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Limitations of Helicopter Training within 14 CFR Part 147

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According to the 2018 Federal Aviation Administration (FAA) aircraft registration database, 10,600 of the 211,800 general aviation aircraft are helicopters. While making up only 5% of aircraft, helicopters are found in niche markets that are highly specialized such as aerial tourism, news reporting, rescue operations, and medical transport. In order to maintain airworthiness, these aircraft are inspected and maintained by Airframe and Powerplant (A&P) mechanics. Due to an increasing number of retirements, there is a need to train new mechanics. In order to earn an A&P certificate, a student must undergo 1,900 hour of training. The current curriculum used to train prospective mechanics is monitored and regulated by the Federal Aviation Administration under 14 CFR Part 147, Aviation Maintenance Technician Schools. However, within Part 147, helicopter training is only taught at a Level 1 which requires only lecture instruction with no hands-on requirements. Furthermore, of the 1,900 hours of training required, only one hour is required for helicopter specific training. This lack of training creates a possible gap in knowledge. When the maintenance on helicopters is performed to subpar levels there are catastrophic results. To demonstrate this, case studies of three specific accidents were used. All three accidents were caused by improper helicopter maintenance and resulted in fatalities. Major helicopter companies have attempted to mitigate this gap by creating additional training for A&P technicians after graduation from a Part 147 school. However, this additional training is costly and requires more time investment from students before they can enter the workforce.

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In total, there are 211,800 general aviation aircraft registered with the FAA. That number can be broken down into 166,200 fixed-wing aircraft, 35,000 experimental/light aircraft (both fixed-wing and helicopters), and 10,600 helicopters (FAA, 2018a). Helicopters occupy an important part of the airspace, assisting in tasks that are often unreachable by other modes of transportation. There are many uses for helicopters in the military, however, general aviation is defined as all civilian flying except scheduled passenger airline service, so only type-certificated civilian helicopters will be considered in the data (Aircraft Owners and Pilots Association [AOPA], n.d.). Ultra-light helicopters are not included in the helicopter data since they have different requirements for airworthiness certification standards, primarily due to their small weight (14 CFR 103).

As helicopters continue to grow in popularity and necessity, it is important that the aviation industry is prepared for the growth to ensure that aviation continues to be as safe as possible. When examining safety factors surrounding helicopters, it can be seen that there is currently a hole in technician training that can greatly impact the aviation industry. With the proper action, it can be resolved through the training of aspiring technicians. There are currently solutions to this issue that helicopter stakeholders are trying to address, however, a more permanent, standardized solution is required. Without such a solution, there is the potential of more tragic events.

In the civilian helicopter sector of the U.S., Robinson and Bell account for approximately 50% of the helicopters currently registered with the FAA. Airbus Helicopter, Enstrom, Sikorsky, and McDonnell Douglas account for another 30%. The remaining 20% are comprised of a number of smaller companies and are grouped together in the “other” category in Table 1.

Table 1.

Major Helicopter Manufacturers in the United States

Manufacturer	Number Registered With the FAA	Percentage of Helicopter Fleet
Robinson	2,749	25.93%
Bell	2,491	23.5%
Airbus Helicopter	1,440	13.58%
McDonnell Douglas	833	7.86%
Sikorsky	498	4.7%
Enstrom	348	3.3%
Other	2,241	21.14%
Total	**~10,600**	**100%**
Helicopter percentage in relation to general aviation		**5.0 % of GA Fleet**

Helicopters Companies

Robinson Helicopter, located in Torrance, California, was founded in 1979. They are currently the industry leader for helicopters. They manufacture the two most popular helicopters worldwide: the R44 and R66 models (Robinson, 2015). The R44 is a four seat, piston-powered helicopter used extensively by flight schools and private owners. In addition to being used by student pilots, the R44 is also used commonly for aerial photography, aerial tourism, and can be equipped with searchlights and an infrared cameras for law-enforcement use (Peltier, 2016). It is known for its versatility in fulfilling a large number of missions.

The R66 is the more powerful cousin to the R44. Turbine powered, the R66 has five seats and has of a greater carrying capacity of both fuel and cargo. According to Robinson Helicopter, part of what makes these helicopters so popular to so many customers is its affordability and easy maintenance, making it ideal both in day-to-day use and for training (Robinson, 2015). The popularity of Robinson is apparent, as they make up roughly 2,750 of the helicopters currently registered with the FAA (FAA, 2018b).

