but the course instructor has traditionally been responsible for after-hours access to and supervision of the labs. As the name implies, study in the MMET Department leads to a Baccalaureate degree in either mechanical or manufacturing engineering technology. Many of the students on the UAV project team are enrolled in the aeronautical concentration, one of several concentrations available to the students. However, this is a very popular project that has attracted other students as well. Approximately ten students have participated in the UAV project team over each of the past three years, and the teams have typically been divided into sub-teams to allow better management and make optimum use of technical skill levels.

Project Description

UAV Configuration and Design Features

Design and development of a transforming fixed wing-autogyro unmanned aerial vehicle (UAV) prototype is the primary goal of the project. This is a truly multidisciplinary design problem involving a wide range of engineering areas and associated technical issues. The scope of the work encompasses the areas of design, development, analysis, testing and evaluation thus making this project a very valuable teaching tool that introduces students to cutting edge technology and application of the technology to realistic projects of national interest. The overall focus is to introduce the students to a design problem that is closely related to current industry interests and technical maturity. Even though this is an undergraduate level project, it lends itself to both undergraduate and graduate programs in areas such as aeronautical engineering, mechanical engineering, electrical engineering, electronics and communication, manufacturing technology, robotics, energy systems, alternate energy generation, dynamics & control, materials, and a variety of related areas. This is an externally funded multiyear project involving the design, development and analysis of components and systems that form part of the overall UAV configuration culminating in the fabrication and assembly of a test article prototype vehicle. Brief descriptions of the features and capabilities of the proposed UAV design are given below.

The UAV can be launched from an aerial platform (helicopter or airplane), take off as a conventional aircraft or, in future versions, takeoff vertically like a rotorcraft. It can land as an autogyro in a very small area or as a conventional aircraft on a short landing strip. It will be capable of operating as an airborne command center, observation platform, delivery vehicle for supplies or smaller vehicles, or land and become a mobile platform for land-based operations or a resource center for the sub-vehicles. For all the missions, the vehicle will be remote launched, fly to a predetermined location either autonomously or guided from a command center and carry out either the first three tasks listed above or land as an autogyro and carry out assigned land-based tasks. Once the task is completed, the UAV can move to another location as a land-vehicle, take off and fly to the new location or self destruct. The UAV will be made of light weight composite materials. The rotor/wing can stow parallel to the fuselage for easy storage and deployment, and to allow taxiing in a landing zone. Thrust is provided by a rear-mounted engine which is not connected to the free-wheeling rotor/wing assembly. It can be used to fly ahead of a manned helicopter as an observation platform, or as a delivery vehicle for supplies or smaller vehicles, or for other purposes. The 2-meter prototype under construction by the Capstone class has more limited objectives. It must take off as a fixed wing craft, transform to auto-gyro mode in flight, and land successfully – that alone will make it a complete success. It is a proof-of-concept prototype only. Figures 1 - 3 show schematic views of the UAV configuration.

