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INSIDE

ATEC JOURNAL

FROM THE EDITOR.

A roundtable discussion regarding the ATEC Journal took place at the recent ATEC conference. A number of people attended, and we thank them for their interest and support. Originally, the objective of this meeting was to share information concerning the review process and submission requirements, with the overall intent of increasing knowledge and awareness of the Journal. The main thrust of the conversations in the meeting soon turned to strategies focused on increasing participation. All in the room agreed that the Journal is an extremely valuable venue in which to publish, particularly for aviation maintenance educators seeking tenure in their institution. Moreover, it was also recognized that the Journal serves as an important conduit through which to share new teaching techniques and research important to our discipline.

Some of the ideas discussed are given below:

- Removing the Journal from behind the "members-only" password, with the goal of increasing visibility and readership.
- Hosting one or more webinars as a platform for authors of white papers to present their findings.
- Issue a Call for Papers requesting white papers on issues to be discussed at the next conference.
- Issue a Call for Papers shortly after the ATEC conference for white papers directly related to main issues from the conference presentations. Topics could include issues under study by ATEC committees, i.e., legislative and regulatory committees.
- Utilize a separate communication for/regarding the Journal, rather than a link (only) in the newsletter.
- Assembling a sub-committee/working group to investigate the possibility and focus of papers from other sources, including students and industry authors. Currently, the Journal accepts submissions from members, who are primarily aviation maintenance instructors.

Our plan is to follow up the roundtable with action; your responses to concepts and ideas above are welcome. The ATEC Journal is important both for the organization and for members; we need to take the necessary steps to ensure that it serves the appropriate mission, and does so successfully. In that vein, I am convinced that consideration should be given to unshackling the Journal from certain constraints with the goal of increasing publications and readership, and to better serve the aviation maintenance community.

Please consider submitting a paper for publication in the Fall edition of the Journal. If you have questions regarding appropriate material for publication, don't hesitate to contact me.

Best Regards,

David L. Stanley

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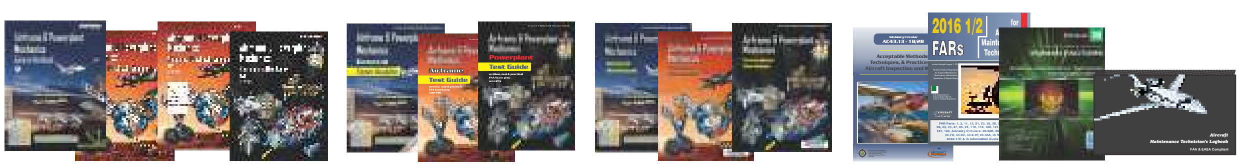

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THE VIN FIZ FLIGHT

COLLIN D. MCDONALD — MIDDLE TENNESSEE STATE UNIVERSITY

Every day multiple airline flights depart New York City for the West Coast, safely and comfortably transporting thousands of passengers in a matter of hours (Rust, 2007). This is an incredible logistical feat involving pilots, dispatchers, controllers, and other critical individuals who are not directly involved with the flight itself such as ticket sales representatives, maintenance technicians, and aircraft manufactures (Rust, 2007). The modern commercial aviation industry is the result of the evolution of aviation since the Wright brothers' first flight in 1903 (Taylor, 1993). Many events such as grueling wars, chasing records, and sobering accidents have molded aviation over the years. For the first decade of its existence, the airplane was not considered a practical method of transportation (Taylor, 1993). Yet one event would change not only how the public perceived aviation but also the future of aviation—it would change the world forever.

After the Wright brothers achieved their momentous flight during the winter of 1903, aviation struggled to take hold in the American people's minds as a practical form of transportation due to its unproven capability (Taylor, 1993). The "aeroplane," as it was called, was seen as more of a daredevil hobby for the brave or foolish (depending on who you asked) (McCullough, 2015). This was partially due to the fact that in 1908, the Wright brothers themselves still struggled to master the machines of their invention with both Orville and Wilbur having multiple accidents, one leaving Orville with broken legs and ribs taking over 4 months to recover from (McCullough, 2015). Furthermore, the advent of "airshows" in which aviators took to the skies to perform death defying and sometimes fatal stunts before thousands of wide-eyed spectators caused the public to have apprehensions of flying (Lebow, 1989). At the Chicago Airmeet of 1911 there were numerous accidents and incidents including two fatalities among the two-dozen aviators who participated in the event (Wendell, 1999). While the crowds still flocked to the airfield by the hundreds of thousands, they only wanted to see the daredevils of the sky and their crafts; the majority of those who had thoughts for the future of aviation were only considering the militaristic or entertainment purposes (Lebow, 1989).

One of the spectators at the Chicago Airmeet was prominent newspaper owner William Randolph Hearst who had already gained attention in the aviation world (Lebow, 1989). Hearst, being a visionary, looked past the present issues with aviation and saw that it could become a feasible means of transportation. In October of 1910, Hearst thought the "general thrust of aviation was misplaced" (Lebow, 1989, p. 71) and the effort should be focused on developing better, more reliable craft. He announced he would reward a $50,000 cash prize to the first aviator who flew from one coast to the other passing through Chicago (location of Hearst's newspaper) in 30 days or less. The offer was made in October of 1910 and would expire one year later on the October 10 per Hearst's stipulations. It was Hearst goal not only to promote research and development of the airplane, but also to prove its capabilities (Lebow, 1989).

One of the many competitors at the Chicago Airmeet was Calbraith Perry Rodgers. Rodgers was born in January of 1879 in Pittsburgh, Pennsylvania to the recently widowed Maria Rodgers (Wentz, 2011). His father, assigned the protection of settlers in the Wyoming Territory, was killed 4 months prior to his birth by a lightening strike. Cal's lineage included famous Naval Commodores such as Matthew Perry Rodgers and Oliver Hazard Perry. His cousin, John Rodgers, would become a Naval aviator after graduating from the Wrights' Flying School and set the record for the longest seaplane flight in 1925. Rodgers would have followed in the family career path but a bout with scarlet fever in 1885 left him entirely death in one ear and partially deaf in the other. His hearing loss caused significant issues in his academic training but did not prevent him from becoming a star guard for his school's football team (Wentz, 2011).

Rodgers benefited from a family fortune and never would need to work a day in his life (Stein, 1985). An adventurer at heart, he moved to New York after graduating from Mercersburg Academy and join a yacht club (Wentz, 2011). After a few years of membership, Rodgers raced with the yacht racing team, becoming a fan of many of the female members with his dashing looks and shy personality. On a race to Bermuda in 1906, he rescued a lady who had fallen into the ocean after losing her footing while boarding a yacht. The daughter of the woman, Mabel Graves, would become his wife less than five months later. The two would live in New York for the next half-decade and sadly never have a child (Wentz, 2011).

Rodgers visited his cousin John in April of 1911 at the Wright Brothers' School of Aviation in Dayton, Ohio (Lebow, 1989). He went up for a pleasure flight and soon began flight training that same month. He was a natural pilot and soloed (flew without instructor supervision) with less than 90 minutes of flight training at Huffman Prairie (Stein, 1985). He became the forty-ninth pilot to be certified by the Wright brothers on August 7, 1911 (Stein, 1985). Three days later, Rodgers arrived in Chicago where he would make a name for himself as an aviator by winning the Endurance Prize at the 1911 Airmeet (Lebow, 1989). During the nine-day event, Rodgers would fly over 29 hours to take home the largest single prize of the Airmeet—$5,000. His total purse was just over $11,000 and he caught the eye of many with his deftness and skill surviving an emergency that could have taken his life (Lebow, 1989). While still at the Airmeet, Rodgers casually mentioned to his wife Mabel he was considering the Hearst Prize. Her response was "I think you should do it. It's a great idea!" (Lebow, 1989, p 59). Neither Cal nor Mabel broached the topic for the remainder of the contest.

The Chicago Airmeet would be a memorable event boasting multiple world records but most impressive was an altitude record of 11,642 feet set by Lincoln Beachey (Lynch, 2003). It was an optimistic time for aviation with daily record breaking and everyone anticipating the next great feat of flying (Lebow, 1989). When Rodgers attended a dinner after the Airmeet and mentioned to J. Ogden Armour he was considering Hearst's transcontinental challenge, Armour broached the topic of sponsorship for the flight. Armour owned the Armour Meat Packing Company in Chicago and saw this as a business venture (Lebow, 1989). Eventually they would come to agree that Rodgers would be compensated $5 per mile as he crossed the country and have a special train with railcars for personnel, an automobile, maintenance equipment, and spare parts (Noel, 1911). In return, Rodgers would pay for his own fuel, oil, maintenance, and personal staff; he also would be required to provide his own aircraft with a specific paint scheme promoting the newest endeavor of the company—a new grape soda called "Vin Fiz." By September 14th, Rodgers, who had only 3 months of experience as a pilot, was traveling to Long Island, New York with his newly modified Wright Model "B" biplane to begin a flight that would change the world (Noel, 1911).

After Rodgers completed his transcontinental flight, many people began to see the capabilities that aviation held. It would be the turning point in three major areas of air commerce: air mail transportation, air passenger transportation, and utilizing aircraft for personal transportation. Rodgers' legacy would set the world on track of researching and developing better aircraft and eventually stem into the scheme we see today.