The next most popular helicopter brand, making up about 2,500 helicopters in the U.S, is Bell Helicopter, a subsidiary to Textron Aviation (FAA, 2018b). Founded in 1935, they were the first company to certify a commercial helicopter, and are known as trend setters in the future of helicopters (Bell, 2018). The two most popular models are the -206 and the -407, both of which are turbine powered. While Bell helicopters are more expensive than Robinson helicopters, they have larger cabins and customization features, making them highly appealing for uses such as corporate transport, firefighting and medical transport. The Association of Air Medical services (AAMS) currently recognizes the Bell -206 and -407 as the most popular helicopters for medical services (AAMS, 2015).

The remainder of the helicopters registered in the FAA are made by Sikorsky, McDonnell Douglas, Enstrom, Airbus Helicopter, and other smaller manufacturers. They range in uses from personal helicopters to utility surveying helicopters.

Airworthy Assurance

FAA airworthiness stipulates that the aircraft must maintain its approved type design, and be in a condition for safe operation (FAA 2015). For aircraft to be considered in a condition for safe operation, an annual inspection must be performed by an A&P with an inspection authorization. During the inspection, the A&P checks flight critical components, such as the condition of all flight instruments, the proper installation of all fittings on subsystems, the condition of structural components such as engine mounts, and the condition of wiring. The maintenance must be completed with a maintenance logbook entry stating the date of completion, description of the work performed, names of all people performing the work and the specific identifying serial numbers of the equipment being worked on (14 CFR 43).

Changing Industry Workforce

According to a recent article in *Transportation Today*, Airframe and Powerplant technicians currently working in industry are rapidly aging, motivating industry leaders to push for enough mechanics to replace them, as well as enough technicians to keep up with the overall growth within the sector (Carey, 2018). There is currently a job growth outlook of 7%, including all maintenance and repair operations (Bureau of Labor Statistics, 2016). According to a site that compares the average salaries for jobs around the U.S., a helicopter mechanic can expect to earn an average salary of $53,997 (Payscale, 2018), which can be compared to a fixed-winged aircraft mechanic's average salary of $61,260 (Bureau of Labor Statistics, 2016).

As stated by the Aircraft Owners and Pilots Association, a recent study done by the University of North Dakota and the Helicopter Association International (HAI) projected that between 2018 and 2036 the industry is expected to experience a deficit of 40,613 mechanics (Collins, 2018). As of 2017, there were currently 286,268 certified mechanics that are active within the U.S. (FAA, 2017). Within the next 18 years, the U.S. will experience a shortage comparable to roughly 14% of its current mechanics. With the salary higher for fixed-wing maintenance, and fixed-wing maintenance being more common, more technicians may seek work with fixed-wing aircraft instead of with helicopters.

Airframe and Powerplant Certification

In order to earn an Airframe and Powerplant certificate, one must adhere to the rules outlined in 14 CFR Part 65 – Certification for Airmen Other Than Flight Crewmembers. Subpart D specifically outlines the requirements for mechanics seeking both their Airframe and Powerplant rating. According to 14 CFR Part 65.77, applicants must provide significant evidence of completion from a certified aviation maintenance school, or a minimum of 30 months of experience in the field performing work requiring both the Airframe and Powerplant ratings.

Part 147 Schools

For a school to be considered a *certified aviation maintenance school*, certain curriculum topics must be taught. These requirements are outlined specifically in 14 CFR Part 147 – Aviation Maintenance Technician Schools. One of the requisites is that the school provides at least 1,900 hours of instruction, broken down into 400 hours of general, 750 of airframe, and 750 of powerplant instruction. According to 14 CFR Part 147, only a primary knowledge--*Level 1*--is necessary on the topic of rigging helicopters in order to complete the airframe part of the A&P certificate. Within the entire Part 147, this is the only mention of rotary aircraft in the curriculum requirements. A Level 1 proficiency is defined in 14 CFR part 147 Appendix A as having an understanding of general concepts, without any practical applications. As a result there is a possibility that of a maintenance technician's entire 1,900 hour aircraft training, they could have only a one-hour lecture devoted to learning about rigging rotary wing aircraft.

