ATEC JOURNAL SPRING 2019

VOL 41 • ISS 1
ISSN 1068 5901

AVIATION TECHNICIAN ATEC EDUCATION COUNCIL

ATEC JOURNAL SUBMISSIONS

The ATEC Journal (ISSN 1068-5901) is a peer-reviewed, biannual electronic publication. The publication provides an opportunity for educators, administrators, students and industry personnel to share teaching techniques and research. Authors are encouraged to submit their articles for publication consideration, whether scholarly, research, application, or opinion, by utilizing the submission form below. Papers supporting the council's regulatory and legislative agenda may be considered for presentation via online webinar and/or at the annual conference. Suggested topics include, but are not limited to:

- Technical and soft-skills curriculum integration
- A history of legislative actions affecting aviation maintenance workforce development
- A study on implementation of employer-education partnerships
- Funding implications stemming from Bureau of Labor Statistics occupational outlooks
- Highlighted innovations in the aviation maintenance industry
- A look at successful online teaching methods and/or subject matter in other technical fields
- Surveying currently used computer-based teaching across aviation maintenance training schools

SUBMISSION DEADLINES

Fall Issue Closing Date: October 1

Spring Issue Closing Date: May 1

EDITORIAL BOARD MEMBERS

SUBMIT AN ARTICLE FOR CONSIDERATION

FROM THE EDITOR.

We are gaining momentum in this spring issue of the *ATEC Journal*. I am pleased to see that our AMT community is continuing to pursue great ideas in both their classrooms and research efforts. With a wide range of topics in this issue, there is sure to be something that each one of us can relate to and possibly find inspiration from to move us towards new projects.

In this issue, we hear from a few of our peers about assessments, incentives, and Airduinos in the AMT classroom. From a well-known agency member, we take a walk through the history of human factors in aviation maintenance. In addition to the five academic articles, is an article from a popular industry member about their new avenues in online training opportunities.

The Editorial Board and I are also glad to introduce a new piece titled "Instructor Spotlight" in which we highlight an AMT instructor that is implementing innovative ideas in the classroom or research arena. For this inaugural spotlight, we chose to interview Martin Segraves from Texas State Technical College, recommended by Kelly Filgo. Our Q&A session with Martin explores his experience developing their avionics program around the ASTM NCATT AET curriculum.

Looking ahead to future issues, if you are aware of an AMT program or instructor who is moving towards new and exciting goals that may serve as insight or challenges to the larger AMT community, we would welcome your recommendations for candidates to be the next Instructor Spotlight.

Please join me in extending many thanks to the Editorial Board who make this journal the success that it is. As always, I pledge my gratitude to them all for their continued work and support. I appreciate them greatly.

I hope that you all enjoy your summer months whether you're in the classroom or not! I look forward to having another exciting issue in the fall and seeing you all again in Dallas!

Best,

Karen Johnson

ATEC Journal Editor
Associate Professor
Department of Aviation Technologies
Southern Illinois University Carbondale
ksulliva@siu.edu

COMMITTEE UPDATES

FRED DYEN
REGULATORY COMMITTEE CHAIR
Professor, Blue Ridge Community College
dyenf@brcc.edu

REGULATORY COMMITTEE

Champions will introduce legislation directing the agency to promulgate the language as a final rule. While we are pursuing a legislative solution to address our outdated curriculum, we will also engage with the agency in the rulemaking process.

To that end, the committee met several times over the course of the recent 90-day comment for the part 147 supplemental notice of proposed rulemaking. It also held an online webinar to educate the membership on the provisions and to ensure consistency in the community's feedback.

The council's comments will be filed the week before the June 17 deadline so that the community may review them in preparation for their own submissions. For more information on the part 147 initiatives and activities, visit www.atec-amt.org/part-147.

JARED BRITT
LEGISLATIVE COMMITTEE CHAIR
Director of Global Aviation Maintenance Training, Southern Utah University
jaredbritt@suu.edu

LEGISLATIVE COMMITTEE

Last October, President Trump signed the FAA Reauthorization Act of 2018 into law. Among other things, the statute directs the agency to issue a part 147 final rule by April 5, a date that has come and gone.

While a supplemental rulemaking was issued on April 16, the content was a disappointment to the education community. As a committee, we do not believe the agency-authored final rule will provide the needed flexibility for AMTS, nor are we hopeful that the final rule will come anytime soon given how long it took the agency to issue the supplement (nearly three years).

In order to move forward with our legislative priorities, we've felt that providing an ATEC-composed part 147 is the only viable option to move forward. Once the regulatory committee finalizes the proposed part 147 language, we will submit it to our congressional allies and begin grassroots efforts to push for a direct, final rule.

We achieved some unprecedented milestones in 2018 and we expect even greater successes this year. Consider supporting our efforts by attending the ATEC Legislative Fly-in September 10-13. Registration is open at www.atec-amt.org/fly-in.

KIM PRITCHARD
MEMBERSHIP COMMITTEE CHAIR
Senior Manager Airframe Overhaul Repair, United Airlines
kim.pritchard@united.com

MEMBERSHIP COMMITTEE

The trade association has enjoyed double digit membership growth the last four years and this year will be no exception. With a 92% membership renewal rate and the addition of 10 new members in the first two quarters alone, the membership roster is on pace to reach a record high in 2019.

ATEC is well supported by the aviation education community—70% of all part 147 schools are council members. That said, the committee thinks we can do better and has set an aggressive goal to expand our network to 85% of A&P schools by 2021. That means we need to convince 25 of the remaining 52 non-member AMTS to join our ranks over the next three years.

Members are our best recruiters, to that end we ask you to utilize the outreach toolkit to help us spread the word about all the good things the council is doing for aviation maintenance education. And be sure to check out the regional outreach meeting calendar and join us for a local gathering near you!

JOEL ENGLISH
MEETING PLANNING COMMITTEE CHAIR
Vice President of Operations, Aviation Institute of Maintenance
jenglish@centura.edu

MEETING PLANNING COMMITTEE

Planning for next year's event is well underway. Get ready for the ATEC Annual Conference taking place in Fort Worth March 29-April 1. An ATEC contingency convened in Dallas last month to set the planning wheels in motion and are happy to announce this year's event host, Tarrant County Community College. The college's Trinity River campus is nestled in downtown Fort Worth and provides ideal facilities for another great event.

As you're planning budgets for next year, please consider conference sponsorship which helps ensure we can keep conference registration fees at affordable levels for our membership. A huge thanks to Lockheed Martin and American Airlines who have already pledged support as our 2020 premier sponsors.

Exhibitor registration will open soon, attendees can reserve their seats starting in October. Stay tuned for more information as details are finalized.

KAREN JOHNSON
COMMUNICATIONS COMMITTEE CHAIR & JOURNAL EDITOR
Associate Professor, Southern Illinois University
ksulliva@siu.edu

COMMUNICATIONS COMMITTEE

The committee focused on two primary initiatives in the past six months, publication of the ATEC Pipeline Report and implementation of a new social media and marketing campaign.

I encourage you to review the Pipeline Report if you have not already. There is a wealth of information on workforce trends that will benefit any school growing or developing technical programs, and employers hiring maintenance personnel. Special thanks to all the school representatives that completed the ATEC survey, which provides foundational data for the annual report. Look for the 2019 survey in your inbox this summer.

The committee also developed and initiated a formal marketing campaign, which will support an enhanced presence on our LinkedIn and Facebook platforms. Join both groups to receive ongoing updates on ATEC initiatives and engage!

INSTRUCTOR SPOTLIGHT

Martin Segraves is the Avionics Department Chair at the Waco campus of Texas State Technical College. The College has recently been certified to offer the ASTM NCATT AET test. The certification verifies that their avionics curriculum meets the NCATT content requirements and allows their students to prepare for the certification test via a one semester class. The NCATT AET certificate brings students one step closer to meeting the experience requirements for the issuance of a FAA Repairman certificate. Martin has provided answers to questions from the ATEC Journal Editor and Editorial Board concerning his experience obtaining and offering this certification.

Can you clarify the involvement of ASTM and SpaceTech with the process?

“ASTM uses SpaceTEC to administer the NCATT. From their web site, SpaceTEC Partners, Inc (SPI) is the administrator for all ASTM NCATT written exams, through Credential Testing Services (CTS), in addition to its other job-oriented knowledge and practical-skill certification examinations. SPI also processes applications from schools and industry training providers for ASTM NCATT Training Provider approval. The website states that you can contact Carolyn Parise at SpaceTEC to get a copy of the application checklist.”

Does the program have plans to add additional NCATT ratings/certificates?

“As the FAA has recognized the NCATT AET certification and one additional endorsement as the equivalent to the experience requirement for issuance of a Repairman Certificate under a Part 145 Repair Station, we may add any of the three endorsements that fit our curriculum to our Industry Certifications class. We currently do not offer the endorsements, but we believe that our current curriculum would support offering three of the four endorsements, including Autonomous Navigation Systems, Dependent Navigation Systems and Radio Communication Systems.”

What is the other content in the Industry Certification class that the preparation is offered in?

“Our class that offers the NCATT testing, CSIR 1355 Industry Certifications, also prepares students to take Elements 1, 3 & 8 of the FCC General Radiotelephone Operators License. The class also offers the International Society of Certified Electronics Technicians test.”

What textbooks and other materials are being used in the Industry Certification class?

“We provide most of the text materials used in the core Avionics classes, as we teach directly from FAA publications and approved maintenance manuals. The students are required to purchase basic tools used for wiring (cutters, pliers), basic supplies for soldering (solder wick, flux), and safety goggles used in labs. Students also are required to purchase textbooks for their academic classes, and textbooks and supplies for their core electronics classes. The purchase of a computer and software is optional, as we have them available in the lab.”

Can students do the A&P and NCATT AET concurrently?

“Students spend much of their time here at TSTC in the lab, practicing hands-on tasks that they will perform in the field. Employers appreciate having new employees that can perform well on the first day, and our programs are often considered by employers as “experience” toward employment.

The NCATT AET is only offered with the Avionics program, as the A&P program at TSTC is a separate set of programs. Students can complete either Avionics or A&P first, and completion of both programs will take 10 semesters, or about 3 years and 4 months. We do encourage students to complete both programs, as employers seek to hire people that can work on the entire airplane.”

How many students are there currently in each of the programs?

“We currently have 31 students enrolled in the program, with a maximum capacity of 54. We are preparing to fill to capacity in Fall 2019, as we had a record enrollment of 26 new students in Fall of 2017, and nearly matched it with 24 new students starting in the Fall of 2018. The A.A.S. for Airframe and Powerplant are offered as two separate A.A.S. awards by TSTC due to our requirements for accreditation. The programs are run simultaneously, and nearly all students that complete the programs graduate with both degrees. Current enrollment is 76 students across three campuses."

What kind of attrition does the program have?

"The Avionics program is very challenging, and we work hard to prepare our students for the diverse requirements of the work force. As a result, only about half of the students that start the program actually complete and earn the degree. We have recently implemented organized study groups and additional tutoring to help ensure that more of our students complete the program."

How does the program attract students?

"We attract students to the Avionics program via the recruiting methods of the college. TSTC uses organized recruiting events, both on and off campus, as well as advertising, internet, and social media to promote the school programs. We actively recruit service members at the end of their obligation from nearby military installations. We also have a number of events, including family day and registration rallies, to encourage prospective students to enroll."

Are there partnerships with any high schools or advanced standing when entering from high school?

"We offer dual-enrollment with local schools, where a student can take two Avionics classes per semester while attending high school. The classes offered to these high school students are some of those that prepare them for the NCATT certification."

In your experience, is the job market able to repay the investment?

"The cost of the Avionics program at TSTC is less than $12,000 for the entire five semesters, including tuition, books, tools and supplies. A graduate of the program can expect to make about $40,000 (base salary) in their first year of employment in Texas as an Avionics Technician. Nearly all of our students find employment in Avionics or a related field. In addition, employers have suggested that the NCATT AET can be a discriminator in the hiring process."

What percentage of graduates stay in the industry after 2, 5 years?

"Aviation is an intense industry, and people tend to fall in love with it. What we have found is that nearly all of our graduates that start in the industry are found working in Aviation after 2 years and beyond. A few graduates use their A.A.S. to pursue employment outside of Aviation, usually as a result of finding an immediate opportunity in a related field. An example is our graduate that is employed at Texas Instruments as a maintainer on their assembly line equipment."

Is there any advice you would like to pass along to other institutions looking at this option?

"The application process is simple and straightforward, if a bit intensive. You must have someone currently holding the NCATT AET to qualify for application for institutional accreditation. I submitted the application, including a copy of my NCATT AET certification and documented experience, classroom layouts, and copies of supporting class syllabi in the application packet, which totaled over 50 pages. I recommend that institutions look at their curriculum and match it against the requirements for NCATT certification. I was pleasantly surprised to find that we offered more than the 85% required for the cert in our first three semesters of our degree program."

Any additional thoughts?

"Our industry partners indicated that the NCATT AET certification can be considered a discriminator for employment during one of our annual Advisory Board meetings. As a result, we pursued the process required to become accredited to offer the certification. This is still fairly new for us, as we've had the accreditation less than two years".

On behalf of the ATEC Journal Editorial Board, I would like to thank Martin Segraves for his willingness to give the AMT community insights to his experience. It is our hope that by providing these spotlights it will encourage other programs and their faculty to strengthen their collaboration efforts on critical research and classroom practices that will move AMTSs forward.

TSTC
Texas State Technical College™

DO INCENTIVES FOR STUDENTS TO COMPLETE ASSIGNMENTS EARLY MAKE A DIFFERENCE?

By **Ed Steigerwald**
Associate Professor
Middle Georgia State University
ed.steigerwald.mga.edu

ABOUT THE AUTHOR

Ed Steigerwald is an Associate Professor of Aviation at Middle Georgia State University. He obtained a MS degree in Space Studies and his Doctorate is in Engineering and Technology Management from Northcentral University.

ABSTRACT

It is a common observation that students who submit work earlier than the due date and time tend to achieve overall better grades than individuals who turn in assignments near or at the due date and time. In this study I examined the benefit to rewarding students with extra credit for turning in assignment before the time and date specified. For each day an assignment was submitted early, the individual was awarded extra points, up to a maximum of five days early. Two groups of students were examined in identical courses with one group being offered the early incentive and the other group being offered no incentive to submit assignments early. All of the students in Group A took advantage of the early submission extra credit in varying degrees of participation; however, there was no statistically significant difference between the final grades of the two groups. The extra credit for early submission was inconsequential in improving the caliber of the work submitted.

INTRODUCTION

Educators have observed and suspected that students who do not wait until the last possible moment to submit an assignment tend to achieve higher grades than individuals who procrastinate until the submission window is about to close. Students have time to engage in research, reflect on the work they have accomplished, think about ways to improve their submission, and create a fine work worthy of the highest marks. In short, because these students are more engaged, improving engagement results in assignments that are submitted early. While this scenario appeals to our ivory tower sense of cognition and learning, students are often attending five courses a semester along with the necessary after school study. In today's world, the adult learners are most likely employed, participating in the running of a home and supporting a family. To the student, time is a precious commodity that must be parceled out wisely with the big picture in mind. A discussion assignment so proudly presented by the teacher might not be perceived by the student to be even important enough to complete.

Educators have experimented with methods to improve assignment engagement such as requiring students to log into and work with a project-planning journal in hopes of improving student organizational and planning skills, resulting in work that is reflective of time well used (Ryan, 2013). Poor performance may result from procrastination influenced by personality traits that leave the student predisposed to putting off required tasks (Rotenstein, Davis, & Neath, 2013). Other studies suggest that while submitting individual assignments at the last minute results in poorer grades for that specific assignment when compared to students who submit work early (Mo & King, 2015), however there is no statistically significant difference in the final exam grades in that course (Beck, Milgrim, & Koons, 2013). To complicate the issue of timely assignment submission even further, the amount of time students actually spend on an assignment has no statistically significant effect on the grade for that assignment (Mo & King, 2015), so why would early submission make any difference?

Helping students become organized and crafting a time management strategy have proven to result in more timely submission of assignments. For courses in which due dates are firm, there will be a natural improvement in student performance because students obtain credit for work that otherwise might have resulted in a grade of zero (Cavanaugh, Hu, & Lamkin, 2012). However, the quality of the submitted work has not improved. From a teaching perspective, it is not the individual parts of the whole course that define the outcome, but rather how well does the student fare at the end, on the final exam, especially if that final includes a practical exam as is often the case in aviation.

Teachers tirelessly seek to encourage students to improve, engage, and to do their best. Reward for such activity is naturally built into education: Do well in the course and the student is rewarded with an A. Unfortunately, such reward does not automatically result in motivation. A good grade motivates some students but not others. Chulkov (2006), found that a good grade works better for female students but not as well for adult learners and even worse for those stuck in a class that has no relation or relevance to their field of study. Pardee (1990), suggests that good grades are not a good motivator, in much the same manner that a good paycheck is not a motivator for the worker. Workers are motivated by teamwork, leadership, challenges, and communication, and they are satisfied by their paycheck (Osabiya, 2015). Similarly, a grade received on an assignment is not a motivator for some students, but rather a satisfier. Instructors often hear a student comment that he or she is happy with a "C," or "that's the best I could hope for with the time I had." Those students are satisfied with the result, but not motivated by receiving any particular grade.