As a student in aerospace, I wanted to make a similar impact on aviation. Rodgers' flight inspired the nation to get into the skies. As a honors student, I chose to fly his route from New York to Long Beach as my thesis project in hopes to quell the recent decline in aviation interest as shown by the lack of new pilots produced and the drop in enrollees in my college (Middle Tennessee State University). Over the next few months, I planned and prepared for the trip. I raised nearly $6,000 in funds for the flight and prepared my personal aircraft for the transcontinental journey.

On May 18, 2016, I departed Murfreesboro Municipal Airport in the heart of Tennessee on the trip of a lifetime. For the next 28 days, I traveled across 25 of the 50 states, following Rodgers' route, speaking at aviation events, dealing with mechanical issues that arose, and speaking to media outlets to showcase aviation in a positive light. The trip was completed without accident and incident. The total flight time was over 85 hours and distance covered nearly 6,500 miles. Nearly a dozen news outlets broadcast the trip, allowing me to represent aviation. My trip demonstrated just how exciting obtaining a pilot's license can be and will hopefully continue to inspire and challenge the next generation to seek a career in the aviation industry!

Collin McDonald was the recipient of the James Rardon Student of the Year Award.

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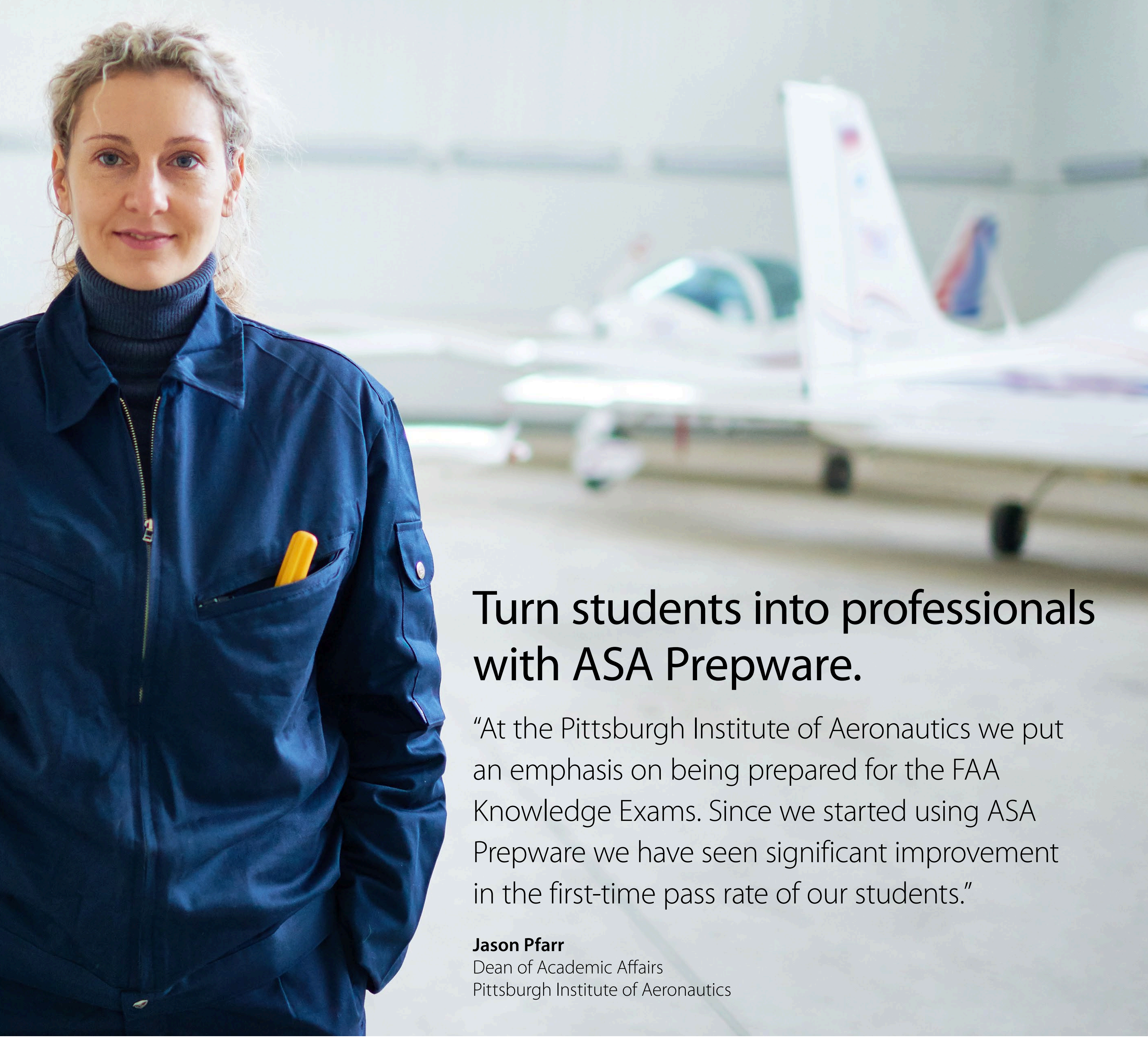
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FACULTY HIRING NEEDS FOR 2-YEAR COLLEGIATE PART 147 PROGRAMS

PEDRAM MOTEVALLI, MARY E. JOHNSON, PHD, ASSOCIATE PROFESSOR & J. MARK THOM, ASSOCIATE PROFESSOR — PURDUE UNIVERSITY, SCHOOL OF AVIATION AND TRANSPORTATION TECHNOLOGY

ABSTRACT

Boeing, Airbus, and the Federal Aviation Administration (FAA) are each forecasting an upcoming shortage of aviation pilots, mechanics and technicians. For collegiate aviation programs, there is a need to produce the required number of airframe and powerplant mechanics, and a need to have the proper number of credentialed faculty to teach these future mechanics.

Recently, there have been several academic papers and news articles on the upcoming shortage of pilots. To the knowledge of the researchers there has not been a study specifically addressing the impact of projected shortages in the aviation industry on the ability to successfully search for faculty for collegiate aviation mechanic programs. For this study, 131 collegiate Part 147 programs were asked about the credentials of current Part 147 faculty, and the potential future need for faculty. This study found that there is an upcoming need for Part 147 faculty at each of the 30 two-year schools that have responded. The data from this study shows that the number of new positions for faculty and the educational requirements for these new positions are anticipated to increase over the next ten years.

INTRODUCTION

"The gray heads in the audience outnumbered the dark heads 10 to 1. 'Are we dying as a profession?' I wondered as I watched the thin gray line file in after a break. 'Where are the younger mechanics to carry on once we retire?'", said Bill O'Brien at a Federal Aviation Administration (FAA) Inspector Authorization meeting in 2005 (O'Brien, 2005, p. 2). Bill O'Brien was a famed A&P and now has a national mechanics awards named for him.

According to the Code of Federal Regulations (CFR), civilian airframe and powerplant (A&P) mechanics are trained at 14 CFR Part 147 certificated schools (Government Publishing Office, 2016). As of August 2016, there are 176 Part 147 schools listed on the FAA website. There are 131 schools offering an associate's degree or higher, and are categorized by the FAA as collegiate programs. All Part 147 schools require that instructors have an A&P, or an A or a P certificate, depending on the subject matter taught, but allows a small number of non-certificated faculty under special, approved circumstances. A collegiate institution may have additional requirements for educational level and experience in the field for faculty.

Recent studies of employment trends for aviation maintenance technician (AMT) are forecasting an upcoming global demand for over 500,000 new technicians (Boeing, 2016b; Airbus, 2016), while in contrast, the U.S. Bureau of Labor Statistics (BLS) reports a very slowly growing need for AMTs (BLS, 2015). For collegiate aviation programs, there is a need to produce the required number of airframe and powerplant mechanics, and a need to have the proper number of credentialed faculty to teach these future mechanics. This paper highlights employment trends for AMTs and the connection to Part 147 schools, presents the methodology for studying Part 147 faculty employment trends, and discusses the data collected from collegiate Part 147 schools on current and future faculty employment at 2-year schools.

LITERATURE REVIEW

Research by Boeing and Airbus indicates a projected shortage of AMTs. Boeing forecasts a global need for 679,000 new aircraft technicians between 2016 and 2035, with 118,000 of those technicians needed in North America (Boeing, 2016b). For the same period, Airbus forecasts a global need for 540,000 new maintenance technicians (Airbus, 2016). The BLS predicted a 1% growth of AMT positions in the United States by 2024 (BLS, 2015). Other studies have focused on pilots, but "… often overlooked is the need for an even greater number of maintenance technicians: about 600,000 by 2031, per Boeing's most recent [2014] forecast." (Adams, 2014, pp. 1).

The U.S. Census in 2010 showed a total of 145,905 aircraft and avionics equipment mechanics and technicians in the United States, with an educational background ranging from non-high school graduates to doctoral graduates. The largest portion (83,260 at 57.1% of total number) of mechanics and technicians in the U.S. had some college or an associate degree, while mechanics and technicians with a graduate degree comprise 1.2 % [Masters: 1,370 at 0.9%; Doctoral: 490 at 0.3%] (U.S. Census Bureau, 2010).

The Aviation Institute of Maintenance (2014), a Part 147 school, predicted a AMTs shortage on their blog and the school is attempting to bring this to the attention of prospective students. Embry-Riddle Aeronautical University professor Charles E. Horning

(2015) stated that there is, "Greater competition among industries for graduates" (p. 8), and that "Despite the rising completion rates, a larger share of the existing workforce is retiring, thus the replacement rate is insufficient to meet employment demand" (p. 8).