In comparison, *Level 3* proficiency defined in 14 CFR part 147 Appendix A as having an understanding of general concepts, a high level of practical applications, with the development of skills that simulate a return to service. Examples of curriculum taught with a Level 3 proficiency for fixed wing maintenance include procedures for, the assembly of flight control surfaces, the rigging of secondary flight control surfaces, and measuring the weight and balance of the aircraft.

Figure 1. Schweizer 269A Trainer Used at a Part 147 School.

While Part 147 provides specific requirements of instruction for fixed-winged aircraft, it leaves the amount of learning about helicopters heavily dependent on each school. Part 147 schools have the freedom to determine how much time they want to spend on helicopter instruction on anything past the required *Level 1* knowledge on rigging helicopters. This choice in curriculum may result in knowledge gaps.

On-the-Job Training

For prospective mechanics, no public training programs exist to prepare them for heavy maintenance on helicopters. Heavy maintenance includes tasks such as overhauling landing gear components, inspection of flight critical components, and the relubrication of specific systems (Quantas, 2016). The closest comparison is from companies such as Airbus and the U.S. National Guard that offer on-the-job training for the helicopters used at their respective organizations, granted that the technician has received their A&P certification first. This type of training is often severely limited, and is focused to only teach what the technician would need to know while performing specific job tasks. While this assists with the current gap in training, helicopter technicians are often stuck, as they have a general idea of fixed-wing maintenance procedures from their prior A&P knowledge, but only have hands-on experience with the helicopters used at their employer. Another factor that is limiting the number of aircraft and powerplant technicians working with helicopters is the amount of training they receive related to helicopters while obtaining their Airframe and Powerplant certificates.

Airframe and Powerplant technicians are expected have a solid understanding and familiarity of: aircraft safety, hardware, tooling, and procedures. However, due to the possible gaps in their A&P training, technicians may have limited knowledge about how helicopter components work together, or how they can impact each other, resulting in unfamiliarity with components that would otherwise be known to them.

Importance of Proper Training

While the current maintenance training for helicopters is focused on theoretical learning in a Part 147 School, many of the helicopter manufacturers provide the hands-on training in order to increase learning and promote understanding of difficult subjects. Almost all major helicopter manufacturers offer some form of additional training.

Airbus, Robinson, and Bell, can be seen as examples, as all three companies train technicians specifically for maintenance on their helicopters. Airbus offers a self-assessment, an airframe refresher course, as well as various other courses, such as Mechanical Assembly, Airframe Repair, and Auto-Pilot Hydraulic Units (Airbus, 2017). Robinson Helicopter offers a $1,100 general maintenance course, with a requisite of already having an Airframe Mechanic Certificate, that specifically covers the maintenance specific to Robinson helicopters (Robinson, 2017). Bell Helicopter offers mechanical and avionics training for its helicopters as well (Bell, 2018). While it is a constructive solution for helicopter manufacturers to provide training for proper helicopter maintenance, it requires significant time, money and other resources. Smaller helicopter manufacturers may not have the resources to provide specialized training, so mechanics working those specific helicopters are at a disadvantage.

Another solution for providing sufficient hands-on learning to prospective helicopter mechanics is to increase the amount of time devoted to helicopter learning in Part 147 schools. If a Part 147-approved curriculum is developed that contains laboratory instruction specifically for flight-critical components on helicopters, students would be able to spend more time learning about these components in a safe environment.

There are three approaches to laboratory instruction: developmental, instructional and laboratories with the goal of research. Instructional laboratories focus specifically on skills and concepts that are expected to be known by engineering professionals (Feisel & Rosa, 2005). By the nature of laboratory instruction, most projects are done in small groups, which allows students the opportunity of also practicing communication and teamwork skills. Teamwork and communication are considered crucial to a student’s learning process, and industry leaders such as the Accreditation Board for Engineering and Technology (ABET) stress the refinement of these skills in the learning environments of institutions (Lingard & Barkataki, 2011). There currently exists a need for such a curriculum to be developed for helicopters.

An additional resource that could be used to further the understanding of helicopter components is the use of accident case studies. Through the use of accident case studies the understanding of current faults in maintenance procedures can be increased, real world problems not experienced in a classroom setting can be introduced, and the students can be engaged by showing them the human aspect of errors (Saleh & Pendley, 2012). Accident case studies can be taught in various ways, such as reading accident reports, listening to recordings of flight data, or watching documentaries about series of events surrounding the incident. While students are given the opportunity to learn about safety culture from classes, case studies provide another method of instruction to increase the safety by ensuring more than one method to learning key-takeaways from lectures (Saleh & Pendley, 2012).