Problem and Purpose

Students should be self-motivated to accomplish their course assignments in compliance with lesson standards and in a timely manner. Course instructors traditionally penalize students for missing submission deadlines. The problem is assignments submitted late have a negative impact on student grades, even if the work eventually submitted met or exceeded the required rubric requirements. The purpose of this study is to evaluate the effects of rewarding students with extra credit for early assignment submission.

METHOD

Participants

This study captured the final grades from Airport Legislative Affairs courses from the spring 2019 semester. No personal contact with the students in the courses was made or attempted while collecting the data, and no personal information of the students was recorded. The age, race, gender, grade point average, degree or program, identification numbers, or other demographic or classifying information was not identified, collected, or recorded. The sample consisted of university-level students enrolled in the courses, and no effort was made to select or remove students from the overall population or from within the courses. Group A contained 27 students and Group B contained 20 students. The project was completed under approval by the Exempt Review protocol of the Middle Georgia State University Review Board.

Assessments and Measures

Students in Group A were offered extra credit points for completing assignments before the due date, up to a maximum of five points toward their final grade, which was on a 100 point scale. Each week, students could earn up to 14 percent of those five extra points, depending on how early the work was submitted. Submitting the weekly assignments five days early would earn the maximum 14 percent (0.7 point) for that week's work. Submitting one day early would earn 0.14 point. No attempt was made to explore the effect of different levels of reward if greater points would result in different results. Students in Group B were not offered any early submission incentive.

The final course grades were collected from two courses of identical length taught by the same instructor, delivering the same content in the same manner. The courses were eight weeks long and delivered online using the D2L Learning Management System. Each assignment had a weekly due date of 8:00 p.m. on Saturday.

RESULTS

The data were analyzed using Microsoft Excel™ and are shown in Table 1 in the appendix. To determine the appropriateness of a parametric test for data analysis, the Kolmogorov-Smirnov Test of Normality was used to first provide a measurement of divergence (Group A: K-S = .208) and (Group B: K-S = .189) from what would be considered normal sample distribution. The high p value (Group A p =.308) (Group B p =.255) indicates the data does not significantly differ from normally distributed data. Additionally, Group A Skewness (1.30) and Kurtosis (0.78) and Group B Skewness (-1.66) and Kurtosis (3.30) confirm the samples are normally distributed and a t-test would be an appropriate method of statistical analysis. The means of the final grades between the two groups were calculated and compared using the t-test (83.86, 76.99, p =.069) and resulting in a t-value of –1.51 (Figure 1). The result between groups is not significant at $p < .05$.

DISCUSSION

No statistically significant difference exists between the final grades from Group A and the final grades from Group B shown in Figure 1 in the appendix. However, students in Group A did score an average of nearly six percentage points higher in the overall final grade than students in Group B, in which no incentive was given to complete the assignments early. This improvement in overall performance was reduced when the final grade scores were adjusted to remove the extra credit points students obtained by submitting assignments early. The result was the average final grade for the Group A students was only slightly better (2.1 percent) than the final grades for the students in Group B and this result was not statistically significant at $p < .05$.

CONCLUSION

On the basis of this analysis, creating an incentive for students to submit work early accomplishes little more than offering extra credit for work the student must accomplish anyway. This study shows no indication that student learning improved. Every student in Group A appeared motivated to participate in early submissions for extra credit; however, the data indicate that they did not spend any more time on the assignment to improve their submission. Submitting work early just for the sake of submitting work early does not imply that the individual will put forth extra effort in the other aspects of assignment engagement. Excellent work requires excellent effort, not just time management and planning to submit assignments early, or for that matter, even on time.

Somewhat surprisingly, students who submitted work one to five days early performed nearly the same on the individual assignments as those who submitted the work the same day it was due. The average grade for work submitted the day it was due was 80.65 percent and the average grade for the work that was submitted one to five days early was

81.00 percent. No discernable difference was found between the grades regardless of how early the assignments were submitted.

Although this study does not provide results supporting an incentive for early assignment submission, additional investigation is necessary to explore the nuances of this conclusion. In this study, varying the reward points or using negative points for late submissions instead of positive points for early submissions was not investigated. Enough statistical evidence exists (2.1 percent improvement) in final grades for Group A to suggest that further study would be beneficial.

REFERENCES

Beck, B., Milgrim, D., & Koons, S. (2013). Correlates and consequences of behavioral procrastination: The effects of academic procrastination, self-consciousness, self-esteem and self-handicapping. Journal of Social Behavior and Personality, 15(5), 3-13.

Cavanaugh, T., Hu, H., & Lamkin, M. (2012). Using a generalized checklist to improve student assignment submission times in an online course. Journal of Asynchronous Learning Networks, 16(3), 39-44.

Chulkov, D. (2006). Student response to grading incentives: Evidence from college economics courses. Journal of Instructional Psychology, 33(3), 206-211.

Galwel, J. (1997). Herzberg's theory of motivation and maslow's hierarchy of needs. Practical Assessment, Research & Evaluation, 5(11), 1-3.

Mo, S., & King, G. H. (2015). The clock is ticking - an analysis of time spent on online assignments. Academy of Educational Leadership Journal, 19(2), 129-134.

Osabiya, B. (2015). The effect of employees' motivation on organizational performance. Journal of Public Administration and Policy, 7(4), 62-75. doi:10.5897/JPAPR2014.0300

Pardee, R. (1990). Motivation theories of Maslow, Herzberg, McGregor & McClelland. A literature review of selected theories dealing with job satisfaction and motivation. ERIC, 1-24.

Rotenstein, A., Davis, H., & Neath, R. (2013). Are personality characteristics behind the link between procrastination and academic performance in accounting? Academic Business Journal, 18(2), 1-18.

Ryan, R. (2013). Postcard from the podium: It's all in the planning. Accounting Education: An International Journal, 22(1), 101-104. doi:http://dx.doi.org/10.1080/09639284.2012.698946

APPENDIX

Table 1: Grade Data for Group A and Group B

Grade Data for Group A and Group B	
Group A	**Group B**
96.07	69.04
77.66	83.92
84.34	33.35
95.48	91.37
12.22	67.47
93.72	96.86
93.49	87.84
87.66	86.69
93.77	91.02
87.03	78.47
90.63	49.82
82.37	90.19
93.36	91.37
85.79	89.41
67.59	86.68
69.53	40.02
65.55	76.86
90.08	79.6
67.96	60.8
93.01	
40.18	
72.36	
96.42	
75.63	
92.66	
94.96	
86.6	

Figure 1: Statistical analysis between final grades from Groups A and B

Means Between Groups A & B		
p-value .069 *t*-value = -151		
Statistic	**Group A**	**Group B**
N_1	27	27
M_1	83.86	76.99
SS_1	4471.61	6266.39
S^2_1	172.10	329.81

AN OPEN SOURCE PRIMARY FLIGHT DISPLAY FOR EXPERIMENTAL AIRCRAFT AND EDUCATION

By **Don Morris**
Assistant Professor, Aviation Technologies
Southern Illinois University, Carbondale
dmorris@siu.edu

and **Chongwen Chen**
Southern Illinois University, Carbondale Graduate
grace963702@gmail.com

ABOUT THE AUTHORS

Don Morris has an MS in Aviation Education from Embry Riddle Aeronautical University and a BS in Physics from Illinois State University. He is currently an Assistant Professor in the Aviation Technologies program at Southern Illinois University, Carbondale (SIUC). His aviation credentials include A&P, I.A., Commercial Pilot, CFI, and CFII. His first exposure to glass cockpits came as an avionics installer for business jets. The Airduino presented here is the outgrowth of his desire to create a glass cockpit that is affordable for most aircraft owners.

Chongwen (Grace) Chen graduated from SIUC in May of 2019 with a dual major in Aviation Technologies and Aviation Management. At the time of graduation, she had already earned her A&P, remote pilot certificate, and FCC license. She is also holds a Commercial Helicopter rating. Her next step in Aviation is employment at Embraer.

ABSTRACT

The most noticeable changes in aircraft today are in the instrument panel, where digital electronics are rapidly changing the way that pilots interact with aircraft. So called “glass cockpits” are computer driven, and are generally associated with better situational awareness than the older “steam gauges” they replace. Unfortunately, modern digital electronics are expensive. They are often too expensive to allow their use in low end experimental aircraft and in aircraft used for training technicians, neither of which legally require expensive certified electronics.

In this article, we present a glass cockpit primary flight display that is built with low cost off-the-shelf components. The individual hardware components and wiring diagram are shared, along with details of the interface. The resulting package is compared to existing glass cockpit solutions, where it is decidedly inferior in all categories except for value and transparency of operation. Details of a sample installation in a ground based trainer are included. Finally, we detail the release of the project source code to the public.

While the project as presented could have value as a low cost system for ground based trainers, this is hardly a burgeoning market. It is our intention to help future avionics technicians understand the inner components of a glass cockpit and how they interact with each other. It is our hope that the open source aspect of the project will allow it to evolve into a viable flight safety device for experimental amateur built aircraft.

RATIONALE

When the Wright brothers first flew their aircraft off the sands of Kitty Hawk and into history, there were many issues that needed to be solved before flight could become the safe mode of transportation that it is today. These included aerodynamic, structural, and propulsion issues. Today, these issues have been largely solved. Our machines are physically capable of safe flight under most conditions. This physical capability, however, is only helpful as long as the aircraft operator maintains situational awareness. A significant portion of this awareness comes from the instrument displays on the panel, an area that is changing rapidly as digital electronics transform the way that man and machine interact.

Figure 1: Steam gauges (Morris, 2017).

Figure 2: Typical glass cockpit (Morris, 2017).

The classic aircraft flight instruments are basically the same as they were before WWII (compare Williamson, 1937 with FAA, 2012). They are known more or less affectionately as "steam gauges." The standardized steam gauge flight instrument layout is known as "the 6 pack," and is shown in figure 1. Computer driven graphical displays are known as "glass cockpits" (GAMA, 2005), and an already fairly dated version is shown in figure 2. Both displays convey the same information, as can be noted by the corresponding numbers in the figures. Steam gauges have internal sensors. The glass cockpit, however, interfaces directly with flight computers and indirectly with sensors. This allows for the easy integration of additional systems such as traffic avoidance and synthetic vision. Many studies have shown that glass cockpits are associated with increased levels of pilot situational awareness.

Most of today's new aircraft are equipped with glass cockpits (NTSB, 2010). However, most of the low-cost aging aircraft that less affluent pilots often fly are still equipped with steam gauges. So are most of the aircraft that are used to train future technicians. When you consider "home-built" aircraft, the situation is even worse. Many of these experimental - amateur built (EAB) aircraft do not even contain the full complement of steam gauges. While our well-equipped commercial aviation accident rate is very low, the general Aviation (GA) accident rate is much higher. The Federal Aviation Administration (FAA) reports that 347 people died in 209 GA accidents in flight year 2017 (FAA, 2018). One of the leading causes of fatal general aviation accidents is unintended flight in instrument meteorological conditions (IMC) and subsequent loss of control (LOC) (Northcutt, 2013). Another common cause of aircraft related death is controlled flight into terrain. The lower fatality rates in commercial aviation are at least in part attributable to better avionics technology (Northcutt, 2013). Modern glass cockpits and avionics systems with advanced features such as synthetic vision systems, enhanced vision systems, head-up guidance systems, and onboard weather systems significantly reduce the pilots' work load and bring their focus back to where it naturally belongs – with their eyes forward.

Our intention for this project was to create a low-cost, high-quality, freely available glass cockpit solution that provides all the essential flight information traditionally provided by the standard six-pack. It was our hope that we could create an instrument package that was affordable enough that it could be installed as backup instrumentation in every EAB aircraft. Coincidentally, this low-cost glass cockpit might also be useful in the world of aviation maintenance training, where most of the aircraft that students are allowed to maintain are quite old and are poorly equipped – if they have anything in the panel at all. These training aircraft are also no longer flight-worthy and could be candidates for uncertified avionics suites.

The creation of a new glass cockpit package is a very large job that is typically undertaken by companies with significant budgets. Our budget, by comparison, was well under a thousand dollars. This meant that the components used in the project had to be low-cost, off-the-shelf components. While this caused a pronounced strain on the creative process, it definitely helped to maintain the low-cost goal of the project.

TECHNICAL DETAILS

We chose to use the very commonly available Arduino Mega 2560 microcontroller as the main processor for our project. This tiny computer is available from Arduino for a cost of around $40 (Arduino, 2019), although clones are commonly available for much less than that. Arduino microcontrollers are programmed with a customized version of "C." Programming an Arduino is accomplished with free software – the Arduino Integrated Development Environment (Badami, 2016). Our chosen version of the Arduino has 54 digital input/output pins that allow it to interface with most modern digital electronics using standard digital protocols such as "inter-integrated circuit" (I2C), "serial peripheral interface" (SPI), and "universal asynchronous receive and transmit" (UART). It is common practice when developing an Arduino-based product to use a name that hints at the Arduino microcontroller on the inside. We chose to maintain that tradition by calling our project the Airduino, as you can see in figure 3.

Figure 3: The prototype Airduino

The most challenging portion of the package proved to be the display itself. A number of low-cost color liquid crystal displays were evaluated, but finding a display that could be easily driven by a low-power Arduino and could be read in direct sunlight was difficult. We finally found the Newhaven Sunlight Viewable 4.3 inch Display Shield, and it met all of our requirements. It is available for about $80 and is the most expensive component in our product. It has its own graphics processing unit on board and communicates with the Arduino via SPI (Newhaven Display International, 2016). Rather than specifying the color of every pixel on the unit, lines and polygons are specified by Cartesian coordinates.

This means that minimal data has to be passed between the units, allowing us to update the Airduino screen up to 16 times a second in the configuration shown in figure 3. The display is vibrantly colorful, easy to read, and allows for flicker-free display animation. In addition to the features we have been able to use, it offers touchscreen capabilities and micro-SD card data storage which could become useful when adding features in the future.

Our primary sensor for attitude heading and reference system (AHRS) data is built by Yost Labs. It senses 3 axes of acceleration data, 3 axes of rotation data, and 3 axes of magnetometer data. These sensors are constantly monitored by an on-chip microprocessor, which keeps track of heading and spatial orientation using proprietary software. This heading and orientation data is reported to the Arduino via UART once per update cycle. Yost Labs claims that it can be relied on to track orientation data to the nearest 1.5 degrees in all dynamic orientations (Yost Labs, n.d.). However, we have not been able to duplicate this level of accuracy. The Yost Labs AHRS costs about $50.

Our final sensors provide air data information. We chose to use two Bosch BMP-280 sensors. These were chosen for their ready availability, low cost, and ease of use. We chose to use the breakout boards for the BMP-280 provided by Adafruit Industries, and they performed easily and flawlessly. Our static system can literally display the difference in altitude when our unit is moved from waist level to head height. Our air data sensors communicate with the Arduino via I2C and are located in sealed compartments on the rear of the unit. The entire wiring diagram is included in figure 4.

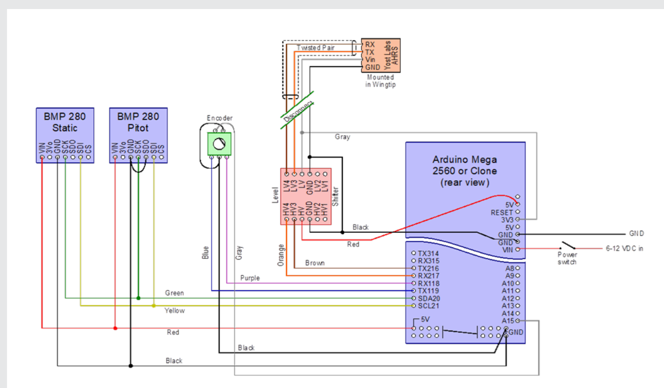

Figure 4: Wiring Diagram

The final component of our project is a 3D printed case. This was designed using Autodesk Inventor Professional (see Morris, 2018), and printed in durable ABS plastic on a Da Vinci 1.0 printer. The completed case measures about 4.8 inches wide by 4.2 inches tall. The bezel juts forward from the panel just over a half inch, and the unit requires just over

1.5 inches of depth behind the panel. Two one-eighth inch barbed fittings are glued into the case for the pitot and static lines. The case is printed in several parts that are then glued together, minimizing the need for printing supports and the corresponding rough surface finish that this would cause.

INTERFACE

The Airduino display is shown in figure 5, and most of the display should be intuitive to anyone with glass cockpit experience. The background and center of the screen form the familiar artificial horizon (1). The airspeed indicator is just to the left, with its colored bands that correspond to the appropriate aircraft speeds in user configurable units (2). The altimeter is to the right, and shows the aircraft's altitude on a sliding ticker tape in user-configured units. It also displays the altitude in animated numbers near the center of the strip (3). Vertical speed is shown on the far right of the unit on a user-configurable scale (4). Compass heading is shown on the top of the unit (5). The rate of turn is displayed by an orange arrow against the top of the bank dial (6). The settings menu is across the bottom of the display, and its brightness can be adjusted on the far left of the unit. A faintly visible battery icon is not yet used but should give the status of the backup battery on the unit when the project is so equipped. On the upper right corner, a sensor error icon flashes red when the serial data steam to the AHRS is momentarily interrupted. If communication with the sensor is lost for more than one second, the sky and ground are replaced by a large red X, indicating that no accurate information can be determined from the unit.