This reported shortage of AMTs begs the question, who is going to be educating the technicians needed to fulfill these needs forecasted by industry? Considering the anticipated shortage of AMTs, is there an anticipated shortage of faculty as well?

PROBLEM STATEMENT

Collegiate Part 147 programs are in need of faculty that meet both the institutional educational requirements and the FAA Airframe and Powerplant certificate requirements. Filling faculty positions that fit both requirements is becoming difficult because the candidate pool is becoming more limited. Future mechanic shortages are predicted by the industry. However, there has been no research conducted on the demand for faculty. There is a need for quantitative data on demand for Part 147 faculty. Therefore, the aim of this study is to collect data from collegiate Part 147 programs to provide quantitative and qualitative information regarding current faculty positions, current needs for filling faculty positions, and future needs for filling faculty positions.

The Part 147 programs included in this research have been listed on the FAA website of Part 147 programs, offer an associates program (or higher), and offer both the Airframe and the Powerplant programs, or a combined A&P program. The research question is:

What are the educational requirements for aviation faculty for current and future positions at collegiate Part 147 schools?

METHOD OF DATA COLLECTION

DATASET OF SCHOOLS FROM FAA

A total of 176 schools were listed on the FAA website as Part 147 mechanic schools in July 2016 (Federal Aviation Administration, 2016b). This list was first delimited to include only the 131 schools that are registered as collegiate programs that offer an associate's degree or higher. The list was further delimited to those programs that offer a combined Airframe and Powerplant program, or both the Airframe and Powerplant program separately. This delimitation removed seven programs that only offered an Airframe or a Powerplant certification separately, but not both certificates. The final dataset included 124 collegiate Part 147 schools.

To create the list of email contacts for the survey, the University Aviation Association (UAA) collegiate directory (University Aviation Association, 2016) contact information was combined with the FAA list of contact information for the Part 147 schools (Federal Aviation Administration, 2016c). Programs that did not have an email listed on either source were contacted via phone numbers on the FAA list or by retrieving contact information found on the Part 147 programs' websites.

SURVEY

The authors developed a survey to gather the data from the schools. To encourage a high response rate, the survey was short; therefore, the survey was limited to 13 questions and an anticipated response time of less than 15 minutes. The Purdue human subject research procedures were followed, and permission was granted for this study by Purdue Institutional Review Board. The survey was prepared using Qualtrics©, a commercial off the shelf software product of Qualtrics LLC.

Three groups of invitations to participate in the survey were emailed to the 124 schools in the dataset, based on the availability of email information. Group one consisted of 85 email contacts sent on July 14, 2016. Emails that bounced were then added to group two, after calling the school or searching the school's website for the contact email. Group two consisted of 31 email contacts sent on July 18, 2016. A reminder email was sent to groups one and two on August 2, 2016. Bounced emails from group two were added to the third group of emails. Group three consisted of six email contacts and were emailed an invitation to participate in the survey on August 23, 2016. Two emails again bounced in group three. The remaining two schools were unable to be reached via phone or email during the survey period. A total of 122 schools are included in the survey data. Of these 122 schools that were emailed, the data from a total of 40 respondents were collected, resulting in a 32.7 % response rate to the survey. In addition, one respondent had started the survey and exited after answering only one of the demographic questions and did not provide any quantitative data; therefore, that response was excluded from this analysis and not included in the 40 respondents.

DATA RESULTS

The majority of the respondents were from two-year schools (30/40 or 75%), and the remaining respondents were from six four-year schools (6/40 or 15%) and four technical/vocational schools (4/40 or 10%). Of the 40 schools that responded to the survey, the total number of current faculty with A&Ps was 261, with an Airframe-only certification was 2, and with a Powerplant certification was 0. For most faculty from the 40 Part 147 schools, the highest educational level attained was an associate's degree (101/245 or 41%). Twenty-five percent of faculty had attained a bachelor's degree, 25% of faculty had attained a master's degree, and only 1.6% had attained a doctoral degree, each of the four doctorates being from a different respondent. The degrees for the doctorates were PhD, JD, EdD, or Other (no details provided). See Table 1 and Figure 1.

TABLE 1

Number of certifications from the 40 Part 147 schools.

HOW MANY FACULTY IN YOUR PROGRAM HOLD AN FAA:	TOTAL
A&P	261
Airframe only	2
Powerplant only	0

OF A&P FACULTY, WHAT IS THEIR HIGHEST LEVEL OF EDUCATION?

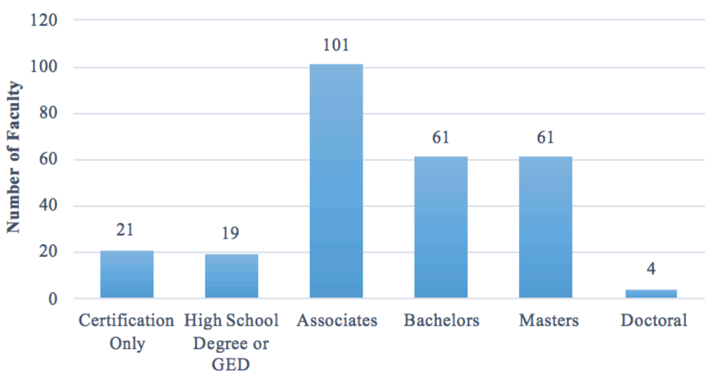

FIGURE 1. A&P FACULTY LEVELS OF EDUCATION FOR ALL 40 PART 147 SCHOOLS

TWO-YEAR COLLEGIATE PROGRAM RESULTS

The respondents were then asked to indicate the level of education requirements for incoming faculty for two time periods: in one to three (1-3) years and in four to ten (4-10) years.

Summaries of the responses are displayed in Figure 2 and 3 for two-year collegiate programs only. According to respondents, the educational requirements for faculty/instructors will increase over the next 4-10 years in 2-year programs, compared to the next 1-3 years.

NUMBER OF SCHOOLS AND LEVEL OF EDUCATION REQUIRED FOR INCOMING FACULTY/INSTRUCTORS IN 1-3 YEARS

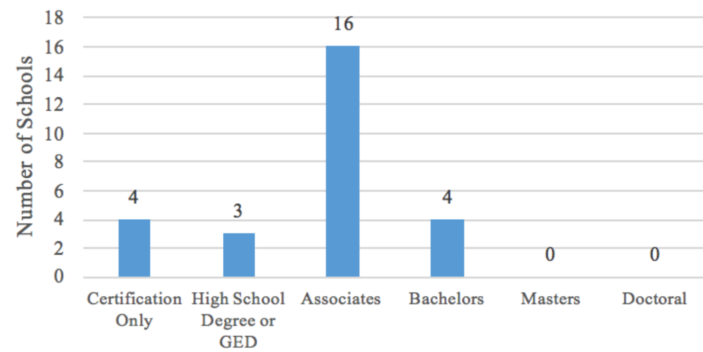

FIGURE 2. NUMBER OF SCHOOLS AND LEVEL OF EDUCATION REQUIRED FOR INCOMING FACULTY/INSTRUCTORS IN 1-3 YEARS

NUMBER OF SCHOOLS AND LEVEL OF EDUCATION REQUIRED FOR INCOMING FACULTY/INSTRUCTORS IN 4-10 YEARS

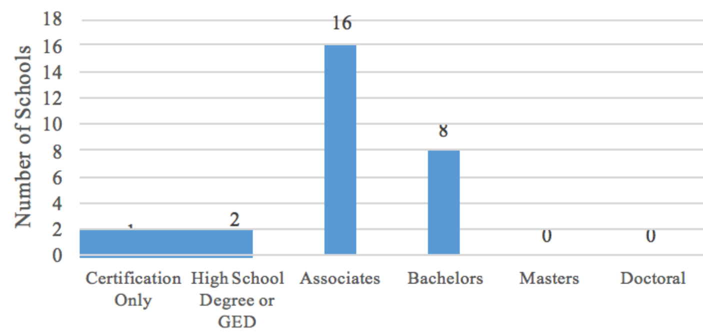

FIGURE 3. NUMBER OF SCHOOLS AND LEVEL OF EDUCATION REQUIRED FOR INCOMING FACULTY/INSTRUCTORS IN 4-10 YEARS

Figure 4 shows the responses from the 30 two-year programs regarding the expected number of Part 147 positions available. There are a total of 67 faculty positions expected to become available in the within the next three years, and another 96 positions within the next four to ten years. More than half of these positions are for faculty with associate's degrees during

these two time periods: 42 within the next three years and 51 within the next four to ten years. Bachelor's degrees are identified for 30 new positions over the next ten years. Master's degrees are identified for 2 new positions over the next ten years. No doctoral degree positions are reported. Therefore, of the 163 new positions identified by these 30 two-year collegiate Part 147 programs, 125 positions require a college degree of associates or higher (125/163 or 77%).

