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Integrating Web-Based Education into Your Curriculum:

An Emphasis on Developing Learning Objectives for Your Students

Rhonda Cooper, M.Ed. A&P
James Allen, MD, MPH Environmental Health Physician
Presented at the 2011 Annual Conference of the Aviation Technician Education Council

This presentation focuses on curriculum development with emphasis on writing objectives and integrating Web-Based Education (WBE) into existing Part 147 subjects. The FAA offers a variety of WBE courses that are available free on the FAASafety.gov web site. Two popular examples are *Working Healthy-8 Steps for Protecting Your Health* and the *Dirty Dozen-Human Error in Aircraft Maintenance*. Five steps to incorporate existing web-based education into your curriculum and examples of learning objectives are provided in this presentation.

Have you ever come across material and thought "this would be great information for my students" but was not sure how to incorporate the material into your course? This presentation will provide you with a five-step process, based on the ADDIE instructional design model to accomplish this. The steps are:

Step 1: Assess the web-based course for alignment with FAR Part 147 and AC 147-3A.

Step 2: Write objectives for a lesson.

Step 3: Develop one or more activities incorporating the web-based course aligning it with the school's curriculum.

Step 4: Implement and Evaluate the lesson and web-based course.

Step 5: Encourage your students to become life-long learners.

When you find material you think would help reinforce or even introduce new concepts of aviation maintenance to your students find a way to use it! We all know the regulated AMT curriculums are in need of an overhaul; however, we cannot wait for this to happen our students need updated information NOW!

The FAA has a mandate to promote safety and with the advent of their website www.FAASafety.gov they accomplish this goal. There are numerous web-based courses available for free and ready to use in your classroom or lab. The authors are using two popular courses *Working Healthy-8 Steps for Protecting Your Health* and the *Dirty Dozen-Human Error in Aircraft Maintenance* to show you how to use the five-step process to incorporate each course into your lesson plans.

Step 1: Assess the web-based course for alignment with FAR Part 147 and AC 147-3A.
Once you locate a web-based course that looks interesting and that you might wish to incorporate into your lesson, the first step is to complete the course yourself. You will be reviewing the course several times before this process is completed. A thorough knowledge of FAR Part 147 and your course/curriculum, including AC 147-3A if incorporated into the curriculum is expected.

As a sample, the authors have reviewed FAR Part 147, Appendix B General Curriculum and compared it to the *Working Healthy-8 Steps for Protecting Your Health* and the *Dirty Dozen-Human Error in Aircraft Maintenance* courses. Correlations are summarized in the following tables.

Part 147 General Curriculum (Appendix B)	Working Healthy-8
f. 20. Start, ground operate, move, service, and secure aircraft and identify typical ground operation hazards.	Step 1: Plan Your Work Step 8: Consider Others Case Study: CO Exposures – "Fueler Who Did Not Return Calls"
f. 21. Identify and select fuels.	Step 4: Don't Forget the Skin
g. 22. Identify and select cleaning materials.	Step 2: Ask for Information Step 4: Don't Forget the Skin Step 6: Anticipate Clean-up Step 7: Use Degreasing Station Case Study: "Mechanic Who Can't Walk"
g. 23. Inspect, identify, remove, and treat aircraft corrosion and perform aircraft cleaning.	Step 3: Think Ventilation Step 5: Focus on the Work Environment Case Study: "DE Who Neglects Ventilation"
j. 30. Use and understand the principles of simple machines; sound, fluid, and heat dynamics; basic aerodynamics; aircraft structures; and theory of flight.	Step 5: Focus on the Work Environment