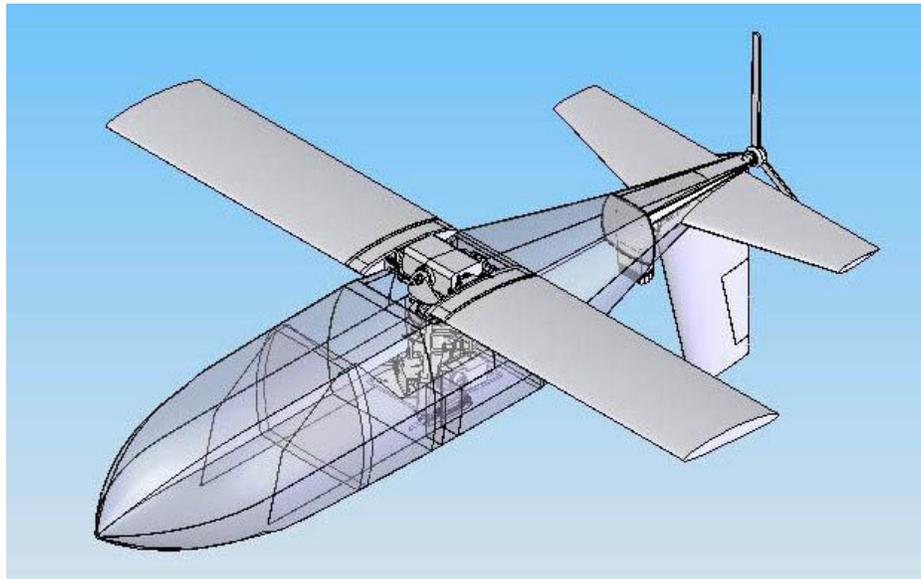


Figure 1. Isometric view of the Capstone UAV

At the aft end of the vehicle, an empennage provides control of the vehicle in all flight modes around the three axes using conventional control surfaces, such as elevons and rudders. The figure shows a triple-vertical, single-horizontal configuration for the tail surfaces, though a V-tail may be considered as an alternative arrangement. The aircraft can use either a propeller or fan engine depending on mission requirements and fuel consumption requirements for long-range or high-endurance operations. The propeller can be configured as a tractor or pusher, but the tractor configuration accommodates the

teetering rotor more easily. The rotary wing, located on top of the fuselage, is unpowered. It consists of two blades mounted on a shaft that is tilted five degrees aft. The rotor-wing airfoil sections are fore-aft symmetrical with blunt leading and trailing edges. This permits the rotor-wing to operate as both a rotor and a fixed wing such that the trailing edge of the rotor retreating blade serves efficiently as the leading edge of the wing on that side. The rotor-wing structure is rigid, with no dependence on centrifugal stiffening as with a conventional rotor.

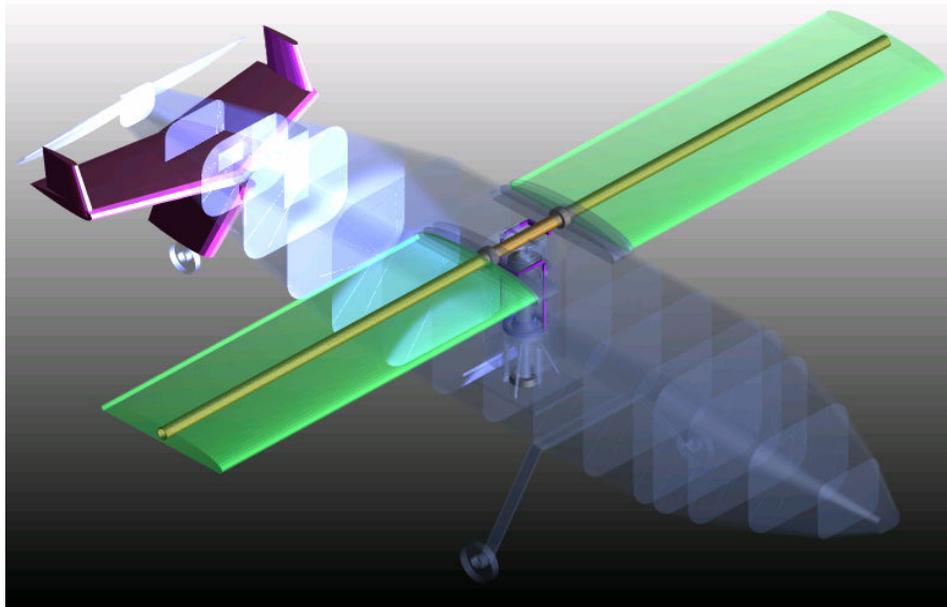


Figure 2. UAV Platform (shown in fixed-wing configuration)

The structure of the rotor-wing is conventional and of thickness ratios typical of conventional wings and rotors. The rotor sections are attached to a hub. A mechanism in the hub locks the rotor-wing longitudinally in the stowed position, allows its deployment to a conventional wing position orthogonal or oblique to the fuselage, and finally releases the rotor so it is free to rotate as an autogyro with collective and cyclic pitch control for recovery landing. The UAV uses conventional control surfaces, such as elevons and rudders. The inverted rudder allows better clearance for the rotor, and facilitates attachment to an aircraft pylon. The two blades of the rotary wing are mounted on a shaft that is tilted five degrees aft.