FACULTY NEEDS FOR 2-YEAR PART 147 PROGRAMS

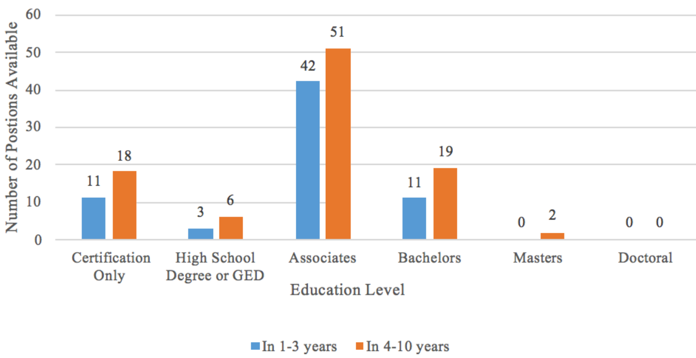

Figure 4. Faculty Needs for 2-year Part 147 Programs

DISCUSSION

The data from this survey shows that the number of new positions for faculty and the educational requirements for these new positions are anticipated to rise over the next ten years. With the reported demand in these survey responses and with a supply of less than 2000 aircraft mechanics with graduate degrees listed in the 2010 US Census, there is support for conducting additional research in this area to better understand the anticipated supply of potential faculty members. Coupling this supply and demand information for faculty with the anticipated shortage of AMTs predicted by industry, there is support for the prediction that Part 147 programs are going to experience a shortage in faculty as well.

At a conference at A4A in Washington DC in November of 2016, representatives of major and regional airlines were presented with some of the findings of this study. The question that arose was whether or not the industry felt that there was a pressing need for instructors in Part 147 schools to have any kind of advanced degrees (B.S., M.S., or PhD.), since the only requirement by the FAA for teaching in a Part 147 program was a Part 65 Mechanic Certificate. After some discussion, the overwhelming consensus emerged that, yes, some form of advanced degree was becoming necessary. The reasons given by the attending members of that group included: the need for A&P schools to be recognized as professional to attract students; that the graduates of these schools needed to be better recognized as professionals; the schools needed faculty and administrators to have advanced degrees in order to survive politically in areas where they had to compete with community colleges, colleges, and universities for funding and recognition by state and local governments; the recognition that the way students were taught and learn was becoming different now than in the past, and the education of these students required some recognized professional education by the instructors; and finally, there was a desire to work nationally to "rebrand" aviation maintained as a highly skilled profession, thus the educators needed to have credentials to support that philosophy (Thom, 2016).

CONCLUSION

To answer the research question, 122 collegiate Part 147 programs were surveyed and asked to respond with the educational attainment of current faculty and the anticipated requirements for future faculty positions. Responses were received from 40 programs, 30 of which were 2-year schools. This survey data showed the increasing importance of college degrees in hiring of faculty for collegiate Part 147 schools. Importantly, for the 30 2-year programs, there were 67 expected faculty job openings in 1-3 years, and 96 expected faculty job openings in the next 4-10 years. Since there were only six 4-year schools that responded, there was not enough data to draw sound conclusions. This survey contributed information to the Part 147 education community. No other studies addressing the educational requirements and number of faculty positions were found.

FUTURE RESEARCH

In the future studies, additional market information is needed to better understand the supply of faculty that meet the needs of collegiate programs. The study may be expanded to include the non-collegiate and 4-year programs, as the demand for faculty is not known for these programs. Including questions about the amount of applicable experience required, or preferred, for new faculty hires is a suggestion by several respondents. This paper reports the quantitative survey responses. Future papers need to address the 76 written responses collected from survey participants. These responses may be very helpful in creating more research questions for further research.

Thank you to all of the respondents for their quick responses!

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APPLICATION OF STATICS USING AVIATION RELATED LABORATORY CASE STUDIES

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ABSTRACT

Aeronautical engineering technology and airframe and powerplant (A&P) students have a unique blend of both theoretical and hands-on skills. A highly theoretical course such as statics has been viewed as a difficult course to relate to these students. In an effort to teach a successful statics course, the class was redesigned to have real word examples and case studies drive the lab projects which in turn drive the lecture topics. These case studies included analysis of a Cessna 150 wing and strut, Piper Arapaho engine mount, and Cessna 310 wing. These focused projects allowed students to have a greater knowledge of statics and its application within aviation.

INTRODUCTION

Statics has been a difficult subject to teach aeronautical engineering students as these students tend to have a more hands on approach than a theoretical one. In an effort to teach an applied physics concept like statics, real world aviation projects were used. These projects were used to teach fundamental parts of statics such as force application, Von Mises forces, translations displacement, and resultant forces. The projects were simplified analyses of aircraft and aircraft components found in a hangar located near the classroom. During pre and post laboratory visits to these aircraft, students learned how various areas of the components were affected by thrust, torque, self-weight, gravity, and internal forces.

Airframe and Powerplant (A&P) mechanics use statics every day when working on aircraft. While many may not realize it, mechanics apply principles of static very often. As an A&P, one of the main jobs is to conduct various inspections on aircraft systems or sub-systems.

During these inspections, the mechanic is looking at the points on the aircraft that are under the most stress. The way a mechanic determines these points is by the use of statics. While some points may be obvious as to where the stresses are occurring, others may be surprising. By using statics that engineers and maintenance instruction writers can tell where the mechanics should be focusing their time during the inspection. However, one other very important job that A&Ps conduct on a regular basis is aircraft repairs. When doing a repair, the mechanic would need to know the strength of the materials to be used, how the forces would transfer through the new repair and how the repair would act in flight. These are all things that statics and finite element analysis can show. Without calculating the stresses on the patch, the patch could fail in flight if the right stresses are encountered which could be catastrophic.

The reason this is important for the aeronautical engineering technology students is that most of the students will have careers writing maintenance instructions or repair instructions, managing a maintenance team or designing aircraft. Without a background in statics, the students would never be able to get these positions. Since all of these positions would require the employee to design repairs or be able to tell mechanics were he or she should focus their attention in the inspection, a background in statics is essential along with a background on how to related statics to real world applications.

LITERATURE REVIEW

Engineering and technology students need to often encounter courses which tend to be contain more theory rather than practical applications (Tullis & Tullis, 2001). While sufficient professional experience on the part of the professor is necessary to help the students bridge the theory with real world applications, the teaching methodology plays part in balancing the contents between theory and real-world engineering applications (Tullis & Tullis, 2001). Professional engineers utilize both development and research laboratories for many purposes including designing and developing new products, evaluate new designs and/or products, and adding new knowledge of products (Feisel & Rosa, 2005).

On the other hand, engineering students attend instructions or education laboratories for the purposes of learn about theories and applications that is already existing (Feisel & Rosa, 2005). Physical laboratory is an applicable tool to help the students to start asking themselves questions about the real world problems and analyzing such scenarios (Lanza, 1984). Although the laboratory problems may not be in the same scale as the problems encountered in the industry, they provide students with introduction of real world examples in their specific majors and help them to understand the concepts in subsequent courses (Lanza, 1984). Other types of laboratories have evolved such as investigative laboratories in which the students are left to choose their problem which they will investigate based on the information provided in the lecture (Sundberg & Moncada, 1994).

Project-based learning is also commended because it helps the students to understand the basic concepts by spurring them toward deep learning, and developing critical thinking and creativity (Mahendran, 1995). While teaching theory is essential for engineering and technology students, theory alone can lead to difficulties in student understanding the fundamental concepts and willingness in students to continue in both engineering and technology majors (Mahendran, 1995). Establishing realistic problems which represent real world situations have been observed to motivate the students because they not only interest the students but also assist in developing creativity and critical thinking of the problem (Mahendran, 1995). By introducing students to real world case studies while teaching fundamental concepts in classroom is essential as it aims to improve student comprehension of the concepts, and critical thinking ability (Mahendran, 1995; Wheway, 1991). It is therefore essential that teaching of the lab projects deviate from the traditional 'cookbook' to help the students develop more participation and conceptual understanding of the concepts taught during the lecture sessions (Burrowes & Nazario, 2008).

Kishore, Arpitha, & Pradeep (2016) conducted an exploratory study among engineering instructors to understand the challenges of inductive teaching in engineering colleges in contrast to deductive teaching. The results of their study suggested that most respondents mentioned that case studies and real world examples were most effective when it came to teaching engineering classes as they helped students to comprehend the topics better (Kishore, Arpitha, & Pradeep, 2016).

In addition, teaching challenges are encountered when it comes to teaching a class with both lecture and laboratory sessions such as text and lab books being separately produced, time limitations, and other technological issues (Burrowes & Nazario, 2008). A traditional laboratory for science, engineering, and technology is referred to when the instructor explains the topic to the students, and monitors the students' development (Dinan, 2005). Training the students to develop skills that may not be found in textbook will help them gaining the experience which is needed during their career life (Hanson & Brophy, 2012). Necessary skills such as observing a phenomenon through scrutiny or evaluating computerized analyses and design instead of heavily depending on outright results may are essential to students (Hanson & Brophy, 2012).

COURSE BACKGROUND

The course consisted of twice weekly 50 minute lectures and once weekly 1 hour and 50 minute lab. In lab, computer aid design (CAD) software called CATIA was used to draw and model aircraft parts. Within CATIA, finite element analysis (FEA), was used to model forces on the parts that were drawn. Some of the labs required the students to draw their own parts based on engineering drawings provided as part of the course or to apply forces on parts that were already modeled by course instructors. After forces were applied in CATIA and FEA applied, a report was generated showing the results of the forces on the modeled part.

Students were provided the model file and were to add forces on the engine mount that would be similar to what the engine mount experiences in flight - gravity, engine thrust, and drag. Students in the lab were required to turn in this report and to answer questions based on the results generated.

Within CATIA, when using FEA, different colors are used to differentiate areas of stress or translations displacement. Areas showing red have the maximum amount of stress or displacement while areas in blue have the least. These colors are relative only to the unique analysis done and cannot be directly related to another analysis. A numerical analysis must conducted.