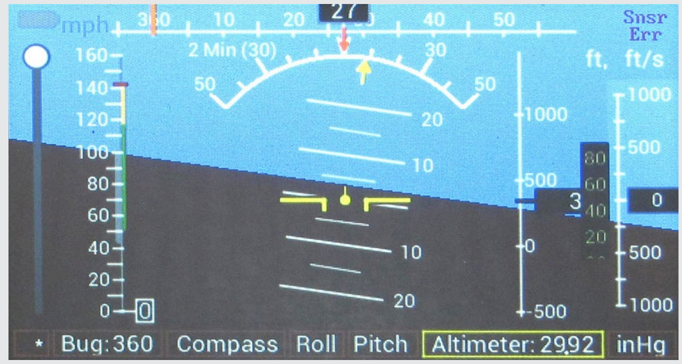

Figure 5: Airduino display. Numbers correspond to those in figures 1 and 2.

The only controls used to interact with the Airduino are a single on/off switch and multi-selector knob. The multi-selector knob moves the yellow cursor box between items. Pressing the knob allows the user to change the items set-

ting. Pressing the knob again returns the user to the menu.

The left menu item adjusts the brightness slider. Moving to the right, the next menu sets the heading bug. This is shown as an orange line on the selected heading. The compass menu allows the user to adjust for magnetic variation. Roll and pitch allow for fine tuning the artificial horizon. The altimeter setting allows the user to set the background pressure (Kollsman window). On the far right of the menu, the user can switch between preferred units of pressure. An additional hidden calibration screen can be accessed by powering on the unit with the multi-selector pressed down, then rotating the knob several times to the right.

FEATURE COMPARISON

Table 1 compares the Airduino to other glass cockpit solutions. It is readily apparent that the Airduino compares quite poorly with the other products except in the obvious price category. It also competes very well in the less easily compared category of panel space required. Additionally, its small size means that it has very low power requirements. We believe that when considering these categories, the Airduino could be a very attractive package for backup instrumentation. Since it provides enough information for pilots to get out of accidental flight into IMC situations without suffering LOC, we hope that someday our Airduino might actually save lives.

Table 1

	Collins Proline Fusion	Garmin G1000	Aspen Evolution 1000	Dynon Skyview Classic[a]	Airduino 4.3[a]
Display (inches x units)	14-15 x 3	10-12 x 1-3	6 x 1-3	7-10 x 1	4.3 x 1
Flight Instrumentation	✓	✓	✓	✓	✓
Terrain and Navigation	✓	✓	✓	✓	
Engine Monitoring	✓	✓		✓	
Approximate Baseline Cost	?	?	$5000	$2400	$200

? – Collins and Garmin do not sell to individuals. The cost of an existing King Air type aircraft retrofitted with either Garmin G1000 or Collins Pro Line Fusion are both between $300K and $350K

a – Denotes that the product is uncertified, and cannot be installed on certificated aircraft. This is usually cheaper. (Collins Aerospace, n.d., Garmin, n.d., Aspen Avionics, n.d., Dynon, n.d.)

RESULTS

At this time we have built two prototype Airduino units. The first unit was used to retrofit a full motion children's aircraft simulator. This installation is shown in figure 6. This simulator previously featured only steam gauges. Southern Illinois University uses the simulator primarily for children's rides at recruiting events. The new avionics were tested at the AOPA fly-in in Carbondale in 2018. Children responded very positively to the unit. After the upgrade, they were far more inclined to interact with what is to them a familiar digital screen than they had been with the much less familiar steam gauges before the upgrade. The unit was a rousing success for children's rides (AOPA, 2018) but did not meet our desired level of quality.

Figure 6: Prototype Airduino in systems trainer. Photo used with permission.

At this point, we do not recommend that the Airduino be installed in any flyable aircraft except for the purpose of research and improvement. We believe that better optimization of the AHRS software to the dynamic environment of a flying aircraft will be necessary before the unit is accurate enough to function in a backup instrumentation role. We are preparing an experimental aircraft to flight test the second prototype Airduino in a controlled flight environment alongside more reliable instrumentation. We hope to be able to begin flight testing sometime before the fall of 2020.

COLLABORATION AND THE OPEN SOURCE IDEAL

As we have mentioned, our goal is that the Airduino will grow into a useful product that is readily available. We are not seeking to benefit financially from it. We have chosen to release all the details and inner workings of this project, making it "open source." We realize that the resources and time that we have is limited. We can only develop this project to a certain point. We hope to build a community that can help to take it beyond our resources and capabilities in the hopes that more people will benefit from this project. By releasing the project source code for this project (referred to by programmers and hereafter as "open-sourcing") we hope it can become something that is much bigger and more capable than it would be without the collaborative environment allowed by publishing the source code (Carillo & Okoli 2008).

Open-sourced products can take on a life of their own (Maia Chagas, 2018). Following fairly common online conventions, our product is now available through three separate websites, all of which link appropriately to each other. We have chosen to license the Airduino through the standard Berkeley Software Distribution (BSD) Three Clause license (FreeBSD, n.d.).

Our main product web site is the central repository for online information. We were able to secure the domain name www.theopencockpit.org, where we have placed the primary website. This site is informational in nature. It puts a short, easy-to-refer-to name on the project. It also gives us a place to present photos and basic information – much like a classic informational brochure. It contains links to the other two sites that actually host and distribute the files: Github and Thingiverse. The cost to maintain our product site is under $5 a month.

Github is designed to host open sourced projects (Finley, 2012). This made it the natural choice to host most of the key files for the project. On Github, you can download the construction manual for the Airduino and the software it requires to operate. Fairly detailed step-by-step instructions are provided for hardware assembly, programming, and customizing the Airduino to individual aircraft. For those who wish to delve deeper, the manufacturer's documentation for the various components used to construct the unit are also included.

Github makes a convenient file server, but it is more than that. It also helps foster collaborative development on open-sourced projects. It tracks known issues with the projects, and allows others to post updates and improvements as branches on the original product. Incredibly, Github operates on an alternative revenue stream and offers most of its services for free.

While the documentation and software files for the Airduino are posted on Github, the three-dimensional data files used to print the ABS case are hosted on the separate site of Thingiverse, which is designed to host maker files and projects for the public (Thingiverse, 2019). Their services are also free. Three-dimensional files are stored on the site in steriolithography (STL) format, which most three-dimensional printers use. Each print file can be viewed directly before printing, and printing instructions are included. This allows for the Airduino case files to be freely distributed painlessly and effectively.

USE IN A TRAINING ENVIRONMENT

While it is our hope that the open source nature of our project will allow it to take on a life of its own, there is another important reason we have chosen to release the product in this manner. The inner workings of most avionics systems are trade secrets that cannot be discovered by disassembly. We hope that the open source nature of this project will allow it to serve a unique purpose in aviation education, giving future technicians a glimpse into the inner workings of a reasonably complete and functional system. Like anyone else, students and educators are free to modify the code as they see fit. We hope that this can help future technicians to understand complex electronics systems on a much deeper level than could ever be understood by studying flowcharts or books.

FUTURE DEVELOPMENT

As it currently exists, we hope that the Airduino is useful for aviation education. With further development, we hope that the Airduino can become useful to experimental aviation. Because the microcontroller that powers our project is so versatile, we also hope the basic unit can be adapted to additional roles. We are already in the early stages of adapting it into an engine monitor, which we hope to fly soon.

Ordinarily, we would end an article like this after talking about our plans. However, since we have open-sourced this project, we have very little control of where it will go. Others may take our project and modify it to use other processors, other screens, and other sensors. Snippets of our code could show up in other projects as diverse as technology can allow. We have already had one person indicate interest in borrowing from our code for use in submarine control. Most people will not request permission or let us know that they have used our code. The BSD-3-clause copyright we have chosen specifically gives them permission to do this.

Since we cannot end with our plans, we will end with our hopes instead. We hope that Airduino will receive a lot of attention and that other programmers will join in the effort to improve it. We hope that after sufficient improvements are made, thousands of Airduinos take flight in EAB aircraft. We hope to be the inspiration for many similar projects. We also hope that the cost of digital instrumentation – both certified and uncertified – plummets. If someday we read about how Airduino was a part of a low-cost avionics revolution, we would be very happy. To find out how this project evolves, check www.theopencockpit.org periodically.

REFERENCES

Aircraft Owners and Pilots Association. (2018). AOPA Carbondale fly-in. AOPA live this week. 40-54. Retrieved from https://aopalive.aopa.org/detail/video/5848005881001/aopa-carbondale-fly-in

Arduino. (2019). Arduino Mega 2560 Rev. 3. Retrieved from https://store.arduino.cc/usa/mega-2560-r3

Aspen Avionics. (n.d.). Evolution 1000. Retrieved from https://aspe-navionics.com/products/general-aviation/evolution-1000

Badami, Vasudhendra. (2016). Arduino programming for beginners. HackerEarth. Retrieved from https://www.hackerearth.com/blog/internet-of-things/arduino-programming-for-beginners/

Carillo, Kevin and Okoli, Chitu. (2018). The open source movement: A revolution in software development. Journal of Computer Information Systems 49(2):1-9. Retrieved from https://www.researchgate.net/publication/258507068

Collins Aerospace. (n.d.) Pro Line Fusion. Retrieved from https://www.rockwellcollins.com/Products-and-Services/Business-Aviation/Flight-Deck/Pro-Line-Fusion.aspx

Dynon. (n.d.). Skyview Classic. Retrieved from http://www.dynonavionics.com/skyview-classic.php

Federal Aviation Administration. (2018). Fact sheet-General Aviation Safety. Retrieved from https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=21274

Federal Aviation Administration. (2012). FAA-H-8083-15B Instrument Flying Handbook. Washington, DC. Retrieved from http://www.faa.gov

Finley, Klint. (2012). What Exactly Is GitHub Anyway? TechCrunch. Retrieved from https://techcrunch.com/2012/07/14/what-exactly-is-github-anyway/

FreeBSD. (n.d.). Software License Policy. Retrieved from https://www.freebsd.org/internal/software-license.html

Garmin. (n.d.). G1000. Retrieved from https://buy.garmin.com/en-US/US/p/6420

General Aviation Manufacturers Association. (2005). GAMA Publication #12 - Recommended Practices and Guidelines for an Integrated Cockpit / Flightdeck in a 14 CFR Part 23 (Or Equivalent) Airplane. Version 2.0. Washington DC. Retrieved from http://www.gama.aero

Maia Chagas, A (2018) Haves and have nots must find a better way: The case for open scientific hardware. PLoS Biol 16(9): e3000014. https://doi.org/10.1371/journal.pbio.3000014

Morris, Don (2018). Modernizing an aircraft drawing curriculum within the boundaries of 14 CFR 147. ATEC Journal. Vol 40, Iss. 1, Article 1.

Morris, Donald R. (2017) 2Fly with RPi - Evaluating Suitability of the Raspberry Pi3 B Single Board Computer for Experimental Glass Cockpit Embedded Applications, Journal of Applied Sciences and Arts: Vol. 1 : Iss. 3 , Article 5. Retrieved from https://opensiuc.lib.siu.edu/jasa/vol1/iss3/5

National Transportation Safety Board. (2010). Introduction of Glass Cockpit Avionics into Light Aircraft (NTSB/SS-01/10 PB2010-917001). Washington, DC. Retrieved from http://www.ntsb.gov

Newhaven Display International. (2016). 4.3" Arduino Shield with Capacitive Touch. Retreived from http://www.newhavendisplay.com/learnmore/Arduino-4_3CTP-N/

Northcutt, M. (2013). General Aviation Accident Rate: How General Aviation differs from Commerical Airline Flight and How to Correct the Discrepany. Journal of Air Law and Commerce

Thingiverse. (2019). What is Thingiverse? Retrieved from https://www.thingiverse.com/about/

Williamson, G. W. (1937). Instrument Planning: The New Service Blind-Flying Panel Described. Flight. Retrieved from https://www.flightglobal.com/pdfarchive/view/1937/1937%20-%202317.html

Yost Labs. (n.d.). 3-Space™ Nano Carrier Board. Retrieved from https://yostlabs.com/product/3-space-nano-embedded/

METHODS OF ASSESSMENT FOR AVIATION MAINTENANCE DISTANCE EDUCATION

By **Daniel Siao**
Assistant Professor, Aerospace Department
Middle Tennessee State University
daniel.siao@mtsu.edu

ABOUT THE AUTHOR

Daniel Siao is an assistant professor in the Aerospace Department at Middle Tennessee State University. He teaches in the maintenance management concentration and serves as the Part 147 coordinator. He is working on his Ph.D. in Aviation from Saint Louis University. He holds an M.S. in Aviation Administration, Safety and Security Management (MTSU), and a B.S. in Aerospace Maintenance Management (MTSU). He is a certificated A&P mechanic and a commercial pilot (ASEL) with instrument rating. His research interests include aviation security, safety reporting systems, and aviation maintenance education. He has been published in Harvard Law School's National Security Journal.

ABSTRACT

Distance education is already a popular learning format in many fields of study, and this trend is finding its way into Aviation Maintenance Technician Schools (AMTSs). One crucial aspect of distance learning is assessment. Many tools are available for assessing students in a distance learning environment including tests, quizzes, and assignments. One of the key considerations for assessing the work of distance learners is academic integrity. Though technology has advanced, and safeguards have been created against cheating in an online environment, academia at-large has not outwitted cheaters. This article provides a broad overview of the methods of assessment for distance education, examining both benefits and drawbacks of the methods discussed.

INTRODUCTION

Assessment is an important aspect of online learning for students and teachers. Assuming that assignments, quizzes, and tests are designed properly, these tools can measure comprehension and competency of course materials. Graded materials allow students to see areas where they are lacking in understanding and competency, and instructors can use the results to examine their own teaching effectiveness. For example, instructors can see the frequency of questions and topics missed on a test or a quiz. In sum, these tools benefit both instructors and students.

In this article, I discuss some of the methods of assessment for an online or hybrid learning environment. For the purposes of this article, an online class has no face-to-face requirements, whereas a hybrid class will be administered partially online with face-to-face requirements. This is not intended to serve as an exhaustive list, nor is it a one-size-fits-all solution to all online classes. Instead, this article should serve as a general guideline.

METHODS OF ASSESSMENT

Even though methods of assessment are myriad, the methods are categorized under two groups: tests and assignments. Tests are relatively straightforward, but this group encompasses everything from quizzes, which account for a smaller percentage of the grade, to midterm and final exams, which typically represents a large percentage of the course grade. On the other hand, there are many variations of assignments: worksheets, individual projects, group projects, writing papers, and reading assignments, to name a few. These assignments may be further parsed ad infinitum. For example, reading assignments may refer to articles, textbook, manuals, advisory circulars, and airworthiness directives.

Many instructors already have a trove of tests, quizzes, and assignments, and over time, many changes might have been made to improve the materials. However, what works best in a face-to-face class might not work as well online.

Before discussing best practices for administering tests and assignments online, it needs to be noted that the format of the class plays a large role in the efficacy of the methods discussed below. For example, an asynchronous online class will differ from a hybrid or a partially synchronous class. For a hybrid class, instructors can require quizzes, tests, and exams to be taken in class. General considerations, accommodating all formats, are discussed in this article.

TESTS

There are advantages and drawbacks to administering tests, exams, and quizzes online. One of the advantages is instant feedback. In most cases, tests can be graded automatically. Instructors can display grades, wrong answers, and feedback immediately after testing (Stowell, 2015). Of course, this does not work with open-ended questions that require answers of more than a few words.

If instructors permit retaking tests, administering online is the most flexible option. Students do not have to arrange a separate time to retake a test, or class time does not have to be allocated for retakes. Additionally, retaking tests and quizzes online is far more conducive to learning than in class. Instructors can create a bank of questions for a test—say, 100 questions—but each student receives 20 to 25 questions in random order (Cabrera, 2013). Students retaking a test would get a different set of questions—perhaps with a few questions they have already seen before—and students cannot "study" by rote memorization. This enhances student learning. Generally, students who are unsatisfied with their scores will attempt a retake, if given the option. If students can anticipate the questions, they are learning the answers rather than learning the material. But if students know that they will be presented with a different set of questions, they are forced to learn the material. Of course, this is not an argument that students should be allowed multiple attempts on all tests, exams, and quizzes, only that a mixture of multiple attempts and single attempt could bolster student learning (Sullivan, 2016).