Part 147 General Curriculum (Appendix B)	Dirty Dozen
a. 6. Inspect and service batteries.	Complacency, Distraction, Awareness, Norms, Fatigue
c. 11. Weigh aircraft.	Communication, Distraction, Teamwork, Awareness
e. 17. Identify and select aircraft hardware and materials.	Resources
e. 18. Inspect and check welds.	Knowledge, Complacency, Distraction, Awareness, Norms, Fatigue
f. 20. Start, ground operate, move, service, and secure aircraft and identify typical ground operation hazards.	Communication, Complacency, Distraction, Teamwork, Pressure, Stress, Awareness, Norms
g. 23. Inspect, identify, remove, and treat aircraft corrosion and perform aircraft cleaning.	Knowledge, Complacency, Distraction, Awareness, Fatigue, Norms, Resources
i. 28. Write descriptions of work performed including aircraft discrepancies and corrective actions using typical aircraft maintenance records.	Communication, Complacency, Knowledge, Teamwork, Pressure, Assertiveness, Norms
i. 29. Complete required maintenance forms, records, and inspection reports.	Communication, Complacency, Knowledge, Teamwork, Pressure, Assertiveness, Norms
k. 31. Demonstrate ability to read, comprehend, and apply information contained in FAA and manufacturers' aircraft maintenance specifications, data sheets, manuals, publications, and related Federal Aviation Regulations, Airworthiness Directives, and Advisory material.	Communication, Complacency, Knowledge, Teamwork, Pressure, Assertiveness, Norms, Awareness
l. 33. Exercise mechanic privileges within the limitations prescribed by part 65 of this chapter.	Communication, Assertiveness, Norms, Pressure, Complacency, Knowledge

As noted in the tables, these two courses can easily be incorporated into your lessons on the subjects listed providing the students with a better understanding of safety and protecting their health and wellbeing. The next step is determining exactly what we want our students to learn from these courses.

STEP 2: WRITE OBJECTIVES FOR A LESSON.

Well-written competency-based or performance-based objectives assist the instructor in designing activities and assessments that allow the student to practice and demonstrate the skills and knowledge desired from a given lesson plan.

The authors have chosen two topic areas from the general curriculum and using the two web-based courses have created objectives for the beginning of a lesson plan.

Part 147 General Curriculum (Appendix B)	Working Healthy-8
g. 22. Identify and select cleaning materials.	Step 2: Ask for Information Step 4: Don't Forget the Skin Step 6: Anticipate Clean-up Step 7: Use Degreasing Station Case Study: "Mechanic Who Can't Walk"
Objectives	
Given an aircraft component that is to be cleaned, the student will: • Identify the manufacturer's approved cleaning materials and methods. • Locate relevant health and safety data on the cleaning materials using various sources (MSDS, Haz-Map, NIOSHTIC, ICSC). • Determine correct Personal Protection Equipment (PPE) for use with the approved cleaning materials and methods. • Present a plan for cleanup in anticipation of spills. • Demonstrate a positive safety attitude by using both appropriate PPEs and procedures at degreasing station.	

Part 147 General Curriculum (Appendix B)	Dirty Dozen
c. 11. Weigh aircraft.	Communication, Distraction, Teamwork, Awareness
Objectives	

During an aircraft-weighing lab, the student will be given an evaluation form to rate both the team and student's performance during the lab. Students will:
• Demonstrate good communication skills by
  o completing a pre-weigh briefing with the team;
  o maintaining continuous contact with team during weighing; and
  o completing a post-weigh "lessons learned" session with the team.
• List possible distractions that might arise during the weighing and provide safety nets to reduce or eliminate these distractions.
• Demonstrate quality team attributes, including preparation, involvement, and encouragement.
• Maintain awareness of surroundings at all times, including assigned aircraft and those working around hangar not involved in assigned aircraft.	

Know that we have our objectives we need to create the activities that will allow the students to practice the knowledge and skill we want them to learn.

STEP 3: DEVELOP ONE OR MORE ACTIVITIES INCORPORATING THE WEB-BASED COURSE ALIGNING IT WITH THE SCHOOL'S CURRICULUM.

Well-designed activities align with the lesson objectives and provide the student with the practice needed to learn the skill or behavior desired. The advantage of being a vocational program and the requirements of Part 147 demands that the students have this hands-on practice, and labs provide the environment to accomplish this.

Continuing with the topic examples, activities expand upon the objective's "given" and have been added to the tables below.