In an effort to engage students in learning statics and how it relates to real-world aviation applications, the course was redesigned around three separate laboratory projects. These projects were based upon aircraft found in the hangar located next to the classrooms and within the same building. The projects drove weekly laboratory work which in turn drove lecture topics. The projects were designed to allow students to study a component on an aircraft in a hangar and then analysis real world forces on the object. The major projects were analysis of: Cessna 150 wing strut, Piper-PA-40 Arapaho engine mount, and Cessna 310 left wing.

The progression of the lab assignments was such that the students would learn the relatively simple concepts of finite elements analysis at the beginning of the semester and continue to harder concepts as the courses progressed along. In the beginning of the semester, the students practiced designing simple parts as instructed in the lab text book and analyzed those parts using the knowledge of static using the Advanced Meshing Analysis and Generative Structural Analysis workbenches of CATIA. After completing the initial lab sessions and assignments, the students were assigned the Cessna 150 wing and strut project. This project was designed to help them to not only familiarize themselves with the concepts of the courses using aviation-related parts but also become more familiar with the aviation components. The lab assignments also required students to apply the fundamental knowledge of CATIA they had obtained from prior courses.

During the midst of the semester, the students were introduced to the second aviation related project in which they had to be able to analyze forces with variety directions of actions acting on a body. To help them understand the concept of resolving forces acting on a body, the Piper PA-40 project was introduced in which the students had to analyze the engine mount of the aircraft under different scenarios. The CATIA file for the engine mount was modeled and provided to the students. The students only had to edit the modeled part by applying and defining the right materials for the part. The engine mount was analyzed to simulate how it is affected by both the engine thrust and weight. The students analyzed the engine mount for the Piper PA-40 under three main scenarios: at stationary, under stationary but the thrust is at 100%, and when stationary but the thrust is set at idle. After analyzing the results, the students were to interpret and describe their results.

During the second half of the semester, the students were learning the relatively more difficult techniques of Finite Element Analysis using CATIA software such as using shell element, beam element, and analyzing hybrid models (models with solid, shell, and beam elements all together). After practicing assignments from the course textbook for several weeks, the Cessna 310 wing assembly project was assigned for the students to analyze the forces acting on the wing assembly. The assembly consisted of the main wing, engine, fuselage attachment, auxiliary tank, and the tip tank. The students had to understand how to manipulate different parts of an assembly design, apply the right types of connection among parts, apply the right loads on the right parts. In this project, the students explored several scenarios among which the weights varied depending on the amounts of fuels available in each of the two tanks. The level of thrust was also varied.

These aviation-related projects helped the students to familiarize themselves with the concepts of the course by relating the applications to aircraft components. Additionally, these projects were designed to serve as motivational factor for the students who will be working with aircraft components during their careers. Instead of students to follow cookbook procedures in the textbook assigned for the course, it was easier for the students to critically think and analyze their results of the projects and develop questions to the instructors because they somewhat expected what the outcomes of the results should have been. Therefore, the projects enforced the students to understand the finite element analysis concepts better.

As part of these projects, the students had to look up for information which they would need to analyze the problems in the projects. Students were given general information on the aircraft whose components they were to analyze. The students had to search for and identify other necessary information such as engine type, fuel tank size and limitations, maximum aircraft weights, to name a few. This information would help to calculate for the forces which they would use to simulate their analyses in CATIA software. Therefore, as part of the projects, the students learned how to look up for information with the help of Aircraft Type Certificate Data Sheet (TCDS), a skill which they would need for their A&P exams.

CLASSROOM PROJECTS

PIPER 40A ENGINE MOUNT ANALYSIS

Due: at the beginning of the Lab session.

Description: You have been asked by the Piper Aircraft Corporation to conduct a statics analysis of their Piper PA-40 engine mount. The company has provided you with a CATIA Part file (provided through your Blackboard account) of the engine mount which also includes the engine, and the fire wall. You will assume that the engine mount is wholly made up of steel with a Young Modulus of 3x107 psi and a Poisson Ratio of 0.3. (Only consider the weight of the engine and ignore the weights of the mounts and firewall)

The company has requested that you conduct a statics analysis for three (3) different scenarios which simulate when the engine is at static full throttle, static idle throttle, and no throttle at all. The values of the engine thrust for these three scenarios are provided on Table 1.

Table 1: Three Scenarios to be analyzed

For each of the scenario's analysis, you are requested to use linear element type with size of 1.3 inches and sag of .1

SCENARIO	STAGE	THRUST (SHP)	STATIC THRUST (LBS.)
Scenario 1	Full Throttle	160	530
Scenario 2	Idle Throttle	16	53
Scenario 3	Zero Throttle	0	0
Note: shp – shaft horse power; lbs. – pounds			

inches.

It is also recommended that you review the respective Type Certificate Data Sheets (TCDS) for both the aircraft and the engine for a both precise and accurate analysis.

Deliverables: You will be expected to submit the following files as your final analysis in your blackboard account no later than the due time indicated above.

i. Scenario 1 (Full Throttle) – Part file, Analysis file, Report PDF

ii. Scenario 2 (Idle Throttle) – Part file, Analysis file, Report PDF

iii. Scenario 3 (Zero Throttle) – Part file, Analysis file, Report PDF

Figure 1. Piper-PA-40 Arapaho engine mount

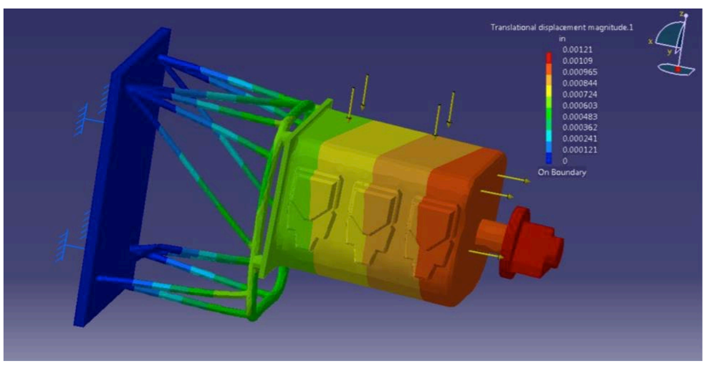

Figure 2. Full Throttle Translational Displacement

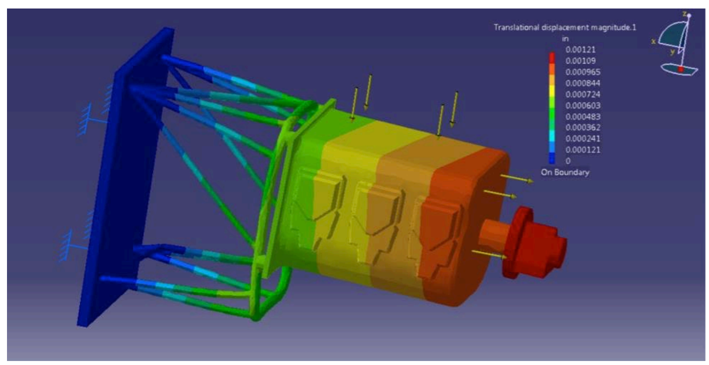

Figure 4. Full Throttle Von Mises Stress

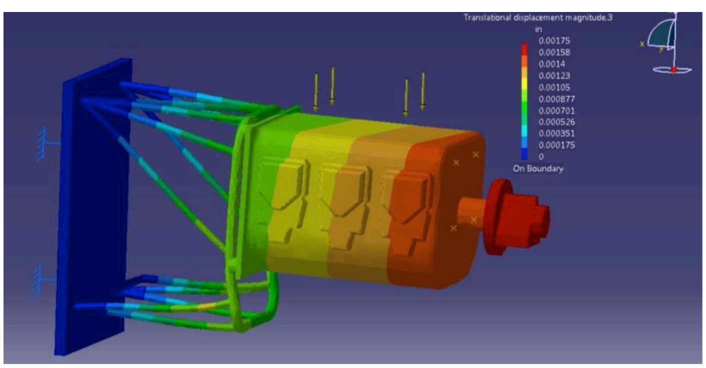

Figure 3. Zero Throttle Translational Displacement

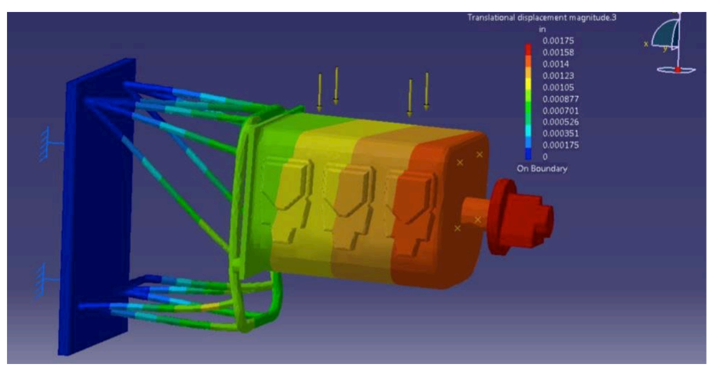

Figure 5. Zero Throttle Von Mises Stress

CESSNA 150 WING STRUT ANALYSIS

Due: at the beginning of the Lab Session

Description: Cessna 150 Wing Strut Analysis
The Cessna Company is initiating a project to reinvent the 1965 Cessna 150 as part of building a next-generation training aircraft. As part of the project, the company has selected you to be one of the engineers to analyze the wing strut of the current Cessna 150 for statics based on several scenarios detailed below.

