International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

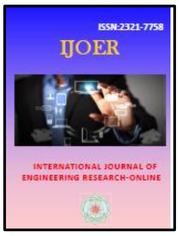
Vol.5., Issue.5, 2017
Sept-Oct

RESEARCH ARTICLE

ISSN: 2321-7758

UAV Design by Advanced Manufacturing Techniques

R.DASHARATH NAIK[1], K ANIL[2], K LAKPATHI[3]
[1]Mechanical-Mechanical Department, JNTUH-JNTUH University, Aurora Engineering College TS India
[1]dasharath.jun1993@gmail.com;[3]ravi8885@gmail.com
[2]Aurora Engineering College, B B Nagar,TS India
[2]coravikak12@gmail.com



ABSTRACT
The ability to remotely control an aerial vehicle capable of surveillance, offensive and defensive manoeuvring, reconnaissance, or numerous other applications without the need to put a human life in jeopardy is a major attraction to their use. Furthermore, there exists opportunities to make these airborne vehicles largely autonomous, further reducing the need for even remote human operators. However, for all of the significant advantages of UAVs, there is a significant negative: Unmanned Aerial Vehicle (UAV) platforms are of major interest to Defence, Government, and commercial industries. the cost of manufacture, and the cost of design. Due in part to the substantial amount of complex electronic equipment on board, UAVs becomes not only a design of aeronautics, but an experiment in energy conservation through optimization. A limited range of UAV power becomes a limiting factor of UAV application. The challenge becomes to optimize the size, weight, and aerodynamics of the UAV based on the application. Along with a NASA faculty research grant, the project has been given seven college engineering students with the singular goal of investigating UAV design techniques using advanced manufacturing techniques and STEM principles. In this paper, it will be shown how a college manufacturing lab, paired with a team of student engineers, and guided by an engineering faculty member, will seek to provide tangible, industry-quality results.

Key Words – Additive Manufacturing, Advanced Manufacturing, Community College, NASA, STEM, UAV

1. INTRODUCTION

What is the cost of a human life? This is a question that has to be considered every single time a pilot is put into a dangerous aerial situation. To be able to avoid this question altogether is the principle advantage to autonomous or remotely-controlled unmanned aerial vehicles (UAVs) used as a replacement in these dangerous applications (Figure 1). Applications such as military operations, national security, border patrol, surveillance, reconnaissance, and combat are naturally hazardous subjects. When a pilot is put into these circumstances, they are risking not only the vehicle that they are piloting, but of course (and more importantly), their very life. It should be noted that the plane or helicopter itself is often very, very expensive, due in part to having to be designed (in both physical size and support systems) around the safety and operations of the pilot himself (seating, steering, communication, environmental (pressurization and oxygen supply), and emergency ejection systems. In many ways the most important element in the operation of the aerial vehicle is also the aerial vehicle's weakest link. If the pilot, or pilots, can be fully removed from (at least) the in-flight equation, the cost of the airborne vehicle can not only be reduced significantly, but the risk of losing human lives can be completely eliminated.

Figure 1: Unmanned Aerial Vehicle (UAV)- While appearing in many forms safety on the Ground[4]

So why haven't all modern human-operated aircraft been replaced with remotely controlled unmanned aerial vehicles? The answer is simple and singular: the cost. Both monetarily and computationally, present-day UAVs have the potential to cost significantly more in usage than a similarly controlled human aircraft. For example, the "Raptor" UAV that the U.S. Government uses for Border Patrol applications, dealing with matters of National Security, costs nearly $4.5 million per unit; however the cost of operating the Raptor UAV can grow into more than double the costs of operating a manned aircraft. In fact, operating a single UAV of this complexity can require a crew of twenty Border Patrol agents, pushing the per-hour operating cost for this application to nearly $3,250. Using this per-hour cost, and multiplying it by its application (24 hour, 7 day a week surveillance), keeping a single Raptor UAV in the air can cost roughly $28.5 million. Moreover, they currently employ four Raptor UAVs [1].

Fortunately, this allows for significant opportunities in design improvements, with the ultimate goal of reducing costs. This can be done through several proven pathways. Reducing overall UAV costs can come in the form of reducing design and prototyping costs, reducing manufacturing costs, or increasing computational speeds (therefore reducing computational costs). By reducing the cost (and time required) to test new designs and produce prototypes, the ability to optimize the global design can lead to reduced operating costs due to improved aerodynamics, higher power-to-weight ratios, and enhanced integrated components. Through reducing the cost to manufacture (by utilizing modern techniques), approved designs will undoubtedly lead to reduced UAV per-unit costs. And finally, by increasing computational speeds (faster processors) and reducing energy consumption (more efficient processors and/or cooling methods), technologies can allow for added (and longer duration) autonomous operation, lowering physical human interface, and therefore further reducing operating costs. In general, UAV usage choices can be made with financially stronger decisions through lower unit costs, or lower operating costs.

In this paper, we have sought to approach the challenge of simultaneously reducing the cost (and improving the speed) to design and prototype future techniques in UAV design as a means of reducing overall UAV unit and operating costs. We will demonstrate techniques that can lead to optimized designs through the use of 3D solid modeling CAD software (with the ability to perform elementary computational fluid dynamics (CFD)) simulations and straightforward stress analysis testing. It will then be shown how the optimized computer designs can be inexpensively produced using state-of-the-art rapid prototyping and rapid production machines (based on additive manufacturing techniques). Finally it will be shown how a student team of college engineering students has adopted this project into an integrated STEM-based National Science Foundation (NSF) grant program.