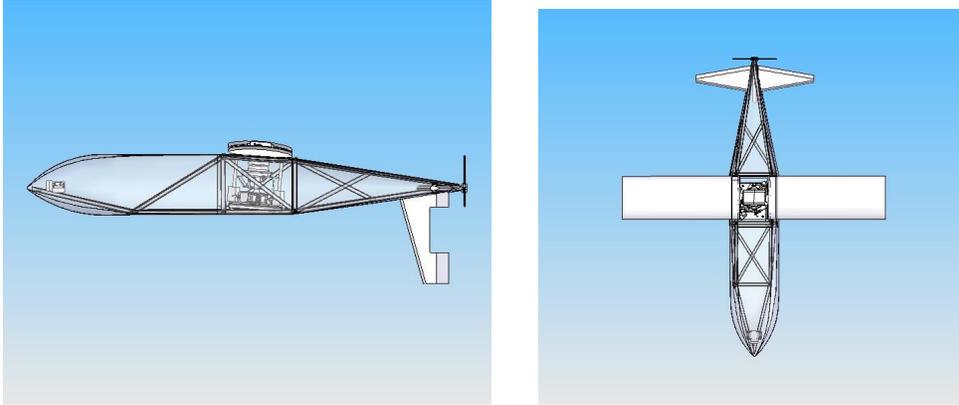


Figure 3. Side and top views of the UAV configuration

In the autogyro mode, the rotor sections accommodate rolling moments by teetering. The rotor sections can flap as much as ten degrees aft, and teetering stops prohibit forward flapping beyond five degrees, preventing rotor-propeller contact. During fixed-wing mode, the rotor sections are prevented from pitching and flapping through contact with the fuselage. The entire rotor system extends when going from fixed to autogyro-flight to unlock the rotor and provide the necessary clearance to operate as a rotor (pitch and flap). The overall design will be modular in such a way as to be adaptable to varied mission requirements, and to be easily serviceable. The process of design, analysis, fabrication and testing of the UAV is done by the students as their capstone project. The use of an autogyro flight mode, as opposed to a helicopter design, greatly reduces cost and weight, because the rotor is not powered. The rotor spins and provides lift as a response to forward motion. Thrust is provided by a rear-mounted engine and propeller. The rotor/ wing can stow parallel to the fuselage for easy storage and deployment. When flying in fixed wing mode, the wing is pressed against the fuselage for stability, and it pops up to provide clearance for rotation and control in rotary wing mode. The dual function of the wing/rotor requires use of a symmetrical airfoil, but the performance penalty for this is very reasonable given its other advantages. The general technical requirements for this type of UAV, and an outline of the rotor hub design, are included in the sponsor's patent¹, but the details are very sketchy and did not provide a significant source of design information for the Capstone team. As a result, they had to design the hardware from the ground up.

Capstone Project Description

A prototype of a transforming fixed wing-autogyro unmanned aerial vehicle (UAV) is under development at ASU Polytechnic as part of the capstone class project. This is a truly multidisciplinary design problem requiring contributions from a wide range of engineering areas. Students in different programs that are related to the disciplines involved participate in the process. The scope of the work encompasses the areas of design, development, analysis, testing and evaluation thus making this project a very valuable teaching tool that introduces students to cutting edge technology and application of the technology to realistic projects of national interest. So far, three capstone teams have

worked on the UAV in succession beginning with the 2004-2005 academic year. Even though this is an undergraduate level project, it lends itself to both undergraduate and graduate programs in a number of engineering areas with aeronautical, mechanical and manufacturing engineering technology areas forming the core group of the design process. This is an externally funded multiyear project with teams of capstone class students addressing different stages of the overall design process.

As mentioned above, three different student teams within a capstone class framework have worked on the UAV in succession. The 2004-2005 team designed and built the transforming hub/rotor assembly and obtained initial lift and drag data for it. A schematic view of the hub/rotor assembly is shown in Figure 4. The wing/rotor cross section is that of a cambered airfoil that is symmetric about the mid-chord point (leading and trailing edges). This unique requirement is due to the fact that the wing transforms into a 2-bladed rotor in the autogyro mode. The basic concept for the rotor hub design has its origin in a patented design belonging to the sponsor for this project. The capstone class expanded this basic design concept into the current form based on the performance and load requirements imposed on the UAV. The technology development was carried out in close collaboration with the faculty members with extensive aerospace background and the engineers at Boeing Helicopters, Mesa, AZ. The aeronautical curriculum of the program in the MMET department includes courses in aircraft design, composites, aircraft structures, propulsion and fluid mechanics in addition to the basic engineering courses. Thus the students have the necessary background to design, build and test such an aircraft and all its major components.