Admittedly, creating pools of questions for each test and quiz requires more preparation on the part of the instructor, but this is a long-term benefit. Instructors are not blind to the fact that old tests can be passed around. Old course materials used in previous semesters can often be found in online repositories. Koofers, for one, allows students to search for an old exam (Paullet, Chawdhry, Douglas, Pinchot, & Morris, 2016). Whether professors are privy to this or care about it, the fact is students can obtain many course materials with relative ease. But if students are assigned random questions—which is difficult to do in a face-to-face class—it would be far more challenging to publish these exams online. Short of a concerted effort by many students to submit test questions to the same repository, the ability to obtain exams in its entirety is diminished greatly. Instructors can also divide the question bank into two sets and administer one for one semester and another for a different semester. The element of surprise can deter even the most ambitious cheater.

While on the topic of cheating, it is important to note that cheating is not more prevalent in an online class versus a face-to-face class (Tolman, 2017). Grijalva, Nowell, and Kerkvliet (2006) found that there are two forms of cheating: planned cheating and panic cheating. In instances of planned cheating, the student has premediated the act of cheating and comes to class prepared to cheat—e.g., hiding notes under the table or sitting next to someone who is well-prepared. Panic cheating, on the other hand, does not involve planning or premeditation (Grijalva et al., 2006). Often, panic cheating occurs when a quiz is given unannounced: Being unprepared, the student panics, and some resort to cheating. Make no mistake, there is no justification for cheating—whether planned or panic—but online courses generally minimize panic cheating (Tolman, 2017).

At this point, it seems intuitive that all forms of cheating could be deterred by deploying anti-cheating software, such as Proctortrack. This software uses the computer's webcam to monitor students while they take exams. To start the test, students are scanned by the software to confirm the student's identity, and during the test, the student is recorded by the software (Singer, 2015). Furthermore, the student sees a live video feed of themselves on the screen as they take the exam (Singer, 2015). Technologies such as these have been criticized as invasive and can even induce test anxiety (Sullivan, 2016). Undoubtedly, this kind of technology is a good deterrent—it deters cheating, but it could also deter students from taking online classes.

For an Aviation Maintenance Technician School (AMTS) offering online courses, perhaps the best method of administering tests is a blend of both online and face-to-face. After all, there is no option for students to take their FAA written exams online, so a mixture of online and in-class tests prepares students to take proctored and timed tests. Here are a few recommendations for administering tests online:

1. Randomize questions and answers. This prevents groups of students from taking tests at the same time and sharing answers.
2. Prevent backtracking. Once the student selects an answer to a question and clicks "next," do not allow them to return to a previous question. This, in combination with other recommended options, prevent students from sharing answers as they skip around the test to find similar questions.
3. Place a time limit on tests. Being restricted by time means that even if some students cheat, they would still have to be familiar with the material to know where to look and find answers in a timely manner. In addition, the FAA written tests are timed.
4. Allow open book tests and quizzes. This, in conjunction with time limits, forces the students to be familiar with the material before beginning the test. They must know where to look—in the book, in the slides, or in their lecture notes—otherwise, they will spend a good portion of time looking for answers to a few questions and unable to answer the others within the time allotment.
5. Require proctoring. If a class is offered completely online, it might be prudent to require one or two tests to be proctored. While software like Proctortrack might be too aggressive, there are testing centers and other less intrusive proctoring methods.
6. Allow multiple attempts. The goal of education—encompassing tests and assignments—is for the students to learn. Randomizing questions and allowing retake attempts promotes learning. Simply allowing students to retake the same test multiple times without randomly introducing new questions is less effective.

Administering online tests, quizzes, and exams can be an effective tool to promote learning. Instructors can implement a variety of methods to enhance learning and curtail cheating through testing. No one-size-fits-all solution exists, and depending on the circumstances and preferences, instructors should experiment with different methods or a mixture of methods to determine what works best.

ASSIGNMENTS

Under the heading of assignments is a plethora of subheadings. In general, when assignments are mentioned in this article, it can mean graded work other than tests. Some assignments are highly scrutinized by the instructors and graded strictly, but there are also assignments where instructors check for completion. A learning management system (LMS) supports both types of grading.

Assigning and grading homework, worksheets, and papers differ little between face-to-face classes and online classes. Students have more freedom to complete the assignments with fewer restrictions: Assignments are usually open-book, can be collaborative, and the only time restriction is the due date. Students then turn in the assignment, and the instructor assigns a grade.

In the online classroom, students submit assignments electronically: through LMS or email. While students usually have more time and resources to complete assignments—compared to quizzes, tests, and exams—academic dishonesty still represents a challenge. Cheating is a legitimate concern, but assignments are intended to supplement lectures and deepen understanding. Therefore, students who cheat may receive high marks on the assignments, but they ultimately hurt themselves when it comes time to test.

Written work, such as papers, presents numerous avenues for academic dishonesty, some of which are nearly impossible to detect, much less prevent. Plagiarism detection software is commonplace (Gabriel, 2010). Instructors of both online and face-to-face classes use this software, and it is employed ad nauseam—it seems that no form of written work escapes its inquisition, from the most miniscule of papers to theses and dissertations. This software certainly deters plagiarism. However, students intending to commit academic dishonesty will not be stopped by "Turnitin." Some try to outsmart it, and others seek to bypass it completely (Gabriel, 2010). In fact, this software is as effective as the Maginot Line. The software is a barrier that is difficult to breach, so the dishonest student circumvents the software altogether.

One major—and worrisome—way in which the cheater can bypass plagiarism detection software is by not plagiarizing. That might sound like mission accomplished, but there is a twist: cheaters turn to professional cheating services such as No Need to Study (Malesky, Baley, & Crow, 2016). This company shamelessly advertises on its front page: "Here our PRO tutors are taking classes, acing exams, doing homework, writing essays, and getting straight A's [sic.] for students like you. All day, every day." Scrolling down a bit, one encounters the phrase, "Paying someone to take your online courses for you has never been easier!"

A journalist reached out to the service—for the sake of journalism—and discovered that for $1,225.15, he would be guaranteed a B or better in an online English Literature class at the vaunted Columbia University (Newton, 2015). It is

Turbine Hydraulic Landing Gear System Trainer Now Available!

This trainer is a fully functioning jet-style landing gear system.

AL45 Turbine Hydraulic Landing Gear System Trainer

- Uses phosphate ester-based fluid—Skydrol®—which is commonly used on modern transport category aircraft
- Operational jet-style multi-disc brake system with brake pedal, master cylinder, brake, wheel and tire assembly
- Hydraulically activated air speed brake system with control valve and safety valve

Item AL45

AVOTEK® Now Offers Ed-Lab Electronic Trainers by Azimuth Aerospace Solutions

Complete your school's set of electronics and avionics trainers with these analog and digital labs:

- KV920 Aircraft Lighting Systems Lab
- CES 500 Exploratory Electronics Lab
- CES 651 Electronics Systems Lab
- CES 702 Digital Systems Lab
- CES 750 Exploratory Digital Lab

AVOTEK®
P.O. Box 219 Weyers Cave, VA 24486
800-828-6835 | Int'l 540-234-9090
www.avotek.com

difficult to determine what is more shocking: the price tag of $1,225.15 or the guarantee of a B or better at a top-10 university in the nation. Setting aside the debate of the value of the dollar, $1,225.15 is not very expensive, especially considering that the student could work to earn just as much in lieu of spending time on coursework.

Regardless of whether professional cheating services have the expertise to complete AMTS courses, this trend is alarming. For one, it is nearly impossible to detect. If students pay someone to do their work, it is considered original, and plagiarism detection software will not flag what is original. To date, plagiarism detection software does not have the ability to identify whether the student did the work or someone else who was paid to do it. This same problem can easily extend into the realm of testing, where students pay someone to take tests for them.

Thankfully, an AMTS is not as easy to perpetrate. Practical hands-on projects must be completed in-person. Instructors can verify the identity of a student by comparing this person to available ID photos (Malesky et al., 2016). Furthermore, government-issued IDs are checked before taking exams required for the A&P certificate. However, it would be remiss of me to say that it is impossible for this to occur at an AMTS. It is extremely difficult—and illegal—but not impossible.

Consider this: a student has to pay someone to take the whole curriculum for them, involving forgery of government issued documents and impersonation. Commitment to completing a whole Part 147 program is measured in years, not months. What keeps this person from quitting halfway? Suing the person is, well, self-incriminating. Additionally, one cannot demand a refund for a service that was never supposed to happen. So, while it is not impossible, the stakes are very high. A more realistic scenario is for students to pay someone to do their work for the portion of class offered online or general education classes required for obtaining degrees.

I spent a great deal of time discussing this pernicious trend in academic dishonesty because to say this will never happen is irresponsible. The Titanic sank. Pearl Harbor was ruthlessly attacked. The Maginot Line was circumvented. While we might have enacted policies to prevent cheaters from listening to recorded answers on their MP3 players, using the memory banks of their TI-83 Plus calculators to store answers, and created software to detect plagiarism, we have not outwitted the cheaters. These are serious issues that will plague academia in the years ahead, and AMTSs are not immune. If we allow these problems to persist, the validity of acquired knowledge might be questioned (Faurer, 2009).

CONCLUSION

Many tools are available to enhance online learning, dissuade academic dishonesty, and offer flexibility. Just like teaching a class face-to-face, online teaching has its unique challenges. Creating or converting a course to be offered online requires an initial investment of time and continuous improvements. Teaching the material well is critical, but assessing students' understanding of the material is equally important. In sum, I discussed methods of assessment for distance education as well as the ever-evolving variants of academic dishonesty. By no means is this article a complete discussion of all facets of online assessments, but it should serve as a starting point and posit pitfalls to consider and avoid.

REFERENCES

Cabrera, D. (2013, March 4). Tips to reduce the impact of cheating in online assessment. Northern Illinois University Instructional Design Center. Retrieved from https://facdevblog.niu.edu/onlinecheating

Faurer, J. C. (2009). Grade validity of online quantitative courses. Contemporary Issues in Education Research, 2(1), 71-74.

Gabriel, T. (2010, July 5). To stop cheats, colleges learn their trickery. The New York Times. Retrieved from https://www.nytimes.com/2010/07/06/education/06cheat.html

Grijalva, T.C., Nowell, C., & Kerkvliet, J. (2006). Academic dishonesty in online courses. College Student Journal, 40(1), 180-185.

Malesky, L. A., Baley, J., & Crow, R. (2016). Academic dishonesty: Assessing the threat of cheating companies to online education. College Teaching, 64(4), 178-183. doi:10.1080/87567555.2015.1133558

Newton, D. (2015, November 4). Cheating in online classes is now big business. The Atlantic. Retrieved from https://www.theatlantic.com/education/archive/2015/11/cheating-through-online-courses/413770/

Paullet, K., Chawdhry, A. A., Douglas, D. M., Pinchot, J., & Morris, R. (2016). Assessing faculty perceptions and techniques to combat academic dishonesty in online courses. Information Systems Education Journal, 14(4), 45-53.

Singer, N. (2015, April 5). Online test-takers feel anti-cheating software's uneasy glare. The New York Times. Retrieved from https://www.nytimes.com/2015/04/06/technology/online-test-takers-feel-anti-cheating-softwares-uneasy-glare.html

Stowell, J. (2015). Online open-book testing in face-to-face classes. Scholarship of Teaching and Learning in Psychology, 1(1), 7-13. doi:10.1037/stl0000014

Sullivan, D. P. (2016). An integrated approach to preempt cheating on asynchronous, objective, online assessments in graduate business classes. Online Learning, 20(3), 195-209.

Tolman, S. (2017). Academic dishonesty in online courses: Considerations for graduate preparatory programs in higher education. College Student Journal, 51(4), 579-584.

ARE WE TRAINING FOR TESTING OR TRAINING FOR INDUSTRY

By **Carlos Smith**
Assistant Professor, Aerospace Department
Middle Tennessee State University
carlos.smith@mtsu.edu

ABOUT THE AUTHOR

Carlos Smith is a tenure-track assistant professor at Middle Tennessee State University. He has his masters in Aviation Administration with a concentration in Education and a bachelor of science in Aeronautical Industry Technology with an emphasis in Industrial electronics. Over the past 13 years, he has held an education career in High School, Technical School and at the University level. Carlos holds his license as an Airframe and Powerplant (A&P) Technician and worked at Embraer Aircraft Maintenance Services on the ERJ Legacy, 135, 145 and 170 airliner aircraft. He sits as an advisory board member for the Tennessee State University Aeronautical Industry Technology department and for McGavock High School's Aviation and Transportation Academy. In his spare time, he also mentors the students of the Middle Tennessee State Aviation Maintenance Club and the youth in different communities.

ABSTRACT

The aviation industry is constantly growing and advancing, especially in terms of technology. The possibilities of this industry are nearly limitless. Air transportation has become a complicated, but highly coordinated, network of people and complex machinery. The contribution of aviation maintenance technicians to keeping the industry running cannot be overstated. Given that, training certificated Aviation Maintenance Technicians (AMTs) who are well prepared to enter the industry is crucial. However, the training standards for testing for the Federal Aviation Administration (FAA) Airframe and Powerplant (A&P) technician exams have only had minor updates within the past 27 years. This is important because students must proficiently pass the A&P exams to exemplify their preparedness to work in the industry by the FAA's standards. However, it is difficult to state that students are being trained for the current industry needs, when the requirements to become certified does not match industry expectations. This paper looks at the current state of maintenance training versus FAA requirements and industry needs, and makes suggestions for improvements.

INTRODUCTION

Based on the anecdotal evidence from recent alumni, students often leave Aviation Maintenance Technician Schools (AMTS) feeling as if they are not prepared for the real world of the aviation maintenance industry. This is especially true for students who are interested in a career at the major airlines, working with corporate business jets or aircraft maintenance repair stations, versus those going into general aviation. The feeling of unpreparedness—or under preparedness—may be traced to several items, one of which is A&P testing procedures, which have remained the same for more than 50 years. Notices of Proposed Rulemakings (NPRM) have been sent forth several times and one is currently under review, but thus far little has changed. Additionally, by the time these changes are reviewed and passed, they may have already become outdated.

Recently a discussion on this subject was held with the students in an AMT class. The majority felt that (AMTS) are designed to teach students how to pass the FAA A&P exams, and this author had a similar experience. Despite doing well in class, understanding the subject material, and receiving good grades, the transition from classroom to industry was not seamless. Once employed by an actual maintenance facility, the competency demands were much different. Most training which had been had helped with preparation for general aviation maintenance but not the transport category maintenance required by airline industry.

For the past three years the author has taken a group of students to compete in the Aerospace Maintenance Competition presented by Snap-on and various industry sponsors. Each year this event is held at a different location along with the Maintenance, Repair, and Overhaul (MRO) Conference. Although students are trained in each area, the requirements and equipment used in this competition are far more modern and advanced than what schools are required to have, and those used during A&P testing. For example, students may use analog vacuum pump equipment to test the pitot static system at their school, however during the competition they are required to use digital electronic equipment. Although the functionality of the maintenance equipment is similar, without being trained to use them, students easily become confused on its use. Luckily they are instructed by the judges at each station on how to use the equipment before each event. After completing the competition, students gain understanding of the current industry standard equipment that is being used in the field versus what they are familiar with in AMTS. However; this can lead to students feeling as if they are not fully prepared for the current industry. The up side to students going to these competitions is that it allows for the exposure and practical experience related to the field.

According to Careers in Aviation Maintenance (n.d.), “The competition’s sole purpose is to raise awareness of the training and skills needed to provide safe and airworthy aircraft worldwide while providing a venue for AMT students to celebrate their technical competency on a grand and public stage,” (para. 6). This is just one example of a type of encounter students may face. If students are not fully prepared for the aviation maintenance industry then how can they properly fill the shortage gap? In order to fill this gap, there has to be a change in the Part 147 curriculum.

Maguire (2017), states the following:

> *Outdated training mandates are more than an impediment; they hinder the aviation maintenance industry’s economic growth. As the global aviation sector expands, economic forecasts predict that U.S. maintenance companies will be unable to meet increased demand because of a significant skilled worker shortage.*
>
> *To meet the need, training organization must produce better prepared aviation mechanics… (para. 14)*

Little emphasis has been made to account for the constantly evolving industry maintenance standards, which means that the knowledge base for technicians has not been holistically addressed. Over the years, people have questioned why welding, fabric covering, wood and pressure carburetors are still taught (Dyen, 2017). It has also been proposed that the level of teaching required for overhauled magnetos, carburetors, and ignition harness as a return to service simulated project is not nearly as necessary anymore (Goldsby & Soulis, 2002). This is mainly because these items are able to be purchased pre-overhauled or assembled at reasonable rates reducing time to be overhaul and possible shipping times to and from a repair station. Although it is still important for students to be familiar with these subject areas, since it is still relevant in the field, it is equally important that there is focus on new and innovative technology that is seen in the industry. With constantly evolving technology and industry practices, it is imperative that maintenance training continues to keep up with new demands.