II. ADDITIVE MANUFACTURING AND DESIGN

Additive manufacturing is defined by the American Society for Testing and Materials (ASTM) as the "process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies, such as traditional machining." [3].

In using one design example, it is generally accepted that, at even the basic level of UAV design that the rotors, or propellers, should remain within the structure of the UAV, and not left unprotected outside of the vehicle. This results in straightforward blade protection, more controlled airflow, additional low-profile strategies, and overall aesthetically pleasing design. However this is where the general similarities to other commercial designs end, and where the ability to take a good design, can be turned into a great design.

While the majority of manufacturing processes currently used for the design of such a housing structure would consist of either a single, solid construction (Figure 2a), or two molded hollow shells, adhered in the middle (Figure 2b), we propose, through the use of the modern technique of “additive manufacturing” to create a dual structure of a solid outer shell (utilizing the lightweight structure of Figure 2b), with no seam lines, with an internal substructure of trusses (modifying the design strength of Figure 2a) to create the perfect balance of strength and weight, therefore working towards optimizing the UAV’s power-to-weight ratio. A design of this could only be realistically produced through additive techniques (Figure 2).

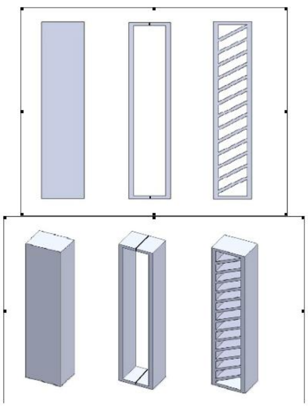


Figure 2: Prototyping the perfect-sold modelling Hollow core Composite Design[4]

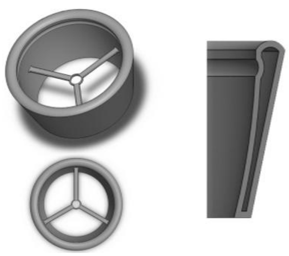


Figure 3: Cutaway [4]

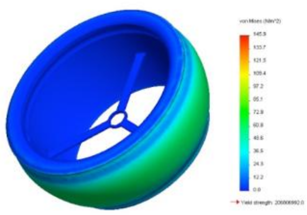


Figure 4: Stress analysis Testing[4]

III. CT NASA CONSORTIUM AND TEAM UAV 7

Due to academic partnerships that exist in the higher-education system in Connecticut, due in part to the Connecticut College of Technology (COT), and its Regional Center for Next Generation Manufacturing (RCNGM), this Connecticut NASA Space Faculty Research grant was able to expand, and tap into the resources of the Connecticut Life Support and Sustainable Living (LSSL) Program to recruit multi-discipline college-level engineering students looking to devote approximately 16 weeks on an industry-level research project. The NASA UAV project was granted seven of thirty-four students for the 2013 winter term. The team of seven students spent the first two weeks performing environmental scans to research what other commercial and defense organizations were prototyping to improve UAV design techniques. Further, searches were

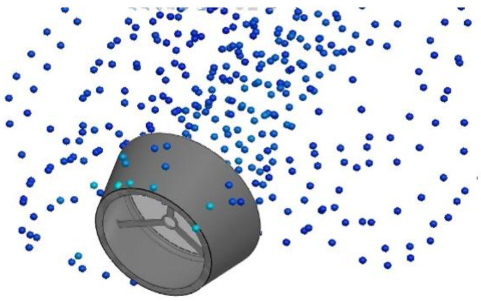


Figure 4: Computational Fluid Dynamics [4]

IV. VISUAL RENDERING OF THE PROPOSED PROTOTYPE(S)

With the recent advancements in personal (let alone commercial) computing power, and complete 3D CAD modelling software packages (Dassault Systems Solid works or CATIA, Autodesk Inventor, Siemens NX, etc.) there is almost no excuse to not complete the task of rendering the project in a photorealistic way. Moreover, it is certainly possible to create animations, demonstrating the way the design will move, or transform through design iterations, or normal operation.

Figure 5: Protorelating Rendering [4]

V. CONCLUSION

It has been shown that advanced design, prototyping and manufacturing capabilities can exist at the community college level and in modest ways rival what can be achieved at the industrial or commercial level. More importantly, it represents how well prepared the community college or university engineering student can be to enter the workforce. We have proven that upper-level engineering and prototyping can exist at any level and excel, and even do so at a relatively inexpensive cost (perhaps "inexpensive investment" is more reasonable in the context). Finally, it has been shown that it can be fully expected that as computational costs decrease, opportunities for advanced modeling and prototyping demands will increase at earlier academic stages, furthering the need to develop this at any academic level.

REFERENCES

[1] McCarter, M.,"The Future of SBInet," Homeland Security Today 2011.

[2] Flynn, E.; "Design to Manufacture — Integrating STEM Principles for Advanced Manufacturing Education," Integrated STEM Education Conference (ISEC), 2012 IEEE 2nd , vol., no., pp.1-4, 9-9 March 2012

[3] Flynn, E.; "From Design to Prototype - Manufacturing STEM Integration in the Classroom and Laboratory," Integrated STEM Education Conference (ISEC), 2011 , vol., no., pp.3B-1-3B-4, 2-2 April 2011

[4] Flynn, Eric P.. "Low-cost approaches to UAV design using advanced manufacturing techniques." *2013 IEEE Integrated STEM Education Conference (ISEC)* (2013): 1-4.