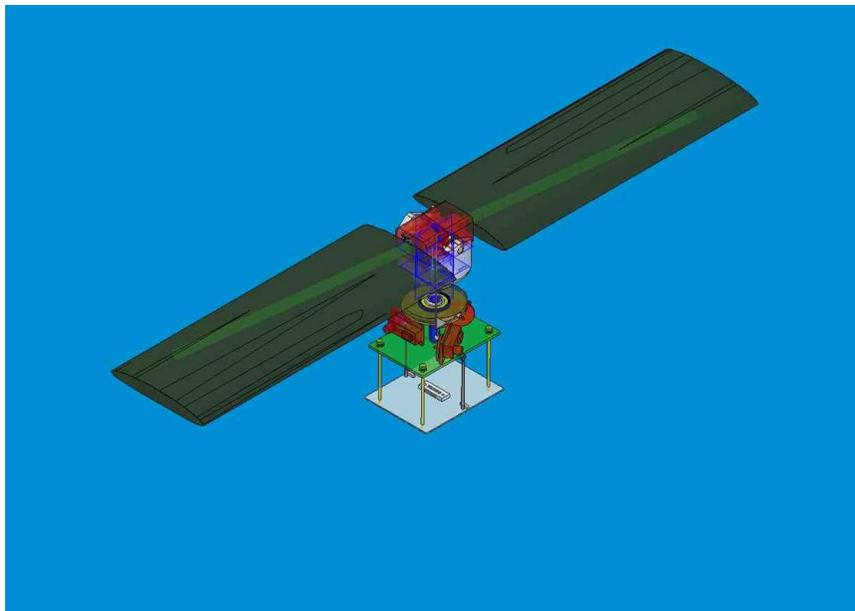


Fig. 4 Hub/Rotor assembly – schematic view

The wing design is a good example of this facet of the student training. The airfoil geometry depends on the required aerodynamic performance in both the fixed-wing and the autogyro modes. This is a challenging task and the resulting design meets the set

requirements. The aerodynamic performance of the wing has been analyzed based on standard procedures and the geometry of the wing/rotor resulted from this analysis. The design of the rotor hub assembly is a complicated task. The hub has to be locked in the fixed wing mode and must be released in flight so as to transform the wing into the rotor. It should also include all the relevant mechanical systems of a typical helicopter rotor (unpowered format). The students have been successful in carrying out this task. The hub/rotor assembly was tested under simulated flight conditions to assess its performance and also to make any modifications, if necessary, to the initial design. This was carried out by mounting the assembly in the bed of a pick-up truck and driving the vehicle at speeds close to the expected flight speeds. The test rig was instrumented with load measuring strain gauges to measure lift and drag acting on the wing/rotor configuration. Tests were carried out in both the fixed-wing and rotary configurations and the resulting performance was very close to the design performance. The capstone team completed this part of the overall design and submitted the designed prototype along with a detailed technical report to the department and the sponsor. The performance evaluation of the team was based on the entire body of work put forth by the team.

During the course of the two semesters, the students made accurate 3-D CAD layouts of the assembly, and prepared CNC programs to machine hub components. They then machined the hub, and fabricated the rotor-wing with composite materials involving carbon cloth and epoxy over a foam core. The team of seven proved quite capable of mastering these very different construction techniques, the assembly worked as intended, and workmanship was excellent. A hinged link that prevents relative rotation between hub sections would sometimes fold in an unanticipated direction, but there were no significant problems during assembly. The hub/rotor assembly is shown in Figure 5. After construction, the team bolted together a test stand that fit in the back of the College pick-up truck, and instrumented it with strain gages to measure lift and drag (Fig. 6). Tests were run while driving the truck at known speeds. Data was acquired and saved using an HP Datalogger. Tests were carried out in both the fixed-wing and rotary configurations and the resulting performance was reasonably close to the calculated performance and sufficient to fly the projected 28 kg (62 lb) aircraft at its intended speed of 95-110 kmph (60-70 mph) in fixed wing mode.