The weight of the wing is estimated to be about 150 pounds. For consistency and comparison with other engineers across the board, the Cessna Company has provided you with a CATIA file of the wing part (check your blackboard account for more details). The designed part incorporates the wing itself and the strut. You will assume that the wing and the strut are wholly made up of aluminum with a Young Modulus of 1.02x107 psi and Poisson ratio of 0.35. (Only consider the weight of the wing and ignore the weight of the strut).

You are requested to conduct a statics analysis of the wing's strut for the following three (3) scenarios:

i. When the aircraft is stationery on the ground

ii. When the aircraft is on a level flight (i.e. angle of attack is zero (0) degrees) with a weight of 1200 lbs.

iii. When the aircraft is on a level flight (i.e. angle of attack is zero (0) degrees) with its maximum weight.

For each of the scenario's analysis, you are requested to use linear element type with size of 1.0 inches and sag of 0.1 inches.

You are encouraged to utilize the respective Type Certificate Data Sheet (TCDS) for this aircraft type for both precise and accurate analyses (Notice that another variance of Cessna 150 is the one manufactured in France with the name F150).

Deliverables: For each of the scenarios explained above, make sure to submit the following files as your final analysis in your blackboard account no later than the due time indicated above.

a) CATIA Part file

b) CATIA Analysis file

c) Report PDF generated from your CATIA analysis file.

Figure 6. Cessna 150 aircraft located in a hangar

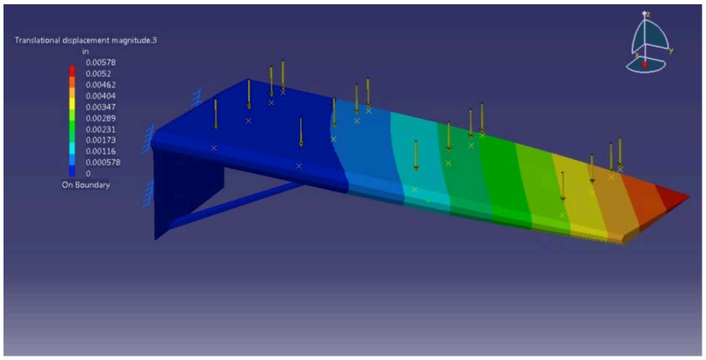

FIGURE 7. DISPLACEMENT WHEN THE AIRCRAFT IS STATIONERY ON THE GROUND

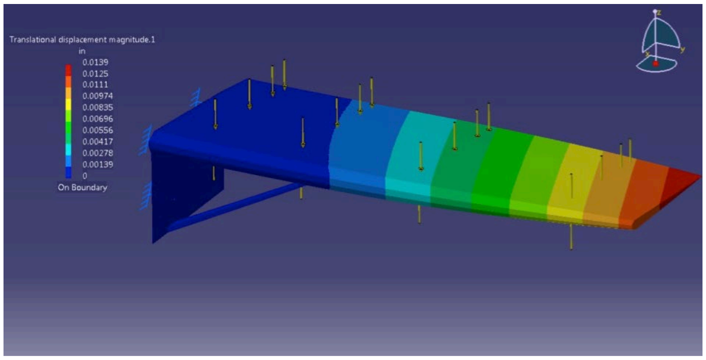

FIGURE 8. DISPLACEMENT WHEN THE AIRCRAFT AT LEVEL FLIGHT WITH A WEIGHT OF 1200 LBS

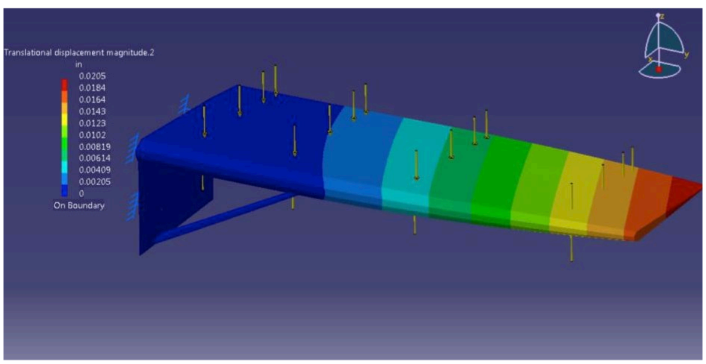

FIGURE 9. DISPLACEMENT WHEN THE AIRCRAFT AT LEVEL FLIGHT WITH A WEIGHT OF 1600 LBS

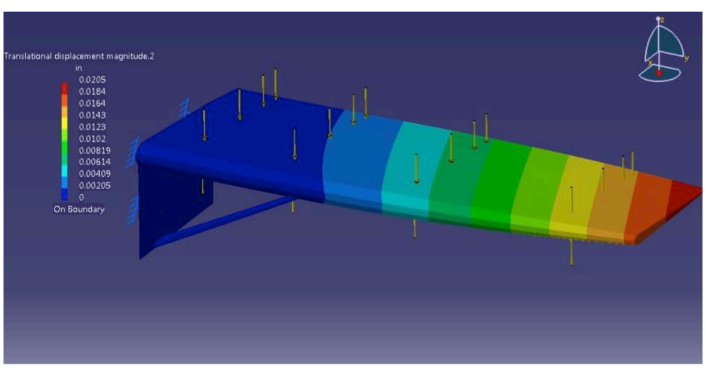

FIGURE 10. VON MISES STRESS WHEN THE AIRCRAFT IS STATIONERY ON THE GROUND

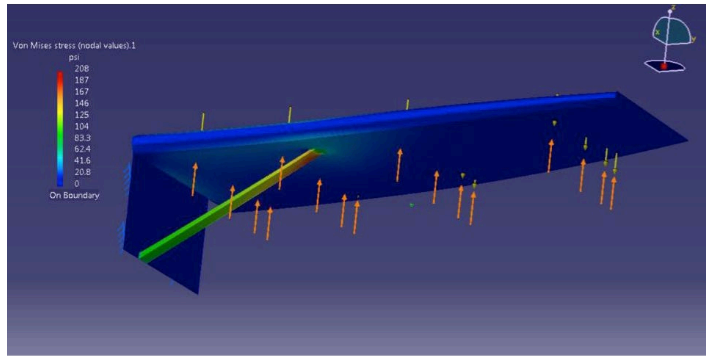

FIGURE 11. VON MISES STRESS WHEN THE AIRCRAFT AT LEVEL FLIGHT WITH A WEIGHT OF 1200 LBS

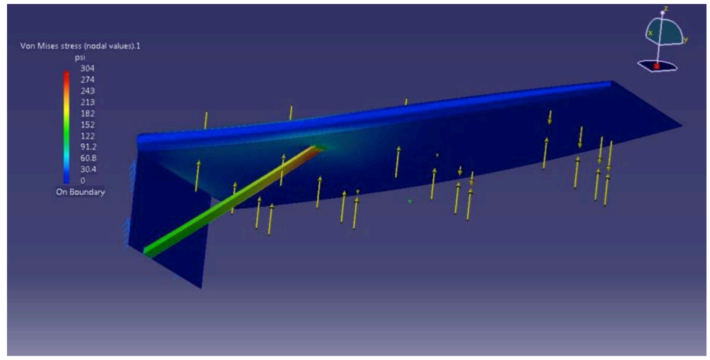

FIGURE 12. VON MISES STRESS WHEN THE AIRCRAFT AT LEVEL FLIGHT WITH A WEIGHT OF 1200 LBS

CESSNA 310 WING & ENGINE ANALYSIS

Due: at the beginning of the Lab Session

Description: The National Transportation Safety Board (NTSB) has asked you to join a team of external contractors to conduct an investigation of an accident involving a Cessna 310R with serial number 310R0835. Your responsibility in the team will be to evaluate different scenarios based on the weight and state of aircraft operations, and your knowledge of statics.

The weight of the wing is estimated to be 400 pounds. For consistency and comparison with other engineers across the board, the NTSB has provided you with a CATIA file detailing the wing, part of the fuselage, and the engine (check your blackboard account for more details).
You are expected to conduct some research to become more familiar with the aircraft type before starting conducting the analysis. You will assume that the wing, fuselage, and the engine are wholly made up of steel with a Young Modulus of Young Modulus of 3.0x107 psi and Poisson ratio of 0.3.

You are requested to conduct a statics analysis of the aircraft for the following scenarios:

SCENARIO	ENGINE THRUST (%)	TIP TANK	AUXILIARY TANK
1	0	Full	Full
2	0	Empty	Empty
3	0	Full	Empty
4	65%	Full	Full
5	65%	Full	Empty
6	100%	Full	Empty
7	100%	Full	Full

For scenarios 4 to 7, the aircraft is flying at a straight level flight with the wing generating a lift of 80,000 slugs.

The engine is estimated to generate about 600 lbs of thrust at full throttle.

You are asked to account for the amount of unusable fuel for each of the scenarios. Also, you are requested to use linear element type with size of 5.0 inches and sag of 1.0 inches for the assembly.

Deliverables: For each of the scenarios explained above, make sure to submit the following files as your final analysis in your blackboard account no later than the due time indicated above.

a) CATIA Part file

b) CATIA Analysis file

c) Report PDF generated from your CATIA analysis file.