BRIEF HISTORY

The FAA certification process is used to enforce and ensure that all AMTS students are receiving proper training, according to Title 14 of the *Code of Federal Regulations* (14 CFR) Part 147. Title 14 CFR Part 147 Subpart B section 21 states that each student is required to meet a minimum of 1,900 hours of training. This includes 400 hours of general, 750 of airframe, and 750 of powerplant which was “originally adopted in 1970.” (DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Final Rule, 1992, p 2). By 1988 it was realized that technicians graduating at that time, under those original standards, were nowhere near prepared for the industry. To address this issue, the FAA made minor changes to best prepare students for the aviation field. Additionally, the FAA held a series of public listening sessions to determine the industry’s needs. Commenters suggested a long list of changes to different sections of Part 147 such as revising, removing and adding paragraphs along with subject descriptions and headings. For example, better highlighting the aircraft maintenance records and mechanic responsibilities, including constant speed drive and integrated drive generator systems, and removing OMEGA navigation systems to replace with LORAN and radar beacon transponders. After receiving feedback, the FAA moved forward with a Notice of Proposed Rulemaking (NPRM) for modifications to 14 C.F.R. Part 147 in 1990. In 1992 this proposed ruling was accepted and amended (DOT

Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Final Rule, 1992). As an additional example to those mentioned, under curriculum subjects in the powerplant systems and components section the following were added. Repair of aluminum propellers, the inspection and troubleshooting of unducted fan systems, and inspection, checking, servicing and troubleshooting of auxiliary power units (DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Final Rule, 1992).

On October 2, 2015 the FAA issued a NPRM to amend the current regulations for Part 147, as it described an out-of-date curriculum and was not meeting industry needs. As of April 16, 2019, the FAA issued a Supplemental Notice of Proposed Rulemaking (SNPRM) to expand the October 2, 2015 NPRM to include competency-based training, satellite training locations, and to change the requirements for national passing norms to a standard pass rate. Competency-based training would help to eliminate the instructional hours and allow students to advance in their training based off of their individual performance. Although not recommended to be accepted by the FAA, the Aviation Technician Education Council is proposing the use of satellite training locations. This would allow satellite training locations such as high schools to be used to help complete secondary training. Although similar programs do exist, this would make it available to all high schools to offer a partnered program with a secondary Part 147 institution (DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Proposed Rule, 2019).

It appears now that history is repeating itself. As many educators know, the wheels may turn very slowly when it comes to improvement. Consider that the prior amendment took about 18 years to realize that the maintenance curriculum standards were not keeping up with industry standards. After realizing this, it then took another two years to propose any changes and improvements. There was then again an additional two-year period for comments and concerns to be considered before finally making amendments statutory, as it did in 1992 (DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Final Rule, 1992).

Since 1992, small changes have been made to 14 CFR Part 147, but we are again at a time of needing a revision and update to the Part 147 curriculum. Because of the ever-changing industry of aviation, current industry demands must be met to produce successfully prepared AMT. Recently; the FAA issued a SNPRM to review comments from the industry for revisions that ended on February 1, 2016 (Barbagallo, 2015). As we take a look back at the previous process, we should be near to receiving a final rulemaking. However, with the SNPRM issued extending this period, we must wait patiently to see the outcome.

PROBLEMS AND SOLUTIONS

It has been stated that, over the past 56 years maintenance training standards have not changed much at all (Bergqvist, 2018). This seems unacceptable in an industry that has experienced as much technological change as aviation has. The FAA should implement a change to match the demands of the industry. The greatest issues with incorporating industry standards are cost, additional training, transitioning to competency-based standards with maintenance operations specifications manual rewrites and approval, and having resources with the energy required by all involved to make the changes necessary, starting with regulatory changes.

One of the major areas of concern deals with the cost required to improve aviation maintenance programs to meet these new standards and to maintain contemporary equipment. The first step toward modernizing AMTS should be updating all outdated equipment. The cost of modern equipment is not cheap; however, with the proper resources and financial planning, it is feasible. Alternative solutions may include the use of emerging technology like simulators and virtual/augmented reality trainers, local repair facilities which may demonstrate the use of modern technology and the ability to train in OEM manufactures maintenance training facilities. However, the downside is that some of the OEM training can be very expensive. Outside the normal allocation of funds, there are grants available that could assist with this movement. For example, those employed at federally funded intuitions can apply for enhancement grants that can be used to improve classrooms and laboratory training environments.

Instructor training is another area of concern. Some maintenance instructors have been teaching the same way for many years and may not want to change. Adapting to new procedures can make it difficult for some types of instructors, especially if they are nearing retirement age or not willing. These types of instructors may also feel that they have done it this way for years and it has worked in the past so why change now (Jenson, 2014). Nevertheless, to enhance training skills for modern technology, manufacturers of products and equipment suppliers offer training courses as well. As an example, National Business Aviation Association (NBAA) is a great scholarship source for additional training or refresher courses offered to current industry professionals and students. The NBAA's goal is to help keep the aviation industry proficient, industrious and prosperous. One of its major scholarships offered to AMTs is the AMT Maintenance Scholarships, with the opportunity for 37 different courses. Students that obtain these scholarships can share their knowledge gained with their classmates and instructors to help improve the AMT programs or instructors may be awarded scholarships as well to attend these courses allowing them to teach at the most modern training level.

We might also find that the learning styles of each individual student can be hindered because of time constraints. Generational gaps must also be accounted for in order to provide the best instruction (Jenson, 2014). The current regulations allow a maximum of 25 students in each laboratory class setting. In the case of having one instructor, this spreads the availability of the instructor to each student very thin, especially for those needing greater attention. While some students lack knowledge and skills in certain subject areas, others may thrive at the same subject areas making it difficult to pace an entire class. This then leads to the fact that not only do the topics to be covered need to be changed, but also the whole approach in the way students are being trained.

As a result, some students can lose drive and motivation while others never fully comprehend the material. Additionally, by requiring students to be present once meeting course objectives does not make them anymore competent. For example, if a student is given a specific set of instructions to perform a task and completes the objective within two hours instead of three, having that student spend an additional hour on that same assignment is not necessary with the benchmark for acceptable practices being met. Likewise, attempting to give students additional projects to keep them engaged takes away from assisting those students who need additional one-one help. These concerns could be solved by transitioning from hours-based training to competency-based standards, even though this would lead to major rewrites of the AMTS's operations specification manual, along with requiring the local Flight Standards District Office and Principle Maintenance Inspector to approve any changes.

CONCLUSION

The job of aviation maintenance training professionals is to produce students who have the confidence and skills necessary to meet the current job requirements. It is not expected that students graduating from AMTS are able to maintain all industry category aircraft, however it is important that their skill level is compatible with the growing industry demands. Many may fear a big change to the Part 147 curriculum, but it is necessary. As an example, the implementation of new equipment requirements potentially would be no different than aircraft owners having to make their aircraft Automatic Dependent Surveillance-Broadcast (ADS-B) compliant by January 1, 2020. To allow aircraft owners to meet this FAA requirement, a grace period was put in place because of cost (Aircraft Owners and Pilots Association, 2015). Using a similar timeframe to get updated equipment into maintenance schools would help to eliminate stress and financial burden of meeting this mandates immediately. For example, after the FAA approves the Part 147 rewrite, each school could be given a 10 year period to become compliant. This would allow for an adjustment in the curriculum and equipment changes from the days of early aviation to more modern technology.

Dyen (2017), states the following:

> *The aviation industry needs an educated and competent technician that can maintain modern aircraft, yet the AMTS have been forced (by FAA regulation) to teach students from a curriculum developed around the Douglas DC-6, including such specialized subjects as dope and fabric, aircraft welding, and pressure carburetors (p. 4).*

Kroes, Watson, and White (2000) state that AMTS are no longer meeting the standards to be considered a world leader in aviation maintenance education. To regain our ranking as such, we need to increase our AMT training and not just prove that our students can correctly answer a series of questions to pass a test. Regaining a better global stance could easily be met if schools had the proper funding and current equipment to meet these demands.

In different articles that pertain to aviation maintenance training, there seems to be a common consensus that the current FAA Part 147 standards are outdated (Maguire, 2017; Broderick, 2017). As we move further into the twenty-first century, we see more modern technology making its way into the aviation industry. We have transitioned from a time of paper documents to electronic filing and record keeping. For example, form 337s had to be submitted in writing and sent through mail, which can now all done on the electronically online. Manuals used to be on microfiche or in a hardcopy paper print form and now electronic searchable format files have become acceptable commonplace use. Navigation was once done via analog instrumentation, and can now be illustrated by visual graphic display units and Global Positioning Systems (GPS). The point of the matter is that change is inevitable, and we must keep up with the times.

According to Shay (2018), the use of new technology is on the rise. As we look at this trend of new technology and how aircraft are advancing, it greatly affects the technician and his or her ability to know how to maintain these aircraft. If an aircraft is equipped with self-diagnosing and self-healing technology, we are then maintaining the computer operation system. This would mean adding additional training and the introduction of new knowledge and skills. As artificial intelligence makes its way into aircraft, it will create a whole new trend of training (Shay, 2018).

Others may say this falls in the hands of avionics technicians. If so, where does this leave all the maintenance technicians? With growing industry trends and the continued need for maintenance technicians we should not skimp on our school training standards. This way we can begin preparing technicians to be able and ready to take on the constant industry changes. If the industry constantly has to adjust for changes, then our school training should very well reflect the same. To keep up with the constantly evolving industry, we must focus our future on our training (Aviation Institute of Maintenance, 2014). Let us now regain our status as leaders in technology and increase the margins for our training procedures as well.

REFERENCES

Aviation Institute of Maintenance (2014). The biggest problem with aviation maintenance, and how you can fix it. FAA Career Training. Retrieved from http://www.aviationmaintenance.edu/blog/aircraft-mechanic/biggest-problem-aviation-maintenance-can-fix/

Aircraft Owners and Pilots Association (2015). Air traffic services brief – automatic dependent surveillance-broadcast (ads-b). AOPA. Retrieved from https://www.aopa.org/advocacy/advocacy-briefs/air-traffic-services-brief-automatic-dependent-surveillance-broadcast-ads-b

Barbagallo, J. (2015). Certification of operation of aviation maintenance technicians schools. Advisory Circular No. 147-3B. Retrieved from https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_147-3B.pdf

Bergqvist, P. (2018). SUU aviation aims to change FAA maintenance curriculum. Flying Mag. Retrieved from https://www.flyingmag.com/suu-aviation-aims-to-change-faa-maintenance-curriculum

Broderick, S. (2017). U.S. maintenance training standards poised for major overhaul. Business Aviation. Retrieved from https://www.ainonline.com/aviation-news/business-aviation/2017-12-27/us-maintenance-training-standards-poised-major-overhaul

Careers in aviation maintenance. (n.d.) AVMRO. Retrieved from http://avmro.arsa.org/careers/

DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Final Rule, 57 Fed. Reg. 41370 (September 9, 1992) (to be codified at 14 C.F.R. pt. 147).

DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Final Rule, 57 Fed. Reg. 28952 (June 29, 1992) (to be codified at 14 C.F.R. pt. 147).

DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Proposed Rule, 80 No. 191 (April 16, 2019) (to be codified at 14 C.F.R. pt. 147).

DOT Federal Aviation Administration; Revision of Aviation Technicians Schools Regulations; Proposed Rule, 84 No. 73 (April 16, 2019) (to be codified at 14 C.F.R. pt. 147).

Dyen, F. D. (2017). A delphi study of aviation maintenance experts' recommendations for a model school curriculum. Old Dominion University Digital Commons. Retrieved from https://digitalcommons.odu.edu/cgi/viewcontent.cgi?article=1007&context=teachinglearning_etds

Goldsby, R. P., & Soulis, A. S. (2002). Optimization of aviation maintenance personnel training and certification. Retrieved from https://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/human_factors_maintenance/optimization_of_aviation_maintenance_personnel_training_and_certification.pdf

Jenson, A. J. (2014). Aviation training going forward: Five ways to improve training. International Civil Aviation Organization (ICAO) Training Report, 4(2), 4-6.

Kroes, M., Watson, J., & White, C. W. (2000). Aviation maintenance technician training: Training requirements for the 21st century. Next Page Live Publish. Retrieved from https://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/human_factors_maintenance/aviation_maintenance_technician_training_training_requirements_for_the_21st_century.pdf

Maguire, C. (2017). Aviation struggles with 50-year-old maintenance training regulation. The Hill. Retrieved from http://thehill.com/blogs/pundits-blog/transportation/345631-aviation-struggles-with-50-year-old-maintenance-training

Maguire, C. (2017). The new part 147: Where are we now? Education and Training. Retrieved from https://www.aviationpros.com/press_release/12339081/the-new-part-147-where-are-we-now

National Business Aviation Association. (2015). It's really about nowgen. NextTech For NextGen. Retrieved from https://www.nbaa.org/prodev/nexttech/2015-nexttech-for-nextgen.pdf

Shay, L. A. (2018). The hype factor behind emerging technologies and blockchain. Inside MRO. Retrieved from https://www.mro-network.com/emerging-technology/hype-factor-behind-emerging-technologies-and-blockchain?NL=AW-022&Issue=AW-022_20180927_AW-022_106&sfvc4enews=42&cl=article_1_b&utm_rid=CPEN1000003193416&utm_campaign=16554&utm_medium=email&elq2=78ac78a5ca2d4f56b1a7752b643eeb12

2019 WASHINGTON FLY-IN

SEPTEMBER 10-13

On September 10-13, ATEC members will crisscross the nation's capital to meet with members of Congress on issues impacting aviation maintenance technician education. Join us for meetings with regulators, legislative leaders, and industry allies.

MORE INFO | REGISTER | PREPARE

> "First time working on Capitol Hill, and I must say it was a learning experience. I would encourage everyone to attend and take an active part in promoting our career agenda. Regardless of your political affiliation, you owe it to yourself to be active, contribute to ATEC efforts and learn from that experience."
>
> La Vern Phillips
> *Director of Business Development, Aviation Institute of Maintenance*

MAINTENANCE TRAINING AND HUMAN FACTORS: A PERSONAL PERSPECTIVE

By **William B. Johnson, Ph.D.**
Chief Scientist and Technical Advisor for
Human Factors in Aircraft Maintenance Systems
Federal Aviation Administration
bill-dr.johnson@faa.gov

ABOUT THE AUTHOR

Dr. William Johnson is the FAA Chief Scientific and Technical Advisor for Human Factors in Aircraft Maintenance Systems. He is the top FAA executive responsible for R&D and technical programs related to human performance in maintenance/engineering. Bill has 40+ years as a Senior Executive and Scientist in private and public engineering and airline companies. He has held pilot and mechanic credentials for over 50 years. Dr. Johnson has deliverd safety-related speeches, to a variety of aviation and other audiencies, in over 50 countries, and has published over 500 technical papers/presentations.

ABSTRACT

This paper offers a personal perspective of selected aviation maintenance (Mx) training and human factors (HF) over the past 40 years. That time frame and content are closely matched to the author's full-time involvement working in those inseparable domains. This paper is much like an annotated bibliography rather than a detailed accounting of each activity. The Federal Aviation Administration (FAA) has been a primary sponsor of much of the more recent activity.

AUTHOR'S AVIATION ROOTS (THE SIXTIES)

It is difficult to designate an exact point to start this treatment of my involvement in aviation maintenance (Mx) training and human factors (HF). Therefore, I will begin with the time I started as an "aviator". I learned to fly in the mid-sixties, earning a Private Pilot Certificate in 1966. Flying from an unpaved airport about 60 miles south of Chicago, I had the opportunity to learn a lot about the maintenance of the training aircraft. The Piper J-3 Cub, Colt, Cherokee, and a Stearman biplane were all maintained on the airport. My flight instructor, Delbert Koerner was one of the Airframe and Powerplant (A&P) Mechanics. He was also the owner of all the aircraft, the hangar, and the field. He took his first certificate check ride from Orville Wright, during an air show in Chicago. I was fortunate to learn about aviation in an era that hardly exists today. Without doubt, it influenced my personal perspective of aviation. It hooked me, not only as a pilot, but as an aviation enthusiast. From the very start, I learned about aircraft building, Mx, and more. It affected my life career decisions. It helped prepare me for the FAA executive scientist position that I hold today.

By my third year as an undergraduate math-physics major I realized that it was time to redirect my education to aviation. I enrolled in an Aviation Maintenance Certificate program at the University of Illinois. That permitted Mx training, more flight training, and advanced degrees in education. Being a few years older than the new college student colleagues in Mx training, I suspect that I became interested in how humans learn about applied mechanical subjects. I believe that I already paid attention to what made one instructor different/better than the other. As I learned the fundamentals of aircraft Mx, I was unconsciously studying human performance in Mx training environments. I was especially interested in how aspiring maintenance personnel engaged in technical decision-making (AKA, troubleshooting). I did not know the educational psychology language at the time, but I was observing and experiencing the training techniques for developing cognitive, psychomotor, and attitudinal goals for aspiring Aviation Maintenance Technicians (AMTs). As a student in Mx and flight, I learned to appreciate the interrelationship of the two. As an undergraduate, I was unfamiliar with the language of HF in Mx. But, I did learn that human knowledge, skill, performance and attitude were critical for flight safety. I earned my A&P Certificate in 1969 and completed a B.S. degree in 1971.