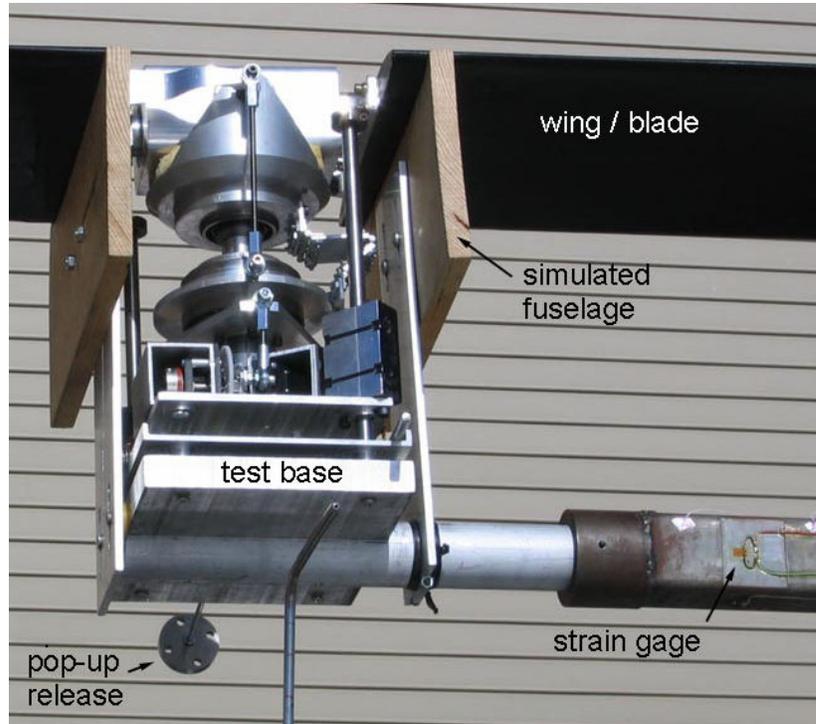


Fig. 5 Hub/Rotor assembly prepared for a fixed-wing lift test.



Fig. 6 Students from the 2004-2005 team prepare for a fixed-wing lift test.

The 2005-2006 team took on the task of building a light weight fuselage to house the rotor/hub assembly, engine and its accessories, the empennage and the landing gear. In addition, the team was given the task of developing performance criteria and the corresponding design parameters for the landing gear, powerplant and the empennage. The team used the data developed by the previous team as the basis for this task. The team built

the fuselage using carbon composite materials, repaired wing damage sustained in the prior year's testing, and carried out additional lift and drag evaluations of the redesigned wing. The fuselage is built in two parts: an upper and a lower half so as to facilitate the integration of all the systems and their components that are housed inside the fuselage. Preliminary structural load analysis was conducted on a number of landing gear designs and configurations and recommendations for a landing gear design were developed. Required powerplant (propeller engine in the pusher configuration) parameters were evaluated based on performance requirements and projected estimations of the loads acting on the UAV airframe. Based on these evaluations, a propeller engine (3.7 kW) was purchased. Initial testing and evaluations of this engine were carried out by the team.

The enthusiastic 2005-2006 project team of ten students was very well organized. They quickly rebuilt the damaged wings, and improved on the manufacturing process by CNC machining foam cores for the new wings. The assembly was then balanced and re-tested for lift and drag as in the preceding year, and better data was obtained for rotary performance. In fact, lifts of up to 400 N (90 lb) were measured at relatively low speeds (~70 kmph or 45 mph) because the rotor spun up very easily well past its design spec of 850 rpm. Forward speeds were limited whenever rotation reached 2000 rpm because of concerns about stresses in the hub and safety. It is noteworthy that the assembly, which is essentially undamped, did not exhibit significant vibration problems during testing. To prevent accidents of any kind, a specific student was designated as a safety officer for every test, and there were no problems. They also built the fuselage and control surfaces, and began work on the engine and support systems such as electrical power and RC actuators for the control surfaces. The carbon-epoxy fuselage and the empennage were made in large, multi-sectioned, CNC machined foam molds, resulting in superb quality. The team did the composites work on their own, but they had the benefit of the professional advice of a Boeing composites engineer, who is associated with the MMET department.