Figure 13. Cessna 310 located in a hangar

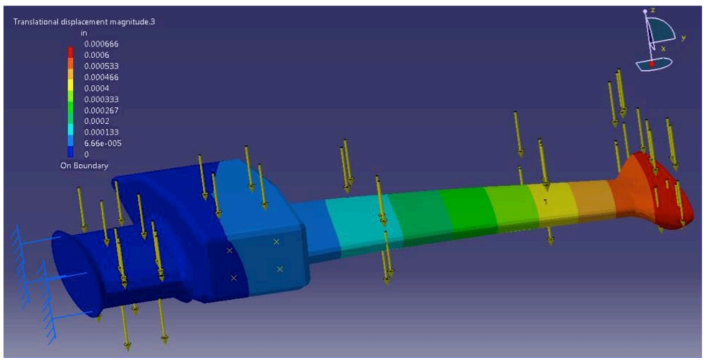

Figure 14. Displacement when thrust is 0, tip tanks are full, auxiliary tanks are full

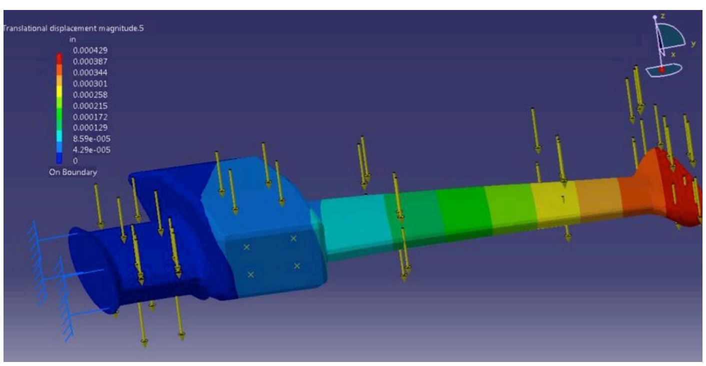

Figure 15. Displacement when thrust is 0, tip tanks are empty, auxiliary tanks are empty

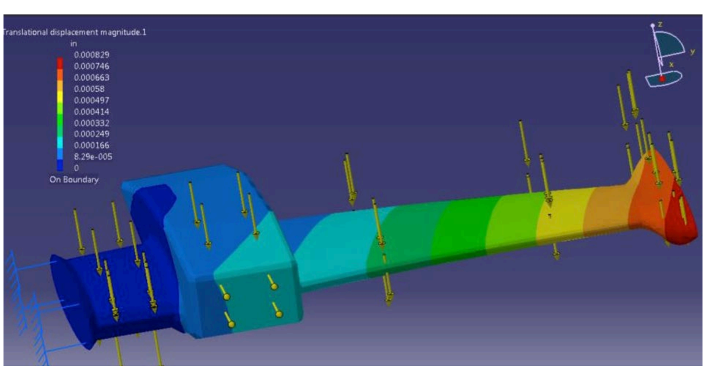

Figure 16. Displacement when thrust is 100%, tip tanks are full, auxiliary tanks are full

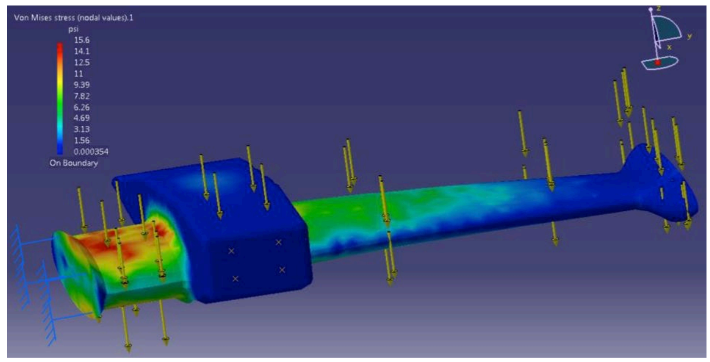

Figure 17. Von Mises Stress when thrust is 0, tip tanks are full, auxiliary tanks are full

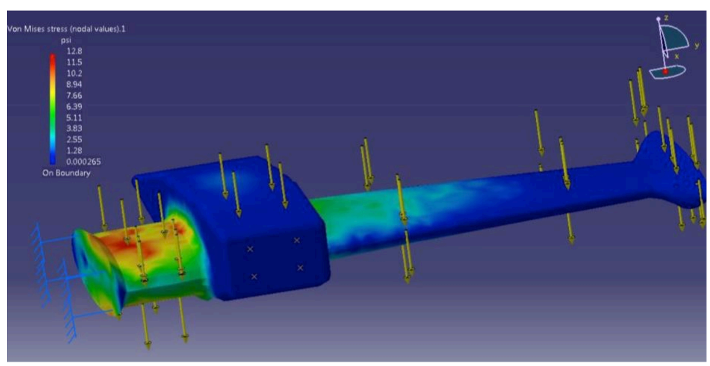

Figure 18. Von Mises Stress when thrust is 0, tip tanks are empty, auxiliary tanks are empty

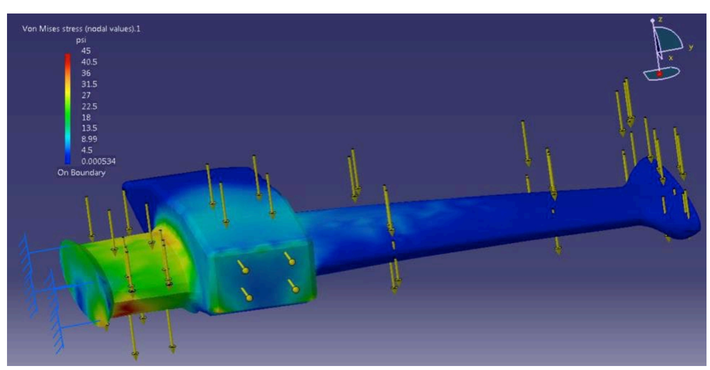

Figure 19. Von Mises Stress when thrust is 100%, tip tanks are full, auxiliary tanks are full

When an FEA analysis is conducted on an engine mount, areas of yellow, orange, and red have the highest levels of stress and displacement. These areas should be subject to additional visual inspect or extra care could be taken during assembly as these are critical areas. Having the students study what an actual aircraft may encounter helps them visualize what an aircraft goes through in all stages of flight. Since many aeronautical engineering technology students go into maintenance or manufacturing management it would them have a better understanding of how aircraft should be maintained. Since most engine mounts and wings would have similar stress points, it would help the student be able to manage where the technicians are focusing their efforts in the inspections. Also in the aspect of design, having the background in FEA would help the students think about how are the stresses handled or if the part would fail immediately.

CONCLUSION

Knowledge of statics and FEA is an essential part of an aeronautical engineering technology and A&P student's studies. However, statics being theoretical and heavily math based has been a difficult to teach to these students. In an effort to teach the subject more effectively, the course was redesigned around several real world projects based upon aircraft located adjacent to the classroom. These project along with pre and post laboratory visits allowed students to visualize internal forces on various aircraft components. These parts are identical to parts which students will inspect, document, design, or repair after graduation.

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MAINTENANCE AND REPAIR OF SMALL UNMANNED AERIAL SYSTEMS

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ABSTRACT

With the official introduction of unmanned aircraft into the national airspace system (NAS) in the form of Federal Aviation Administration (FAA) CFR14-FAR107, there has been an increased need for training in the areas that support unmanned operations. One such area is the maintenance and repair of those systems. This paper seeks to examine select differences, and similarities in the service and repair of manned vs. unmanned aircraft and suggest strategies for effective maintenance and repair of unmanned types.

INTRODUCTION

Unmanned aircraft structures and control systems share commonalities from classic model aviation through the largest and most complex space vehicles. One of the unique aspects of small unmanned aircraft is that they are free of regulation regarding construction and repair of systems and structures. This freedom allows choosing the material or system, and its corresponding repair, which best suits the mission of the aircraft. The smaller the UAS, the more it resembles a model aircraft and the larger platforms more closely resemble manned aircraft, however there are exceptions to this comparison. The service and repair of unmanned systems will span the entire spectrum of aeronautical vehicles and may even include elements of ground or water based machines.

STRUCTURES

The materials utilized in an unmanned aircraft typically include carbon fiber, fiberglass, aluminum, foam, wood, and thermoplastics of various types. There are commonalities to the repair of each material type. These commonalities include performing repairs in a manner that aerodynamic and weight characteristics of the repair do not adversely affect the vehicle. Repairs that spread the stresses of operation over the structure smoothly, as to not create weak points and stress concentrations are also used just as in manned aircraft. Wood scarf joints and composite laminate slope sanding are examples of this type of repair strategy borrowed from typical manned aircraft techniques.