AUTHOR'S INITIAL RESEARCH ON TRAINING AND HF (THE SEVENTIES)

By the mid-seventies, I was teaching in the Mx program at the University of Illinois, Institute of Aviation while pursuing a Ph.D., in education. I became involved in a multi-disciplinary unit (called the Coordinated Science Unit) of the University. It combined industrial and mechanical engineering, computer science, psychology, and education. We used unfamiliar terms like "Human Factors," "Artificial Intelligence," "Decision Support Systems," "Computer-Based Training," "Intelligent Tutoring Systems," and more. Such concepts, at that time, were ill-defined and certainly not household words in any discipline, much less aviation Mx. Our team focused on decision-making and fault diagnosis (Rouse, 2007). My work concentrated on how to apply decision support systems to help mechanics develop, or improve, their skills as diagnosticians (Johnson & Rouse, 1980). An example of graphic displays from our 1970s training systems are shown in Figure 1. The graphic, running from a large old-school main frame computer, precedes the advent of today's

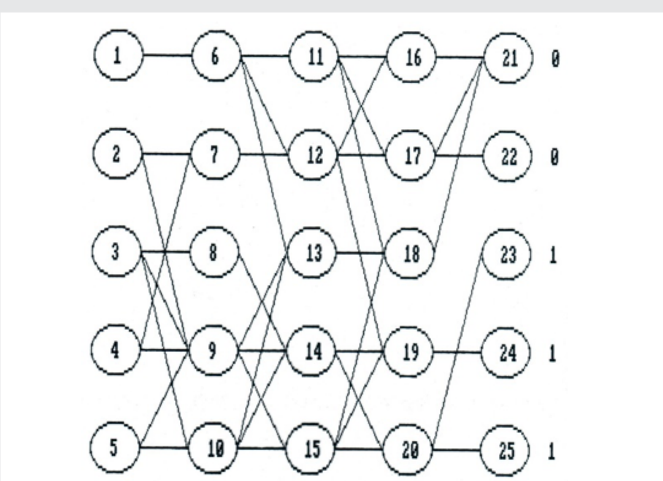

Figure 1: Fault diagnosis training systems from 1970s research.

graphical user interfaces. We created computer-based decision support and training approaches that evaluated the learner's transfer from training to live systems (Johnson, 1981; Johnson & Rouse, 1982a, 1982b). Our laboratories had the benefit of state-of-the-art large computers and new emerging microcomputers that were in their infancy.

To summarize our research and development of the late seventies, we learned that we could develop training approaches that affected the mechanic's approach to troubleshooting technical systems. We proved that training for logical decision making was a significant enhancement to the traditional training of only the technical systems. We learned how computer-based training could be designed to deliver much more than mere declarative information. We learned that the computer could adapt to individual learners so that it could match the diagnostic challenges to the level of individual learners (Johnson, 1981). My Ph.D. work (Johnson, 1981; Johnson & Rouse, 1982a, 1982b) left our laboratories and was adopted by the Flight Safety International (FSI) training company. FSI has continuously evolved and continues to apply the *Fundamentals of Troubleshooting* for more than 25 years, delivering training to thousands of Mx personnel.

FROM TECHNOLOGY-BASED MX TRAINING TO HF (THE EIGHTIES)

Early Microcomputer Simulations for Aviation Training

In the early eighties our applied research and development expanded from aviation (Trollip & Johnson, 1982), to military systems (Johnson, 1984; Johnson & Fath, 1984), to the electric power industry (Johnson & Maddox, 1983; Johnson et al., 1984).

As our training systems evolved, we capitalized on increased microcomputer processing and display capability to help the maintainer be able to transfer the classroom theory into operational practice. The sponsor was the U.S. Army Research Institute. The operational environ was for diagnostic training for electronics troubleshooting at the U.S. Army Signal School at Fort Gordon, Georgia. We coined the term Simulation-Oriented, Computer-Based Instruction (SOCBI) (see Figure 2). That meant that the training system acted and looked like the real system, but it did not contain a full simulation model. It provided sufficient fidelity to enhance practice in diagnostic decision making (Johnson & Fath, 1984).

Intelligent Tutoring

Since the seventies, our research and development sought ways to adapt the training to the specific needs of individual learners. We tried to mimic the behavior of a human tutor. Thus, we were developing and measuring the effect of a mix of computer-based simulation and Intelligent Tutoring software (Johnson, 1987; Johnson, 1988a, 1988b).

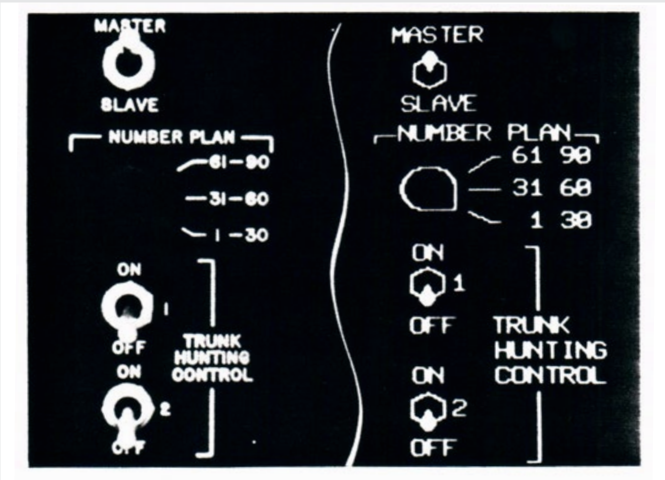

Figure 2: Early 1980s graphics for SOCBI – real vs. graphic.

Authoring Tools

During the eighties, we created and tested new Mx training approaches, mostly technology-based. Our next obvious step was to build tools and guidance for others to create or modify these training systems to meet specific training requirements. The tools were called authoring systems and were aimed at training developers rather than computer scientists (Johnson, 1989; Johnson, Neste, & Duncan, 1989). We noticed that the authoring systems helped trainers to conceptualize training and simulation plans. However, as the graphics and intelligence became complex, the trainers often reverted to software specialists to complete the development.

Triggering Events Drive Human Factors Research

The late eighties presented many reasons to increase attention to the human in the system. The examples contain system or location names like Three Mile Island, Aloha Airlines, Challenger, Chernobyl, Bhopal, MS Herald Ferry, Exxon Valdez, and more. The shared characteristic of these events was the quality of human performance in the design, operation, or Mx of these systems. A careful review, in hindsight, shows that all of these events were preventable. Governments, industry, research laboratories, universities, and engineering consulting companies shifted attention and resources to HF. The author was among that group. Much of the activity has been well documented elsewhere (Rankin & Johnson, 2017).

Our research and development group gained significant training and human-centered design experience in the electric power industry. That multiyear research was sponsored by the Electric Power Research Institute. We had significant interaction, regarding HF, with equipment designers, control room operators, licensed and unlicensed Mx personnel, training organizations, and senior management. Ninety percent of our work was HF. However, there was always a component of Mx and training. We published a significant amount of our work, gaining a reputation as experienced Mx HF consultants. That reputation affects the remainder of this paper. In 1988 I received a phone call, from the FAA, asking me if I knew anything about aviation Mx.

BUILDING THE MX-HF FOUNDATION (THE NINETIES)

The Aloha event happened in 1988. It became the primary impetus for a large portion of the aviation Mx HF programs that we know, even today (see Figure 3). That event brought attention to aging aircraft as well. The Aviation Safety Research Act of 1988 (Public Law 100-591- November 3, 1988) became the driver and ensured the funding. In addition to the language on aging aircraft, the law specifically stated that there shall be research, "...to develop a better understanding of the relationship between HF and aircraft accidents...." The law also said that there must be specific attention to aircraft Mx. Further, the law specified that the FAA must develop a National Plan for Aviation Safety Research (Johnson, 1991). Most importantly the law came with congressional funding including earmarks for research in Mx HF.

Figure 3: Aloha Airlines – Triggering Event for Research on Aging Aircraft and HF.

FAA Office of Aviation Medicine Takes Mx HF Lead

The Office of Aviation Medicine had the responsibility to lead the FAA HF research program. Dr. William Shepherd was the leader of that effort. When Dr. Shepherd called me for information about HF, it was a lengthy discussion. The call ended with an invitation to work on the team and to help the FAA write the National Plan for Aviation Safety Research (Johnson, 1991). I was not aware that my participation in that effort was a forecast of my professional work until now. Thank you, Dr. Shepherd.

Working with the FAA Office of Aviation Medicine, we did a

lot of planning to determine how we would get the HF message to the aviation Mx organizations. The found the answer by offering a series of annual MxHF workshops. For nearly 14 years, from 1988 to 2002, FAA conducted an annual conference on Human Factors in Maintenance and Inspection. The meetings were three-day events that permitted the FAA and others to showcase research and development findings and products (for examples, see Johnson, 1991; Shepherd & Johnson, 1991; Shepherd et al., 1991). The workshops became international events. Transport Canada and the Civil Aviation Authority of the United Kingdom joined in as co-sponsors. Delegate numbers started at 25 (1988) and expanded to a high of about 600 (2001). The event eventually became the current industry-government "Infoshare" for the Aviation Safety Action Program. The proceedings for all the meetings from 1989 through 2004 remain available on the FAA maintenance HF website at www.humanfactorsinfo.com.

When the workshops started, HF was not a household aviation industry term. That is true, especially in Mx organizations. In the early nineties, I recall HF training being called, Tree Hugging 101, or less favorable names.

Organized Labor Joins the HF Cause

As time passed, many saw the value of HF. Organized labor, like the International Association of Machinists (IAM), embraced HF research teams and helped convince workers that attention to human performance was a good thing. One IAM leader, the Honorable John Goglia, who later became a National Transportation Safety Board (NTSB) board member, was especially vocal about the potential value of HF research activities.

As industry labor and their management increasingly saw value in HF, activity in the area increased. The scientific, academic, and workshop speakers were joined by industry practitioners from U.S. and international airlines, repair organizations, and manufacturers. Industry and government also increased their cooperation related to HF. Some examples of the increased activities included the following:

- Personnel selection, training and certification
- Increased application of high and mid-fidelity training simulations
- System design for usability
- Creation of new processes, review of procedures and documentation
- Voluntary reporting
- Creation of new Mx test equipment

Activity was not limited to workshops. From 1989 through about 2002, FAA was well funded to conduct a variety of applied research and educational activities. During that time, the topics covered HF initial training development, training for regulations, creating of HF error taxonomies, helping FAA inspectors with automated job aides, challenges and solutions developing technical documentation, and more. The funded research team during that period consisted of about 10 universities, 10 engineering companies, and numerous individual consultants. All technical reports were included on an annual CD-ROM, which eventually migrated to the FAA Maintenance Human factors website (see Figure 4). The historical legacy of the entire research program remains on that site.

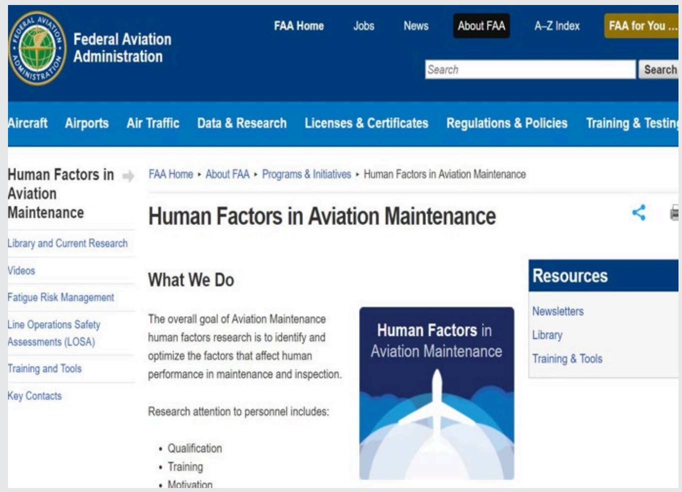

Figure 4: FAA Maintenance Human Factors Website.

The Human Factors Guide

An excellent example of significant outputs during the nineties was The Human Factors Guide for Maintenance and Inspection (Maddox, 1997). The 400-page, 15-chapter document was edited by Dr. Michael Maddox, who was also the primary author (HF, Shiftwork and Scheduling, Facility Design, Troubleshooting, Training). This significant document not only helped organizations to understand and establish HF programs but it also provided information to establish training programs. A Second Edition of the Guide was published in 2007 (Maddox, 2007).

A discussion of HF in the nineties must mention three models that remain influential for describing and helping recall HF concepts. The Dirty Dozen (Gordon Dupont), The Swiss Cheese (James Reason), and PEAR (Bill Johnson and Michael Maddox) (see Figure 5 and Johnson, 2016d for explanation of all models) all emerged around 1995. Continuing today, most HF fundamental courses introduce one of or all these models.

Return on Investment

Throughout the nineties, we were always interested in showing that there is a high return on investment (ROI)

in HF interventions (Hastings, Merriken, & Johnson, 2000; Johnson, 1997a, 1997b; Johnson, 1999). We used several popular calculations to make the point. We always felt that these techniques have not yet sufficiently attained their full potential to promote the value of HF and other safety interventions. We continued this type of research into the 2000s.

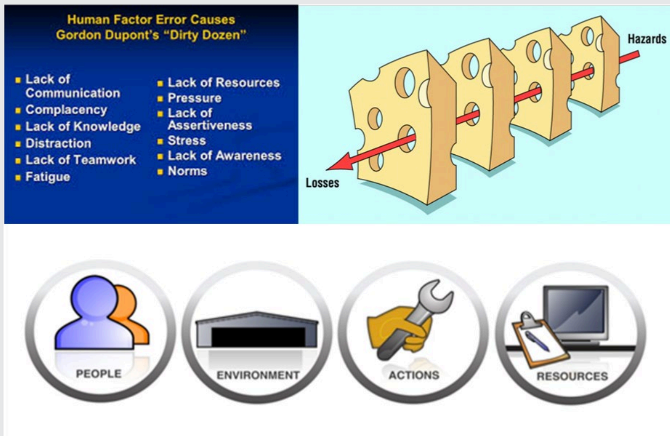

Figure 5: Ways to Learn and Recall HF.

HF in the United Kingdom and Europe

By the end of the nineties, the industry was familiar with HF. The Joint Aviation Authority (JAA), like the FAA, published numerous guidelines. By then, JAA created regulations that member states would deliver HF training to all engineering/Mx personnel. The European Aviation Safety Agency (EASA), when it began in 1992, adopted the JAA regulations. Many international National Aviation Authorities (NAAs) have since adopted similar regulations.

EXPANDING MX HF PROGRAMS WITH APPLIED RESEARCH (THE TWO THOUSANDS)

The 10-year period, starting in 2000, was abundant with Mx HF activity. The industry, universities, and government had accepted the importance of attention to the human for continuing aviation safety. This section describes a few of the hundreds of significant activities in which I became a prominent participant.

A research project, started in 1998 continuing to 2000, was the first significant study of the work conditions in aviation Mx environments. Nearly 200 AMTs from airlines and Maintenance, Repair, and Overhaul (MRO) stations agreed to wear instrumentation that measured noise levels, temperature, humidity, and level of activity at work. The activity level also equated to sleep duration, because participants wore a watch-like actigraphy instrument (larger than today's activity watches) continuously 14 days. The data represented large and small organizations, multiple age groups, and all shifts. The project resulted in the first accurate, valid, and reliable indication that the Mx workforce was not getting sufficient rest (Hall, Johnson, & Watson, 2001; Johnson, Hall, & Watson, 2002; Watson & Johnson, 2001). Fatigue is a hazard to Mx-related safety. It has been a focus of continuing applied research and development since then (Johnson, 2018j).

Human Factors Training in Europe

In the early 2000s, when EASA established regulations for HF training, there was a big push to develop HF training aligned with the specific EASA training content requirements. All international Mx providers that did business with EASA countries had to have HF training programs.

Lufthansa Technical Training took the international lead in the development of EASA-approved training. They created a two-day course that they classified as Blended Human Factors Training (Johnson & Poetter, 2003). The blend was about eight hours of declarative information training delivered via a modern computer-based training format.

They were especially careful to design the training with adult learners in mind (Johnson, 2004c). That system contained more than 250 animation files to cover the fundamentals of HF. After learners completed the computer-based training, they had to complete and pass a test to proceed to the second stage of training. Stage 2 was a full day of classroom training that included extensive interaction and application of HF principles. While building the training, they were very sensitive to evolving regulations and standards (Johnson, 2003, 2004a, 2004b; Johnson & Meyerrose, 2004). Lufthansa promoted the course as a substantial cost savings over other HF course offerings (Johnson, 2004a, 2004b, 2004c). The product was very successful for Lufthansa, using it to train more than 12,000 of their engineering employees and selling the training package and consulting services to many Mx organizations throughout the world.

FAA HF Training

FAA's venture into HF training was the Maintenance Human Factors Presentation System (MHFPS) (Johnson, 2007, see https://www.faa.gov/tv/?mediaId=799). The system is designed for Mx /engineering trainers to build HF training that is matched to their organizational requirements. It is a multimedia presentation with 11 original video productions, 150 support PowerPoint slides, and 50 animation files, and a set of 200+ PowerPoint slides. All the slides can be edited by the user. The videos are short dialogues between the author and a colleague named Dagmar. The 50 animation files were provided from Lufthansa Technical Training. The MHFPS is likely the most widely used human support training materials in the world (see Figure 6).