<table>
<tr><th>Part 147 General Curriculum (Appendix B)</th><th>Working Healthy-8</th></tr>
<tr><td>g. 22. Identify and select cleaning materials.</td><td>Step 2: Ask for Information
Step 4: Don't Forget the Skin
Step 6: Anticipate Clean-up
Step 7: Use Degreasing Station
Case Study: "Mechanic Who Can't Walk"</td></tr>
<tr><th colspan="2">Objectives</th></tr>
<tr><td colspan="2">Given an aircraft component that is to be cleaned, the student will:
• Identify the manufacturer's approved cleaning materials and methods.
• Locate relevant health and safety data on the cleaning materials using various sources (MSDS, Haz-Map, NIOSHTIC, ICSC).
• Determine correct PPE for use with the approved cleaning materials and methods.
• Present a plan for cleanup in anticipation of spills.
• Demonstrate a positive safety attitude by using both appropriate PPEs and procedures at degreasing station.</td></tr>
<tr><th colspan="2">Activities</th></tr>
<tr><td colspan="2">Note: This topic has a teaching level of "3" which requires "Knowledge of general principles, and performance of a high degree of practical application" and "development of sufficient manipulative skills to simulate return to service" per Part 147.

Assign the <u>Working Healthy-8 Steps for Protecting Your Health</u> course as homework or an in-class assignment if individual computers and time allows as early in the student's course of study as possible and appropriate. Student should print certificate and turn in as proof of course completion.

Suggested activities might include the student:
• Actually cleaning an aircraft component. Have students complete lab using the manufacturer's approved cleaning materials and methods and applying the Working Healthy 8 Steps.
• Answering specific questions about the cleaning materials health and safety data using the various sources of information available.
• Researching for approved alternative cleaners that are less toxic.
• Suggesting other possible alternatives for safer use of materials (administrative/engineering).
• Creating a safety program for course.
• Demonstrating to the class the proper use of PPEs.
• Participating in a contest to create a safety poster for degreasing station with a prize for the winner.
• Practicing a 'drill' on a spill.
• Participating in a facilitated discussion of the "Mechanic Who Can't Walk" case study.</td></tr>
</table>

Student assessment or testing has not been discussed in this presentation, however should be a part of any lesson plan. Remember that the test questions or skill assessments must be in alignment with objectives and activities or they are not valid.

STEP 4: EVALUATE THE LESSON AND WEB-BASED COURSE.

Evaluation helps determine if student's expectations were met. Most schools have some form of end of class evaluation; however, a lesson evaluation would be beneficial particularly for new lessons with new material. Encourage your students to be honest with the evaluations and to elaborate on both low and high scoring qualities. Let them understand that this type of feedback will make future lessons more effective.

Also, encourage your students to honestly evaluate the web-based courses upon completion. This provides the designers with information to make any corrections to incorrect/misleading information and improve the overall content of the presentation.

Learning to provide constructive feedback helps the student learn that they are a part of the system. It is hoped that this skill will continue into future classes as well as submitting corrections/suggestions to reference materials such as maintenance manuals, engineering drawings, etc.

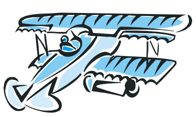
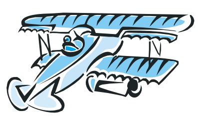
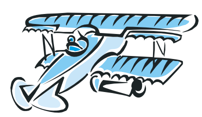
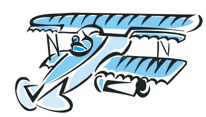
STEP 5: ENCOURAGE YOUR STUDENTS TO BECOME LIFELONG LEARNERS.

Success as an AMT requires lifetime learning. The best way to help your students incorporate this personal habit is to demonstrate it yourself, remembering the old saying "walk the walk, talk the talk." You must complete the courses you include in your classroom; attend outside training, including local FAASTeam presentations and IA renewals (even if not an IA); participate in the AMT Awards program; and become an NCATT certified instructor which requires recurrent training in instructional/educational subjects as well as technical subjects.

Encourage your students to research other courses, learning activities (FAASTeam presentations, FAASafety.gov courses, AMT Awards Program, IA renewals, electronic magazines, etc.), and participating in aviation maintenance groups (PAMA, AMTSociety, and AWAM).