The 2005-2006 team had initially hoped to complete the aircraft, but there was an unrealistic amount of work necessary to achieve that goal. The goal was recognized as aggressive from the beginning, and the scope of work was later limited, but in hind sight it would have been better to start with more realistic expectations and, if necessary, scale back sooner. Along with the composites work, the students worked out the weight and required balance for the aircraft, making changes to the hub and fuselage design to reduce weight and stay within the design specification. They began integration of internal components and systems. They sized, selected, and broke in the 3.73 KW (5-HP) motor, and began design of a motor mount. This included analysis of vibration frequencies and modes for an extended drive shaft. Preliminary structural load analysis was conducted on a number of landing gear designs and configurations and recommendations for a landing gear design were also developed. This team made great progress, and the core tasks of the team were completed with high quality, as the figures 7 and 8 show. It must be noted that in figure 8, the stand is temporary and the top half the fuselage has been removed for better view.



Fig. 7 A CNC-machined foam mold and the thin, light carbon-epoxy fuselage



Fig. 8 The UAV at the end of the 2005-2006 year .

The vehicle in its present configuration (2-meter prototype) is projected to weigh 28 kg and will be powered by the 3.7 kW propeller engine mentioned above. It is 2 meters in length, but can be easily scaled up or down if necessary. The 2006-2007 team has undertaken the task to design, develop and integrate the powerplant , empennage, and landing gear into the existing UAV airframe and incorporate the wing/rotor assembly into the vehicle. The project team has nine students, this time organized into three clearly defined and independently assessed sub-teams. One team is responsible for developing a

viable design for the gear based on the recommendations from the previous teams and the expected characteristics of the UAV. A steerable tricycle configuration is being developed in this regard. Another is responsible for the empennage and engine, which share the space at the rear of the fuselage and require reinforcement. A third team is responsible for upgrades to the hub and wing/rotor assembly. The empennage with the required control surfaces (elevons and rudder) has been designed and the tail section of the fuselage that will support the empennage is being redesigned by the current team. This design will have a truss configuration and the necessary analysis background comes from the Aircraft Structures course that the students have already completed in the program. Additional tests have been carried out on the engine. The current design places the main part of the engine along with its fuel tank(s) inside the fuselage in the vicinity of the vehicle center of gravity along with a power shaft to deliver the power to the externally configured propeller. Engine mounts and power shaft (engine to propeller) are under development at present. A landing gear team is working on a viable design for the gear based on the recommendations from the previous teams and the expected performance of the UAV in its present configuration. A tricycle configuration is being developed in this regard. Load and failure analysis based on relevant physics is being carried out at present and this will lead to the final design in the near future. In addition, the team will prepare the aircraft for its initial flight. In this regard, a network of controllers, sensors and actuators and their energy sources (batteries) is being developed by the entire team. The interior of the fuselage is being designed to accommodate this network and the attendant mechanical systems in addition to the hub assembly and the engine and its subsystems. Flight testing this UAV is a complex task and will require skilled test pilots who can fly the aircraft using a number of remote controls. The capstone team will configure the control surfaces and their actuators, the rotor assembly and its actuators and the engine and its controls in an optimum fashion to make the flight testing process as easy as possible. The strategies for designing the control systems in this respect are being developed by the current team in close collaboration with the experts mentioned earlier.

The project described above is a very complex one requiring technical capabilities that are multidisciplinary in nature. Overall design and development of the vehicle requires a substantial amount of time which led to the three capstone class teams working in succession on the project. Each team faced different technical challenges, but completed their portions of the work successfully and professionally and left the design well documented along with the carefully fabricated subsystems and components for the following team to build on. As mentioned above, the transforming wing/rotor and hub have been built and tested. The fuselage has been built using carbon composites, and the students are currently completing the design and fabrication of the empennage and the landing gear. The power plant (engine) and its mountings are being designed by the current team and will be integrated into the vehicle in Spring semester of 2007. The final task for the present team will be to assemble the UAV and deliver the prototype for flight testing by the testing team. The overall design process will be well documented and a number of technical information dissemination outlets (reports, presentations, models, analysis tools and data set) will be provided.