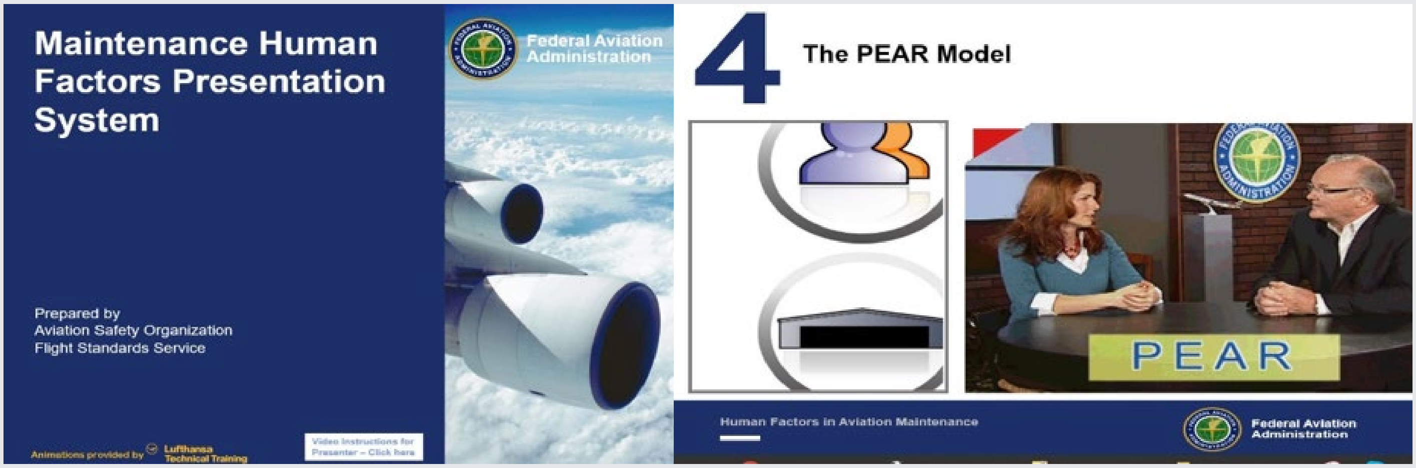

Figure 6: The MX HF Presentation System.HF.

The Operator's Manual for HF in Aviation Maintenance

The mid-nineties is abound with excellent additional examples of cooperative efforts between government and industry. A team wrote the Operators Manual for Human Factors in Maintenance, (see Figure 7). That document addresses critical issues including: HF Training; Voluntary Reporting; Procedures and Documentation; Industrial Safety; Practical HF Issues in Field Approvals, and more. The document received a rare FAA Administrator's Award for Excellence in Plain Language (Federal Aviation Administration, 2005). Industry partners translated the document into Chinese and Spanish for international applications. A second edition of the Operator's Manual was published in 2014 (Johnson & Avers, 2014). A related copy of this manual was developed for Airport Operations (Federal Aviation Administration, 2007).

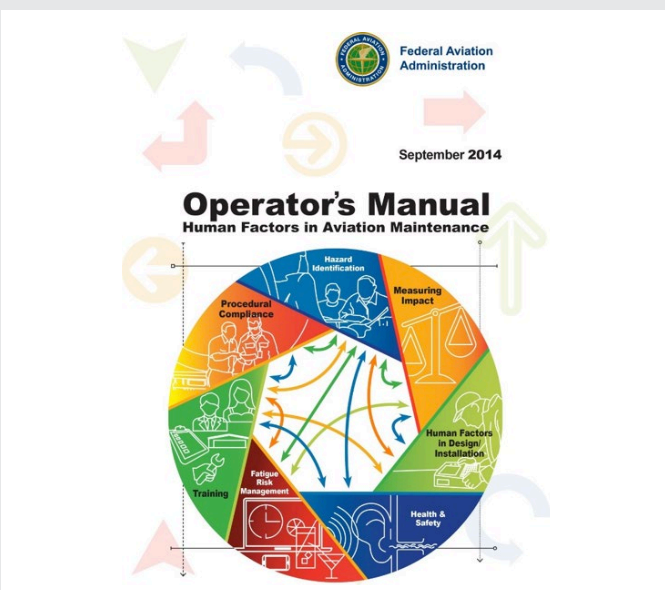

Figure 5: The Operator's Manual for Human Factors in Aviation Maintenance.

Maintenance Line Operations Safety Assessment (MLOSA)

Voluntary reporting, just culture, and safety management are three concepts/programs that matured from 2000 on. A high-value industry-government, human-centered project that came from the FAA HF applied research was Maintenance and Ramp Line Operations Safety Assessment (MLOSA). Modeled from the flight operations LOSA, the MLOSA was centered on an extensive hierarchy of checklists of specific operations. Those checklists are used for voluntary, peer-to-peer audits of normal operations. The checklists were developed by Airlines for America members (Airlines for America, 2012) and the FAA Office of Aviation research team (Crayton, Hackworth, Roberts, & King, 2017). Industry participants, like UPS, JetBlue, Continental, and United spent endless hours testing, validating and improving the MLOSA product. Boeing Company, led by its HF team (Ma & Rankin, 2012, 2013), helped the United States and world implement LOSA (Rankin & Carlyon, 2012). I believe it is an excellent example of how applied government research becomes a critical safety tool for the industry. MLOSA remains active today (Zylawski & Ma, 2016b, 2017).

THE TWO THOUSAND TENS

HF is now a household word in aviation Mx. The phrase, Human Factors training is most likely to be preceded by the word recurrent. Most mechanics have had one or more HF courses. The HF initiatives, today, focus on known risk areas like organizational culture, worker fatigue, procedure following, enhancing the capability of those delivering HF training, and more.

Human Factors Committment

FAA is a major international force in affecting Mx HF. FAA is committed to the importance of HF in Mx. The annual investments in HF, described in this paper, are an indication of that longstanding commitment reinforced by the projects described in this section.

Training the FAA Inspector Workforce

FAA is serious about training their Airworthiness Aviation Safety Inspector Workforce. FAA airworthiness inspectors receive more HF training than any inspectors in the world. Since 2006 more than 2,300 airworthiness inspectors completed a three-day Mx HF course. That training supplements the pre-FAA employment HF training they received from their aviation industry or military experience. Nearly 100 of FAA airworthiness inspectors have taken an additional three-day Train-the-HF Trainer course (Johnson, 2015a, 2016a, 2016b). That course has capitalized on traditional HF training. It is always evolving to match the latest HF topics (Johnson, 2014b, 2019).

Worker Fatigue

Worker fatigue is a known risk in Mx organizations. As far back as 1999-2000, the FAA HF has studied this issue (Johnson, Mason, Hall, & Watson, 2001). The work that resumed around 2010 was focused on solutions and development of training materials rather than on quantifying the known fatigue hazard (Johnson, 2010a, 2010b, 2010c, 2013a; Johnson, Avers, & Banks, 2011; Avers & Johnson, 2012; Avers, Johnson, & Hauck, 2010). Of course, the discussion about FAA regulations on duty time continues today. FAA contends that fatigue is a known risk. Such risk must be managed by the principles and associated regulations from Safety Management Systems.

The primary products from the applied fatigue research are the Fatigue Awareness Toolbox (Avers & Johnson, 2010), and a Fatigue Risk Management Advisory Circular (FAA, 2016; Johnson, 2016c).

The Fatigue Awareness Toolbox (www.mxfatigue.com) is a combination of information about fatigue in Mx. It includes links to an extensive fatigue countermeasures training program that can be downloaded or delivered via the www.FAAsafety.gov website. It has been delivered to an estimated 150,000 aviators worldwide. Some airlines have customized that training for their organizations. The training is accompanied by a video production titled, Grounded (Johnson, 2010c, See Figure 8) for screen displays of the training system.

In 2016 the FAA published the Maintainer Fatigue Risk Management Advisory Circular (FAA, 2016; Johnson, 2016c). That document recommends steps to establishing an Mx fatigue risk management system and it provides extensive references on the topic.

Justifying the Investment

The FAA has continuously made the case for justifying the investment in HF (Johnson, 2009, Johnson, 2012a, 2012b; Johnson & Avers, 2012a, 2012b). In 2011 the FAA published tools and extensive guidance to calculate ROI for HF interventions and training. The ROI calculators operates on an Excel database. That software remains available on the FAA website www.humanfactorsinfo.com. For an example calculation result from the software, see Figure 9.

Figure 8: Fatigue training support examples.

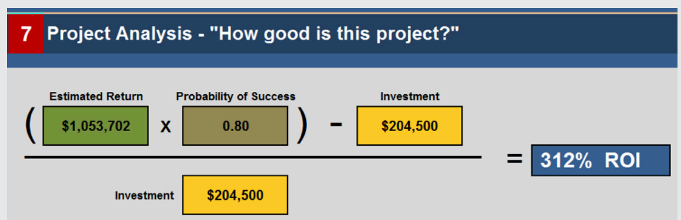

Figure 9: Example output from ROI calculator.

Following Procedures

One of the greatest hazards in aviation Mx is Failure to Follow Procedures (FFP) (Avers, Johnson, Bank, & Wenzel, 2012; Johnson, 2012c). Mx personnel know that following procedures is a regulation, they know where to find procedures, and they know how to follow them. However, too often, procedures are not followed, and resultant events occur. The most recent attempt to address this challenge is a web-based training product titled, Follow Procedures: The Buck Stops Here (Johnson, 2018a, 2018f, 2018i; Malone, Johnson, King, & Avers, 2018; see Figure 10). The training program takes an innovative approach of addressing the culture of following procedures. It stresses that everyone in the Mx organization, from the manufacturer to the accountable manager, to the mechanic/engineer has responsibility for following procedures. It takes safety champions to cooperate that procedures are followed 100 percent of the time. The training is about the characteristics of a safety champion. The training comes with a set of job cards for mechanics/engineers, procedure writers, and Mx managers. The training is available from the FAA Safety Team website or at www.followprocedures.com. The web-based training must be supplemented with discussions and continuous reinforcement. It was launched in late 2018 and had about 5,000 users in the initial six months. At press time of this article, it is too soon to report the industry acceptance and effect.

Figure 5: The Follow Procedures web-based training system.

Current and Future Considerations

The number of topics that are affected by HF in Mx is large. This includes topics like Mx personnel in the next decade (Johnson, 2017, 2018d, 2018e); voluntary reporting and just culture (Johnson, 2015a, 2018g, 2018h); Safety Management in Maintenance (Johnson, 2011, 2012, 2013a, 2014c, 2018b, 2018c); Risk-Based Decision Making (RBDM) and FAA Compliance Philosophy Programs (Johnson, 2015b, 2015c) and many more.

SUMMARY REMARKS

This paper summarizes 40-plus years of the author's activity in technical training and Mx HF. Most of the work was sponsored and conducted by the FAA or associated contractors. I believe that the work has had a significant effect on addressing the HF that affect AMTs, aircraft engineers, and all who affect aircraft maintenance. This paper describes projects that helped addressed today's challenges. Those challenges will change in time. However, it is certain that the necessity for attention to HF and to Mx training in aviation will endure.

REFERENCES

Airlines for America (2012). SG M-LOSA & R-LOSA: Implementation Guideline for MTCE & Ramp Line Ops Safety Assessment. Retrieved from https://publications.airlines.org/CommerceProductDetail.aspx?Product=146.

Avers, K. E., Johnson, W. B., & Hauck, E. (2010). To sleep, perchance to rest – combating maintenance fatigue. The Journal for Civil Aviation Training, 2, 28-31.

Avers, K., & Johnson, W. B. (2010). Fatigue survival toolbox. FAA Aviation News, 49(1), 29-30.

Avers, K., & Johnson, W. B. (2012). Applying Fundamental Sleep Science to the Aviation Workplace: A review of FAA Fatigue Research. The Journal of Aviation Psychology and Applied Human Factors.

Avers, K., Johnson, W., Banks, J., & Wenzel, B. (2012). Technical Documentation Challenges and Solutions in Aviation Maintenance: A Proceedings Report (Report No. DOT/FAA/AM-12/16). Washington, DC: Office of Aerospace Medicine.

Crayton, L., Hackworth, C., Roberts, C., & King, S. J. (2017). Line Operations Safety Assessments (LOSA) in Maintenance and Ramp Environments (Report No. DOT/FAA/AM-17/7). Washington, DC: Office of Aerospace Medicine.

Federal Aviation Administration. (2005). The Operator's Manual for Human Factors in Aviation Maintenance (1st ed.). Washington: Federal Aviation Administration. Retrieved from http://www.hf.faa.gov/opsmanual.

Federal Aviation Administration. (2016). Maintainer Fatigue Risk Management (Report No. AC 120-115,). Washington, DC: Federal Aviation Administration.

Federal Aviation Administration. (2007). The Operator's Manual for Human Factors in Airport Operations (Report No. HFM-AO-07-01). Washington: Federal Aviation Administration. Retrieved from http://www.hf.faa.gov.

Hastings, P. A., Merriken, M., & Johnson, W. B. (2000). An analysis of the costs and benefits of a system for FAA safety inspectors. International Journal of Industrial Ergonomics, 26(2000), 231-248.

Johnson, W. B. (1981). Computer simulations for fault diagnosis training: An empirical study of learning transfer from simulation to live system performance (Doctoral dissertation, University of Illinois). Dissertation Abstracts International, 41(11) 4625 A. (University Microfilms No. 8108555).

Johnson, W. B. (1984) Simulation oriented computer based instruction for fault diagnosis. Simulation and Training Technology for Increased Military Systems Effectiveness (pp. 66 72). Warrenton, VA: Society for Applied Learning Technology.

Johnson, W. B. (1987). Development and evaluation of simulation oriented computer based instruction for diagnostic training. In W. B. Rouse (Ed.), Advances in man machine systems research: Vol. 3 (pp. 99 127). Greenwich, CT: JAI Press, Inc.

Johnson, W. B. (1988a). Developing expert system knowledge bases for technical training. In L. D. Massey, J. Psotka, & S. A. Mutter (Eds.), Intelligent Tutoring Systems: Lessons Learned (pp. 83 92). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Johnson, W. B. (1988b). Pragmatic considerations in development and implementation of intelligent tutoring systems. In J. R. Richardson & M. C. Polson (Eds.), Foundations of intelligent tutoring systems (pp. 189 205). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Johnson, W. B. (1989). MITT writer research program: Building smart simulation and authoring tools. Proceedings of the Research Institute for Computing and Information Science '89 Symposium. Houston, TX: University of Houston Clear Lake.

Johnson, W. B. (1991). The national plan for aviation human factors: maintenance research issues. Proceedings of the 35th Annual Meeting of the Human Factors Society, 27-32. San Francisco, CA: The Human Factors and Ergonomics Society.

Johnson, W.B., Mason, F, Hall, S., and Watson, J. (2001).Evaluation of Aviation Maintenance Working Environments, Fatigue, and Human Performance. An FAA Conference Report. Available at: http://www.humanfactorsinfo.com.

Johnson, W. B. (2003, June). Comparing International Training Requirements for Maintenance Personnel. The Aviation Industry Group 7th Annual Latin American & Caribbean Airline Engineering and Maintenance Conference, Miami, FL.

Johnson, W. B. (2004a). Blended-training for human factors: ensuring quality and cost control for initial and continuation training. Proceedings of the Aviation Technician Education Council Annual Meeting.

Johnson, W. B. (2004b). Lowering training costs by raising applications of training technology. Proceedings of the 3rd Conference "New Tendencies in Aircraft Maintenance."

Johnson, W. B. (2004c). Matching Human Factors Training to the Fundamentals of Adult Learning. Meeting of the Royal Aeronautical Society. United Kingdom: Bently Priory. Retrieved from http://www.raes-hfg.com.

Johnson, W. B. (2007). The Maintenance Human Factors Presentation System. Multimedia presentation with 135 PowerPoint slides with notes and 11 video programs written and co-produced. Retrieved from http://www.humanfactorsinfo.com.

Johnson, W. B. (2009, December). Show me the money. Aviation Week Overhaul & Maintenance Magazine, 20.

Johnson, W. B. (2010a). Do we need MX fatigue rules? MxFatigue Focus Newsletter, 3(2), 1. Retrieved from http://www.Mxfatigue.com.

Johnson, W. B. (2010b). Do we need rules to apply common sense about worker fatigue? MxFatigue Focus Newsletter, 2(1), 3. Retrieved from http://www.Mxfatigue.com.

Johnson, W. B. (2010c, September). Grounded [YouTube Video]. Available at http://www.mxfatigue.com or https://www.youtube.com/watch?v=FNsXpG4J8AQ.

Johnson, W. B. (2010d, December). The Role of Tech Pubs in "Failure to Follow Procedures" Specifying the R&D Challenge. Presentation at The Boeing Technical Publication Usability Workshop, Seattle, WA.

Johnson, W. B. (2011, September). Collecting predictive SMS data. Ground Support Worldwide.

Johnson, W. B. (2012a, February). Navigating the maze of SMS jargon. Ground Support Worldwide, 42-43. Also published in Aircraft Maintenance Technology, 6-8.