Helicopter accidents that were investigated by the National Transportation Safety Board (NTSB) were researched to provide an example of applicable case studies for helicopter training, focusing specifically on accidents due to improper maintenance. The NTSB cases DCA12MA020, WPR10FA371, and WPR16FA072 can potentially be used to help emphasize the importance of proper helicopter training.

Impacts of Improper Training

In accident WPR16FA072, a Bell-206 tour helicopter was flying in Hawaii on February 18th, 2016, when it experienced vibrations while in the air. The vibrations soon turned into a grinding sensation before the helicopter began to lose main rotor RPM. As the helicopter continued to lose its rotor RPM, it eventually stalled and began to fall into the water near the shoreline. Of the five people onboard, there were three serious injuries and one fatality. The NTSB conducted an investigation that discovered the maintenance technician did not apply grease to the forward coupling of the engine-to-transmission drive shaft, thus causing the failure of the drive shaft (NTSB, 2018).

Accident WPR10FA371was a Eurocopter AS350 helicopter flying in Arizona on July 28th, 2010, when it lost engine power. As the pilot began to perform autorotation procedures, the helicopter hit a concrete wall and burst into flames. There were three fatalities in total. Upon investigation, the NTSB determined the maintenance technician did not properly torque the nuts on the fuel inlet union, resulting in a separation between the fuel inlet union from the fuel injection manifold (NTSB, 2012).

In the case of DCA12MA020, a Eurocopter AS350 tour helicopter was flying in Nevada on December 7th, 2011 when the helicopter had an in-flight separation of the servo control input rod from the fore/aft servo, causing it to lose power and crash into the mountains. All 5 people onboard died. The NTSB determined three main causes for the accident: reusing a self-locking nut, improper installation of a cotter pin, and improper inspection of the parts after maintenance was completed (NTSB, 2013).

While all three of these incidents were caused by maintenance technician errors that could have been prevented through Airframe and Powerplant training, the technicians did not have the helicopter system understanding that would have prompted them to check vital connections, practices and procedures. Had they known the importance of each component of the helicopter, they would be able to not only ensure the quality of their work, but also have the experience to identify potential problems.

Conclusion

As of 2018, approximately 5% of the general aviation aircraft within the United States are helicopters. As aircraft with airworthiness certificates, they must be inspected and maintained by Part 147-certified Airframe and Powerplant mechanics. As the workforce of A&P personnel ages, an increasing number of technicians are being trained to replace retirements. In order to earn an A&P, a student must either attend at Part 147 school or complete on the job training. Within Part 147, a student is only required to complete lecture training on helicopters. As a result of this limited training, there exists a possible gap in helicopter knowledge. Major companies acknowledge this gap and are trying to correct it by providing supplemental instruction; however, these courses provide experience in only their brand of helicopters. By limiting the knowledge to only one brand of helicopters, mechanics are unable to have the same kind of freedom and experience possessed by fixed-wing aircraft mechanics. Part 147 curriculum should be reevaluated to include more instruction on helicopters. In its current state, the Part 147 curriculum allows the students to pass the Part 147 examinations required for an Airframe and Powerplant Certificate, however, it may lack the training necessary to be adequately prepared for the demands of the workforce.

Future Works

To address this lack of training for helicopter maintenance in Part 147 curriculum, an adjustment in the curriculum may be required to either increase the exposure to helicopter maintenance practices, or the limited time assigned to helicopters needs to be more focused towards hands-on learning. Hands-on experience is highly beneficial to students in the process of learning about safety. The authors believe the development of a laboratory project that models the stresses of components within a Computer Aided Design (CAD) software would be beneficial in teaching flight-critical components. Due to the complex nature of CAD, the project would require more time spent learning about helicopter components. Additionally, the CAD project would provide a more hands-on experience than a theoretical lecture.

Furthermore, assignments involving case studies of NTSB accidents DCA12MA020, WPR10FA371, and WPR16FA072 could also be incorporated into the curriculum. In order to test the effectiveness of such training, a pre- and post-survey as well as post-class interviews could be conducted.

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