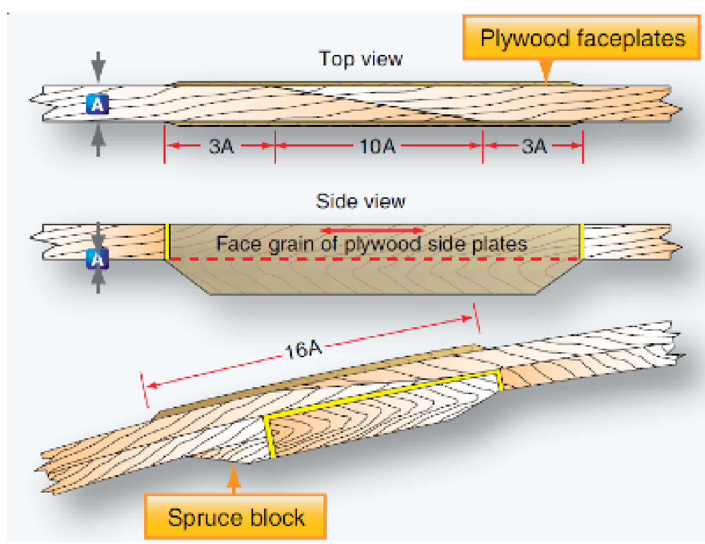

Fig.1 Wood capstrip repair, FAA, AMT Airframe Handbook H-8083-31

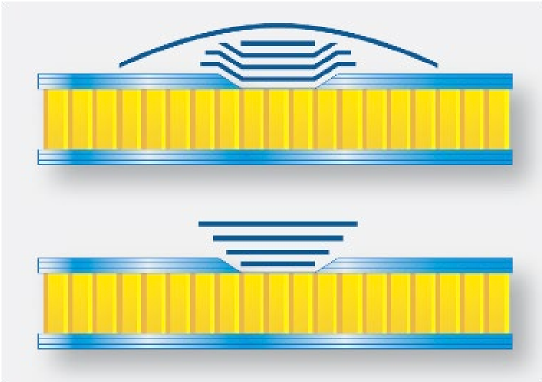

Fig. 2 Composite repair with slope sanded profile, FAA, AMT Airframe Handbook H-8083-31

Manned aircraft virtually never use carbon fiber tubing as primary structural parts; however small unmanned aircraft utilize them extensively. The following repairs may be used when the component is either unavailable new, or the repair must be completed in a time sensitive situation. The repair does add weight to the structure and this must be considered when evaluating this technique. The method of inserting slugs within the tube, or sleeves on the outside of the tube borrows from the manned experimental aircraft industry including techniques used in repairing welded steel tube structures. A wood dowel (slug) is shaped, inserted, and bonded within the tube to span beyond the fractured area on each end. This reinforces the tube with no aerodynamic penalty. Alternatively, a sleeve can be cut from a length of carbon fiber tubing where the inside diameter matches the outside diameter of the damaged tube. The sleeve is attached with epoxy adhesive to secure and reinforce the damaged tube after careful roughening and cleaning. This technique has limitations if clamps and other braces must be mounted to the repaired tube as the increased outside diameter may interfere with the installation.

Fig. 3 Wood dowel inserted and bonded within damaged carbon fiber tube (Leasure)

Foam structures in unmanned aircraft are often partially or fully load bearing. This requires that repairs be made that restore the original strength and not just the shape. It is often more practical to replace an entire structure, such as a wing or tail than it is to effect a suitable repair. Non load bearing foam structures are repaired by inserting filler blocks of the same foam material and blending them to the original contour. If the structure is load bearing but is not required to flex in use, the broken foam pieces may be bonded back together to reestablish the original shape. Filler that is compatible with the foam may then be used to smooth the repair or the surface may be recovered with a plastic covering patch or even self-adhesive plastic packaging tape in the case of very small unmanned aerial vehicles (sUAV).

Aluminum repair follows the recommendations of FAA AC 43.13 for manned aircraft, however unmanned aircraft use epoxy bonding of load bearing aluminum structures more commonly. Fasteners such as rivets and bolts follow conventional manned aircraft techniques. As examples, blind rivet application, torque application, self-locking nuts, and use of thread locking compounds are all applicable to unmanned aircraft as well.

BATTERIES

The batteries used in unmanned aircraft are primarily of the lithium polymer (LiPo) type. This battery type is a practical compromise between weight, power delivery, and cost. The major drawback of LiPo batteries is their propensity for burning or exploding if mishandled. They must be properly charged, discharged, and handled to minimize the risk. Chargers that are specifically designed for LiPo batteries are used. The main feature of the modern LiPo charger that sets it apart from other types of chargers is the inclusion of a balancing port. This port is used to connect the balancing lead of the battery to the charger. While the primary charge of the battery is occurring at approximately 1X the rated capacity, the balancing port is equalizing the charge across each individual cell of the pack. This prevents under or over charging of individual cells which would shorten the life of the pack.

A LiPo battery pack is considered no longer serviceable when a discharge test shows that it has lost 20% of its rated capacity. If the pack has an unusual odor indicat-

FIG. 4 LITHIUM POLYMER CHARGER WITH BALANCING PORT CAPABILITY, (HYPERION MEDIA)

ing cell leakage, or the pack is puffed up, it is considered unusable and possibly unsafe for further use.

FLIGHT CONTROL AND ELECTRONICS

The repair and maintenance of flight controls and electronics is primarily in maintaining integrity of wires, soldered connections, and connectors. The flight controllers themselves (autopilots) are self-diagnosing in many cases and will indicate deficiencies when connected to their display and programming interface (ground station). This is usually via a USB cord or wireless telemetry connection to a notebook or laptop computer. When a deficiency is displayed, it is a straightforward process to research the possible causes of the indication and take measures to correct it. Wires are commonly chafed or damaged and if the strands are not broken it is acceptable to reapply the insulation by liquid tape, heat shrink tubing, or as a temporary fix vinyl electrical tape. If strands of the wire are broken or a connector contact appears worn, corroded, or damaged, replacement of the component is recommended. Solder connections should be inspected for corrosion, fatigue, and integrity. Many UAV crashes can be prevented by simply preflight inspecting all of the solder connections. Anti-chafe measures should be used in unmanned installations just as they are in manned.

ADVANCED COMPONENT REPAIR AND FABRICATION

When a repair part is needed and not available from the original manufacturer, an improved part is desired, or a repair needs to be completed quickly, it is often advantageous to fabricate the part using rapid production methods. 3D printing has become common in the UAS industry and is a method of producing repair or replacement parts quickly. The parts are going to be limited to those that can utilize the properties of thermoplastic (heat softened) plastics and these strength and heat resistance characteristics must be considered when proposing a 3D print part replacement. Another method of producing parts rapidly is the use of a computer numerical control (CNC) laser cutter. This machine can accurately and quickly cut parts that would normally require a type of conventional jig, or band saw. The bed of the laser cutter or printer must be able to accommodate the size of the part being produced and is often the limiting factor when considering these methods. The power of the laser must also be varied based on material composition and thickness. Wood, composites, and plastics may be conveniently cut with lasers.

ADHESIVES

The adhesive to select when bonding unmanned aircraft components is dictated by the material. Wood may be bonded with approved manned aircraft structural adhesives such as resorcinol, however the epoxy resins and even common aliphatic resins designed for wood bonding may be used. Aluminum structural bonding is best performed with epoxy resins after careful cleaning and lightly roughening the surfaces. An aluminum reinforcing plate or doubler is commonly used to achieve a large bonding area while reinforcing the damage. Composite structures use epoxy resin during manufacture and therefore are best repaired with compatible epoxy. Foam load bearing structures may be repaired with epoxy or an adhesive sold under the brand name Goop. Caution must be exercised as some adhesives will attack various foams and it is best to test the adhesive in question on a piece of scrap material first. Cyanoacrylate (super glue) is often used to bond wood, plastics, and metal but is a brittle adhesive and not compatible with many plastics. The nearly instant bonding characteristics make it an attractive glue for rapid field repairs. When considering a repair strategy and adhesives, it is best to research the material and adhesive manufacturer's recommendations, if available.

SUMMARY

The maintenance and repair of unmanned aircraft follow many of the conventions of the manned aircraft industry.

Unfortunately, many small unmanned systems in operation have little or no service support beyond factory replacement parts when repairs could just as easily, and safely be performed to prolong the useful life of the original components. Unmanned pilots and technicians may also be unaware of the vast service industry established for manned aircraft and the techniques employed in that industry. It is the authors hope that a bridge can be established where service related skills and knowledge can be offered to better support manned aircraft personnel transitioning to unmanned and vice versa.

FIGURE REFERENCES:

FAA Handbook H-8083-31, Chapter 06, Aircraft Wood and Structural Repair, figure 6-15, retrieved from:

https://www.faa.gov/regulations_policies/handbooks_manuals/aircraft/amt_airframe_handbook/

FAA Handbook H-8083-31, Chapter 07, Advanced Composite Materials, figure 7-47, retrieved from:

https://www.faa.gov/regulations_policies/handbooks_manuals/aircraft/amt_airframe_handbook/

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ADDITIONAL RESOURCES:

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FAA AC43-13 1A, (1988) Aircraft inspection, repair, and alteration. Acceptable methods, techniques, and practices. An advisory document for the repair, maintenance, and alteration of manned aircraft

BIOGRAPHY

Michael Leasure teaches at Purdue University at the level of Associate Professor in the School of Aviation and Transportation Technology. His unmanned interest, and activities, span over 4 decades including the design, test, and publication of multiple unique model aircraft designs beginning in 1984. His federal licenses include FAA airframe and powerplant, Inspection Authorization, remote pilot, and private pilot. His professional unmanned activities began in earnest in 2002 with the construction and flight test of a precision agricultural UAV with autopilot and dual camera installation. The aircraft spanned 10 feet and was flown successfully for over 12 years. Subsequently, he has flown and tested multiple unmanned systems including rotorcraft, as well as fixed wing designs. Current efforts involve the development, and delivery of unmanned aircraft instruction at Purdue. He has published a textbook on the subject: Leasure, M.L. (2016). Unmanned Aerial Systems: The Definitive Guide. Tabernash, CO. Aircraft Technical Book Company. This is a comprehensive textbook of unmanned aircraft science that is utilized throughout the major plan of study in unmanned systems. He is also the acting Director of unmanned aerial operations for the Beck agronomy center at Purdue.

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