Johnson, W. B. (2012b, April). Procedures 101. Ground Support Worldwide, 18-19.

Johnson, W. B. (2012c, October). Fatigue training proven cost effective. Mx Fatigue Newsletter, 4(1). Retrieved from hfskyway.faa.gov/fatigue/documents/.

Johnson, W. B. (2013a, May). Human factors implications: EASA's proposed safety management systems rule. Aircraft Maintenance Technology, 20-23.

Johnson, W. B. (2014b, April). Maintenance human factors training: 25 years – Then and now. Aircraft Maintenance Technology, 10-11.

Johnson, W. B. (2014c, March). Relationships between human factors, safety management systems, and safety culture. FAA Aviation Mx Human Factors Newsletter, 2(1). Retrieved from http://www.humanfactorsinfo.com.

Johnson, W. B. (2015a, August). Human factors Training: How FAA Trains Airworthiness Inspectors. Aircraft Maintenance Technology Magazine, 30-31.

Johnson, W. B. (2015b, May). Risk-Based Decision-Making for Part 147 Schools. Aircraft Maintenance Technology Magazine, 24-25.

Johnson, W. B. (2015c, December). The New Compliance Philosophy and its Relationship to Safety Management. FAA Aviation Mx Human Factors Quarterly Newsletter, 3(4), 1-5. Retrieved from http://www.humanfactorsinfo.com.

Johnson, W. B. (2016a, September). Training the Maintenance Human Factors Trainer. FAA Aviation Mx Human Factors Quarterly Newsletter, 4(3). Retrieved from http://www.humanfactorsinfo.com.

Johnson, W. B. (2016b, September). How to Train the Human Factors Trainer - FAA Style. Aircraft Maintenance Technology Magazine, 38-40.

Johnson, W. B. (2016c, December). Maintenance Fatigue Advisory Circular has arrived. FAA Aviation Mx Human Factors Quarterly Newsletter, 4(4). Retrieved from http://www.humanfactorsinfo.com.

Johnson, W. B. (2016d). PEAR Model Approach in Applying Human Factors to Enhance Aviation Safety. Journal of Aviation Management, 19-28. Singapore: Singapore Aviation Academy.

Johnson, W. B. (2017, November-December). What is the "Right Stuff" for Aviation Maintenance Professionals? Aviation Maintenance Technology Magazine, 18-20.

Johnson, W. B. (2018a, August). It Takes a Village to Follow Procedures: What is Your Role? Presentation to Webinar for the Aviation Maintenance Technician Education Council.

Johnson, W. B. (2018b, August-September). Increasing the Human Factors in Maintenance Safety Management Systems. Aviation Maintenance Technology Magazine, 20-21.

Johnson, W. B. (2018c, September). Workshop Report: The Integration of Human Factors into Safety Management Systems. FAA Maintenance Human Factors Newsletter, 6(4). Retrieved from https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/publications/.

Johnson, W. B. (2018d, June-July). Another Look at the Aviation Maintenance Personnel Shortage and the Solutions. Aviation Maintenance Technology Magazine, 12-14.

Johnson, W. B. (2018e, June). Training Solutions to Meet Looming Mechanic Personnel Shortages, P3, and Coming Soon to a Computer Near You. FAA Maintenance Human Factors Newsletter, 6(3). Retrieved from https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/publications/.

Johnson, W. B. (2018f, June). Following Procedures: More about Culture than Knowledge. Airworthiness Matters, 28-31. United Kingdom: International Federation of Airworthiness.

Johnson, W. B. (2018g, April-May). Just Culture Stories: The Good, the Bad, and the Ugly. Aviation Maintenance Technology Magazine, 44-47.

Johnson, W. B. (2018h). Just Culture Stories: What can go right and what can go wrong. FAA Maintenance Human Factors Newsletter, 6(2). Retrieved from https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/publications/.

Johnson, W. B. (2018i). Addressing Failure to Follow Procedures - Again. FAA Aviation Mx Human Factors Quarterly Newsletter, 6(1), 1-5. Retrieved from http://www.humanfactorsinfo.com.

Johnson, W. B. (2018j, March). A Fatigue Speech that Won't Put You to Sleep. Speech given at the Minnesota Aviation Maintenance Technician Conference, Brooklyn Center, MN.

jJohnson, W. B. (2019, March). What Experts Want to Know. Aviation Maintenance Technology Magazine, 38-40.

Johnson, W. B., & Avers, K. (2012a). Calculating payback for safety and training programs. The Journal for Civil Aviation. Training, 2.

Johnson, W. B., & Avers, K. (2012b, November). Calculating safety ROI. AeroSafety World.

Johnson, W. B., & Avers, K. A. (Eds.). (2014). The Operator's Manual for Human Factors in Aviation Maintenance (2nd ed.). Washington, DC: Federal Aviation Administration. Retrieved from http://www.humanfactorsinfo.com.

Johnson, W. B., & Fath, J. L. (1984). Implementation of a mixed fidelity approach to maintenance training (Report No. TR 661). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Johnson, W. B., & Maddox, M. E. (1983). Status of diagnostic training in the nuclear utility industry. Proceedings of the 27th Annual Meeting of the Human Factors Society, 151 155. Norfolk, VA: Human Factors Society.

Johnson, W. B., & Meyerrose, C. (2004, April). EASA vs. FAA Rules Regarding: Certification, Training, and MRO Requirements. Aviation Week Maintenance Repair & Overhaul Conference, Atlanta, GA.

Johnson, W. B., & Poetter, L. (2003). Blended-training for maintenance human factors. Proceedings of the World Airline Training Conference and Tradeshow.

Johnson, W. B., & Rouse, W. B. (1980). Computer simulations for fault diagnosis training: From simulation to live system performance. Proceedings of the 24th Annual Meeting of the Human Factors Society, 69 73. Los Angeles, CA: Human Factors Society. (This paper was awarded Best Student Paper Award [Runner up] at 24th Annual Meeting of Human Factors Society).

Johnson, W. B., & Rouse, W. B. (1982a). Training maintenance technicians for troubleshooting: Two experiments with computer simulations. Human Factors, 24(3), 271 276.

Johnson, W. B., & Rouse, W. B. (1982b). Analysis and classification of human errors in troubleshooting live aircraft powerplants. IEEE Transactions on Systems, Man, and Cybernetics, SMC, 12(3), 389 393.

Johnson, W. B., Avers, K., & Banks, J. (2011, June). CSTA report. Proceedings for AVS Maintenance Fatigue Workshop. Retrieved from mxfatigue.com.

Johnson, W. B., Hall, S., & Watson, J. (2002, April). The Current Picture of Rest Among Aviation Maintenance Technicians in Airline Environments. Proceedings of the 16th Symposium on Human Factors in Aviation Maintenance. San Francisco, CA: Joint meeting of CAA, FAA, and Transport Canada at the Hyatt Regency.

Johnson, W. B., Maddox, M. E., & Kiel, G. C. (1984). Simulation oriented computer based instruction for training nuclear plant personnel. Proceedings of the 28th Annual Meeting of the Human Factors Society, 1008 1012. San Antonio, TX: Human Factors and Ergonomics Society.

Johnson, W. B., Neste, L. O., & Duncan, P. C. (1989). An authoring environment for intelligent tutoring systems. Proceedings of the 1989 Institute of Electrical and Electronic Engineers Conference on Systems, Man, and Cybernetics, 761 765.

Ma, M. J., & Rankin, W. L. (2012). Implementation Guideline for Maintenance Line Operations Safety Assessment (M-LOSA) and Ramp LOSA (R-LOSA) programs (Report No. DOT/FAA/AM-12/9). Washington DC: Office of Aerospace Medicine. Retrieved from http://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201209.pdf.

Ma, M. J., & Rankin, W. L. (2013, June). Maintenance Line Operations Safety Assessment (M-LOSA) Is Gaining Popularity around the

World. FAA Aviation Maintenance Human Factors Newsletter.

Maddox, M. (Ed.). (2007). Human Factors Guide for Aviation Maintenance and Inspection. Washington, DC: Federal Aviation Administration. Retrieved from http://www.humanfactorsinfo.com.

Malone, A., Johnson, W. B., King, S. J., & Avers, K. E. (2018). Follow Procedures Training: The Buck Stops with Me [Web-based training]. Retrieved from http://www.faa.gov/about/initiatives/maintenance_hf/training_tools/.

Rankin, W., & Carlyon, W. (2012). Assessing the Safety of Ramp and Maintenance Operations. Boeing AERO Magazine ATR 2(12). Retrieved from https://www.boeing.com/commercial/aeromagazine/articles/2012_q2/3/.

Rankin, W., & Johnson, W. (2017). Maintenance Human Factors. In S. J. Landry (Ed.), Handbook of Human Factors in Air Transportation. London, UK: CRC Press, Taylor and Francis Group.

Rouse, W. B. (2007). "Task, Errors, and Automation" with" Failures, Detection, Diagnosis." In W. Rouse (Ed.), People and Organizations: Explorations of Human Centered Design (pp 77-144). New Jersey: John Wiley & Son Publications, Inc.

Shepherd, W. T., & Johnson, W. B. (1991). Aircraft maintenance challenges and human factors solutions. Proceedings of the ICAO Flight Safety and Human Factors Seminar, 204-220. Bangkok, Thailand.

Shepherd, W. T., Johnson, W. B., Drury, C. G., Taylor, J. C., & Berninger, D. (1991). Human Factors in Aviation Maintenance Phase 1: Progress Report (Report No. DOT/FAA/AM-91/16). Washington, DC: U.S. Department of Transportation, Federal Aviation Administration. Retrieved from http://hfskyway.faa.gov.

The Aviation Safety Research Act of 1988. (Public Law 100-591- November 3, 1988).

Trollip, S. R., & Johnson, W. B. (1982). Computer applications in an aviation training environment. Journal of Educational Technology Systems, 4(3), 223 233.

Watson, J., & Johnson, W. B. (2001, March). Assessing aviation maintenance work environments and worker rest. Proceedings of the 15th Symposium on Human Factors in Aviation Maintenance. London, UK: Joint meeting of CAA, FAA, and Transport Canada at the Brewery.

Zylawski, C., & Ma, M. (2016b, September). Air France Embraces Maintenance Line Operations Safety Assessment (MLOSA). FAA Maintenance HF Newsletter, 4-6. Retrieved from https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/publications/media/september_2016_Newsleter_508_Compliant.pdf.

Zylawski, C., & Ma, M. (2017, June). Maintenance Line Operations Safety Assessment (MLOSA) at Air France: A Three-year Journey. FAA Maintenance HF Newsletter. Retrieved from https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/publications/media/Aviation_MX_HF_June_2017_Newsletter.pdf.

A WORD FROM THE INDUSTRY.

AVOTEK-ONLINE COURSES CREATED TO SUPPORT MULTIPLE LEARNING STYLES

ABOUT AVOTEK

Avotek develops and manufactures modern, fully functional training systems; cutaway components; and display materials in support of Part 147 schools. The company also publishes textbooks, other media, and now online courses (at Avotek-Online.com) that can be used in a school's curriculum or by an individual interested in learning more about aircraft.

ABSTRACT

Avotek continues to support Part 147 schools in their efforts of teaching students with many learning styles. The latest offering of online courses (at Avotek-Online.com) present material that helps students prepare to take the Aircraft Electronics Technician exam and could be useful in an Aviation Maintenance Technician (AMT) school's curriculum.

AVOTEK-ONLINE COURSES CREATED TO SUPPORT MULTIPLE LEARNING STYLES

Avotek has been providing curriculum support to Aviation Maintenance Technician (AMT) schools for more than 50 years. Known for its system trainers, cutaway components, and display materials, Avotek has continuously updated its products to meet the training industry's needs. The popular hardware lines were supplemented with textbooks, computer-based training, and videos.

The latest addition to the Avotek lineup is online training courses. Avotek originally designed these courses to meet the needs of avionics repair stations who had asked for help with their training. The courses might also enhance the learning environment in Part 147 schools. While it is widely accepted in educational circles that technology offers many benefits, the products available to AMT schools have been nearly nonexistent.

Technology brings great benefits to the educational setting, and the prevalence of laptop, notebook, tablet, and smartphone devices has put that technology in the hands of most students. The days of scheduling time in a computer lab are becoming a thing of the past. Instructors are using devices in their classrooms and labs to enhance instruction and provide educational content in many formats. This encourages students to learn in the best way for them. This ability to differentiate instruction to meet the needs of every student is one of the major benefits of using technology in the classroom/lab setting.

Classes are filled with students from a variety of age groups, academic strengths, and work backgrounds. Each one brings his or her own best learning style to the class. The students expect their training needs to be met. This diverse population is the first challenge to most new instructors: How can I teach all these people at the same time?

To understand how to reach each student, you need a basic understanding of learning styles. This subject has been deeply researched and categorized over the years. Across the studies, the results are nearly identical. Learning styles can be divided into four categories: reading/writing, auditory, visual, and tactile/kinesthetic.

- Reading/writing learners learn best from the traditional textbook and writing assignment method of teaching.
- Auditory learners prefer to hear the information instead of reading it. These students learn best from lectures (both live and recorded) and presentations by guest speakers, or even other students presenting.
- Visual learners best understand information presented using actual components, charts, diagrams, or photographs.
- Tactile/kinesthetic learners are the "hands-on" folks. They need a tactile connection to their learning. This is the student who learns best in the lab/shop environment. You will probably discover that for most AMT students, this is their primary learning style.

However, few learners use or have only one learning style, so restricting students to activities matched to their reported preferences could hinder their progress. Differentiation of instruction—offering training in the different styles—becomes a serious challenge for the instructor. This requires the instructor to alternate the style to which their lessons are focused to ensure that some material meets each possible learning style or to prepare multiple versions of the same lesson. Either alternative means a lot of work for instructors who are probably already stretched to the limit of their available time. Lesson planning is a very time-consuming task and is probably not the favorite activity of any instructor. Technology now makes it possible for students to access the information in a manner that best supports their preferred learning style. The new online courses at Avotek-Online might offer a solution.

Primarily developed for students to use as study/review material for the Aircraft Electronics Technician (AET) exam, the courses might be useful in other situations: to refresh new instructors on electronics theory or to remediate when a student has difficulties. The online lessons focus on those areas that are most important to AET certification, and the companion textbook delves more deeply into the subjects.

The online lessons present the material in a narrated video format that appears much like a PowerPoint presentation that can be used in the classroom. This format is designed for both reading/writing and auditory learners. The visual learner is provided with the charts, examples, and figures used in the textbook with an accompanying explanation.

An additional benefit to these programs comes from the narrated "slide shows." The lessons present the content in written form and are simultaneously narrated; they could prove beneficial to students with hearing or language competency issues.

Avotek has always been dedicated to providing the classroom support materials that the industry needs. Through its development of these online courses, Avotek hopes to deepen its collaboration with AMT schools.

ADVERTISE WITH ATEC.

ATEC is the only organization dedicated to promoting and supporting aviation maintenance technician education. Its audiences include aviation maintenance technician schools, airline technical and workforce development executives, private aircraft operators, MRO providers, and key suppliers. If your product or service is a fit with these groups, then advertising with ATEC is a fit for your business plan.

ATEC ADVERTISING PLANS

JOURNAL PACKAGE

YOUR AD IN ATEC JOURNAL

The ATEC Journal is an electronic publication that provides a bi-annual opportunity for educators, administrators and industry personnel to share teaching techniques and research. This package includes half page (7 X 4.75 in), one page (7 X 10 in), or two page (14 X 10 in), four-color ad (in PDF format).

Ad size – one issue / two issues:
Half page - $125 / $225
One page - $250 / $450
Two pages - $350 / $650

DIGITAL PACKAGE

YOUR AD IN ATEC NEWS
& ON ATEC WEBSITE

ATEC News, the council's monthly e-newsletter, is the premier source for policy, academic and industry news for aviation maintenance training schools. ATEC-AMT.org is the primary online destination for aviation maintenance training news and resources. This package Includes one horizontal banner ad (max. size 600 X 125 pixels JPEG format) in each issue of ATEC News, PLUS the same ad randomly displayed on our website.

6 MONTHS: $750
12 MONTHS: $1,250

JOURNAL + DIGITAL COMBO

YOUR AD IN ATEC JOURNAL,
ATEC NEWS & ON ATEC WEBSITE

Includes 12 monthly ATEC News distributions, 12 months of banner on website, and two semi-annual ATEC Journal distributions. Prices determined by ATEC Journal ad size.

Half page - $1,300
One page - $1,500
Two pages - $1,700

PURCHASE AT WWW.ATEC-AMT.ORG/ADVERTISE

TOTAL MEMBERS	180+
MONTHLY SITE TRAFFIC	5,000+ UNIQUE VISITORS • 27,000+ PAGE VIEWS
MONTHLY ATEC E-NEWSLETTER DISTRIBUTION	2,000+ READERS • 35% OPEN RATE
ATEC JOURNAL READERSHIP	250+

703.548.2030 • ATEC@ATEC-AMT.ORG
ATEC-AMT.ORG