This Capstone project differs from typical capstone class projects in the sense that it spanned a three-year timeline unlike the typical one-year duration. The primary reason for

this is the fact that the design, analysis, fabrication and testing of the components and the full vehicle is time-consuming and cannot be scaled down to fit within a one-year timeline. Certain sequencing had to be maintained requiring the appropriate clock time extending over a few weeks at a time. The whole process was very similar to industry practice involving unconventional and exploratory designs. The project lends itself to involving various engineering topic areas at various times (for example, during the first year, the project required more mechanical and manufacturing skills than aeronautical ones which led to a largely mechanical/manufacturing look to it) which was a big factor in generating interest on the part of the students to work on it (purely voluntary basis). The goals set from the outset for the overall project as well as the parts of it addressed in the various years were constantly addressed and were met during the prescribed timeframes. Assessment of the projects and the related goals followed well established procedures including individual contributions, group work, meeting deadlines, adapting to changing circumstances, relationship of the work to student backgrounds, setting and meeting design tolerances, following established fabrication guidelines, disseminating the technical information via reports, presentations, interacting with relevant industry entities (Boeing helicopters, for e.g.), testing and analysis and redesign issues. Based on the assessment process, various recommendations have been made regarding refining the curriculum. For example, more hands-on exposure to composite manufacturing and flight loads testing and analysis were recommended and are expected to be incorporated in a variety of courses in the curriculum. Design of experiments was an area that received special attention in the process and changes are being made to courses such as AET210: Measurement and Testing and AET420: Wind Tunnel Design and Testing. It is expected that at the completion of the project, a thorough technology transfer and the related debriefing involving the industry sponsor will take place and the results will be incorporated in the existing curriculum in related subject areas.

Future Directions

One key development resulting from this project will address the area of identifying possible funding sources among government and industry entities that might have future applications where the UAV or its derivative(s) will be of utility. Should such sources become available, this project will be further expanded involving both undergraduate and graduate students and a team of faculty and industry partners with multidisciplinary design and analysis backgrounds. One of the sponsor's objectives is to attract funding from government or industry to develop the UAV. A number of potential sponsors are being investigated. In particular, the Capstone project sponsor and faculty recently organized a proposal to the U.S. Air Force around this UAV, in response to the Air Force's 2006 "Campus Challenge"², to propose next generation technology for UAVs. The proposal calls for developing a fully featured but smaller version of this UAV, which would deliver microvehicles to perform surveillance and ground operations. This proposal made it through the first round of reviews, and is now competing with ten others for a significant grant to research the concept in depth. The proposal's success in the first round may well be attributed to the significant and professional progress MMET students have made toward completing the prototype. If the funding becomes available, this project will be greatly

expanded to include both undergraduate and graduate students, faculty, and industry, to address the Air Force's interests.

Conclusion

A multidisciplinary design problem requiring contributions from a wide range of engineering areas in the context of a senior-level capstone project is described. Design and development of a transforming fixed wing-autogyro unmanned aerial vehicle (UAV) is described. Students in different programs that are related to the disciplines involved participated in the project. Overall design and development of the vehicle requires a substantial amount of time, thus far requiring the efforts of three capstone class teams working in succession. Mechanical, aeronautical and manufacturing engineering technology students participated in the project. The design process was comprehensive and required the students to use all the skills they had acquired as part of their Engineering Technology program to design, analyze, fabricate and test the components of the UAV. Testing of the complete aircraft is scheduled for the end of the current semester involving the students enrolled in the capstone class at present. The project described above is a very complex one requiring technical capabilities that are multidisciplinary in nature. Each team faced different technical challenges, but completed their portions of the work successfully and professionally. Teams not only documented their work, they also learned the importance of the documentation because they had to rely on the materials left by preceding teams. They witnessed the successes of preceding teams, and had to remedy the occasional errors made by them as well. The UAV will make its demonstration flight in 2007.

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