If your school offers an Associate Degree program encourage them to take the extra courses; even if they never go on in their formal education the degree can help them in getting their first job and management positions usually require some type of degree. If they should decide to go for additional formal education, the Associate Degree might help them reduce the number of course requirements for the higher degree, saving time and money in the future.

With these five simple steps, you can now incorporate any existing web-based educational media into your lesson plans. In our examples using Working Healthy-8 Steps for Protecting Your Health and the Dirty Dozen-Human Error in Aircraft Maintenance, the five steps guided you in writing objects and developing activates. Incorporating these objectives and implementing the activities into your course will enhance your current curriculum with no additional class time added. Proper evaluation will ensure continuous improvement and both student and instructor become lifelong learners. The result is a well informed and safety-conscience AMT.

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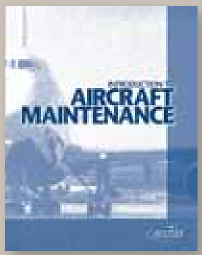

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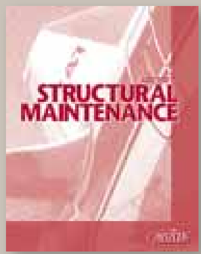

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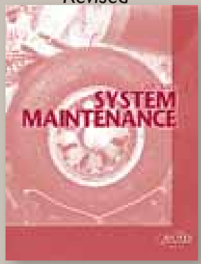

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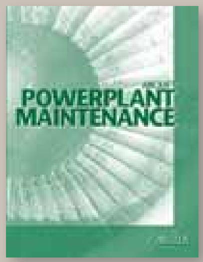

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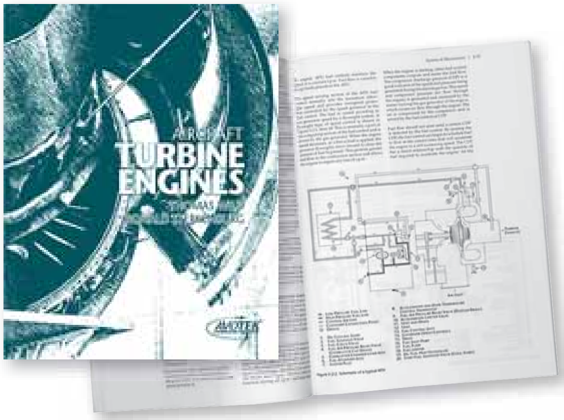

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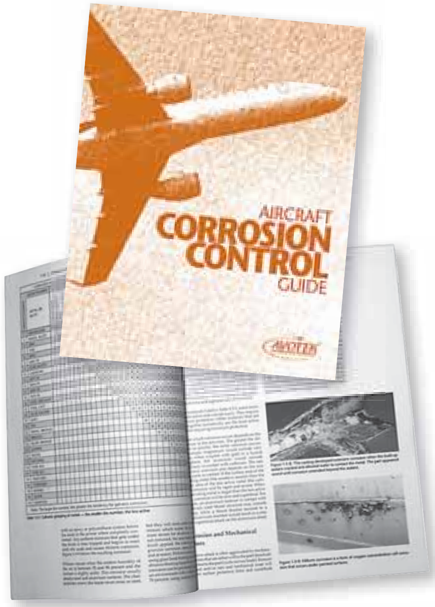

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Flight Control Design Characteristics of a Civilian Powered Lift Category Aircraft

Daniel Mattingly
Southern Illinois University Department of Aviation Technologies

ABSTRACT

The purpose of this paper is to educate the reader in the unique fly-by-wire flight control design characteristics for the BA609 that allow the aircraft to fly in both the helicopter and airplane modes of operation. The helicopter mode is considered to be the flight regime where the aircraft takes off, lands and flies like a helicopter and the airplane mode is considered the flight regime where the aircraft is flown during forward flight as compared to an airplane. There is also another flight regime called the conversion stage, which is when the left and right nacelles are rotated forward or aft and converts the aircraft between the vertical lift and fixed wing stages of flight. A top level overview and comparison will be provided for both modes of operation as they relate to traditional rotary wing and fixed wing aircraft. The major components that allow the conversion mode to take place and information on the aircraft's three hydraulic systems will also be discussed.

INTRODUCTION

As our technology has continued to advance with respect to composites, avionics and digital fly-by-wire flight controls, they have contributed greatly to the design and development of powered-lift category aircraft. The powered-lift category was developed by the Federal Aviation Administration (FAA) specifically for the BA609 and other similar aircraft that may produced in the future (Gerzanics, 2008). As defined by the Federal Aviation Regulations (FARs), the Federal Aviation Administration (FAA) defines powered-lift as "means a heavier-than-air aircraft capable of vertical takeoff, vertical landing, and low speed flight that depends principally on engine-driven lift devices or engine thrust for lift during these flight regimes and on nonrotating airfoil(s) for lift during horizontal flight" (Federal Aviation Regulations, 2011).

Examples of powered-lift category aircraft are the Boeing Vertol VZ-2 tilt-wing aircraft that first flew in August of 1957, Bell Helicopter's XV-15 tiltrotor that first flew in 1977, the McDonnell Douglas AV-8B Harrier with vectored thrust that first flew in November of 1978, and the Bell/Boeing V-22 Osprey tiltrotor that first flew in March of 1989. As you can see, powered-lift technology has been in work for over fifty years and the only aircraft that have actually gone into production and in service are the military's AV-8B Harrier and the V-22 Osprey.

In November of 1996, Bell Helicopter and Boeing announced a partnership to design and produce the 609 civil tiltrotor. In March of 1998 Boeing withdrew as a partner for the tiltrotor and in September of 1998 AgustaWestland joined Bell for the tiltrotor's development. At this time four test aircraft have been produced with one prototype aircraft conducting flight test operations at Bell's facility in Arlington, TX and another prototype aircraft conducting flight test operations at AgustaWestland's facility in Cameri, Italy. The remaining two aircraft have been delivered to the facility in Italy and will be used in support of test and evaluation efforts beginning in 2011 and 2012 (Dubois and Huber, 2011). The design of the BA09 is primarily based on the technology and test results from operations of the XV-15 and V-22 aircraft.

HELICOPTER AND AIRPLANE MODES OF OPERATION

As a fixed wing student pilot, the student is first introduced to the world of basic aerodynamics and what flight control surfaces allow the aircraft to be controlled on the ground and in forward flight. They are told that the rudder controls the aircraft around the vertical axis resulting in yaw control, the elevator controls the aircraft around lateral axis for pitch control and the ailerons control the aircraft the around the longitudinal axis and allow the aircraft to roll. The flaperons, also referred to as flaps, change the wing's lift and drag characteristics and are typically used by the pilot during their approach and landing.

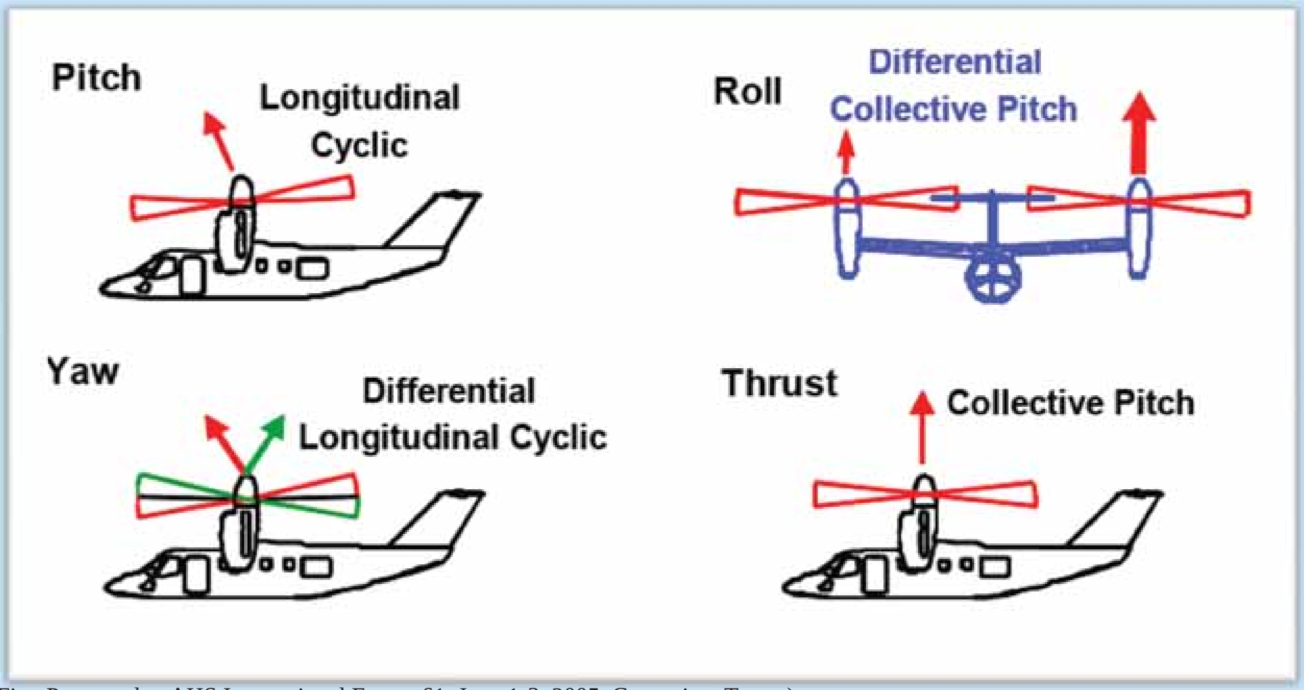
As shown in figure 1, what is truly unique about the BA609 is that the aircraft has no rudder for yaw control about the vertical axis. Also, the left-hand and right-hand wings have no ailerons, but instead they each have only a single flaperon control surface. Let's take a closer look and see how this is possible. First, we will need to discuss the basics on how a standard helicopter is able to be flown and controlled by the pilot.

(Courtesy of Wikimedia)

Figure 1. Bell/Agusta BA609 Test Aircraft

A standard helicopter has three basic controls in the cockpit that used by the pilot in order to control it during flight. The cyclic stick is centered in front of each pilot's seat that extends up from the floor and is used to control the aircraft around the longitudinal and lateral axis. It basically controls the tilt of the main rotor disc. The anti-torque pedals, which are sometimes referred to as rudder pedals, are operated by the pilot's feet and allow the aircraft to be controlled about the vertical axis. The collective lever is located to the left of the pilot and it serves two purposes which are for vertical ascents and descents and it also incorporates a means to control the engine's power output. As the lever is raised and the aircraft ascends the aircraft requires more power and as the aircraft descends then less power is required. On helicopters powered by reciprocating engines, the engine power is manually controlled by using a twist grip on the pilot's collective lever. (Schafer, 1980) There are several different systems that are used with helicopters powered by turbine engines that adjust the engine's power based on the position of the collective lever, atmospheric conditions and load demanded by the aircraft. The goal is to maintain a rotor RPM (Revolutions Per Minute) of 100 percent. This RPM varies from one rotorcraft to another and is based on the rotor blade dimensions and design of the aircraft. The rotor speed for the BA609 aircraft in helicopter mode is 569 RPM while the rotor speed in airplane mode is 478 RPM (Gerzanics, 2008).

When the BA609 is in helicopter mode and the pilot wants to achieve a roll around the longitudinal axis, they will move the cyclic stick to the left or right and the aircraft will roll as a result of differential collective pitch. The collective pitch on one of the rotors will increase more while the collective pitch on the other rotor increases to a lesser degree and basically what that means is that one rotor is providing more lift than the opposite rotor (Figure 2).



(First Presented at AHS International Forum 61, June 1-3, 2005, Grapevine, Texas.)

Figure 2. BA609 Primary Controls in Helicopter Mode

The pitch, yaw and thrust inputs are accomplished in a similar fashion as compared to a tandem rotor helicopter except that the rotor orientation on the BA609 is configured laterally. In order to pitch the aircraft about the lateral axis using the cyclic in the forward or aft directions, both the left and right rotor discs tilt in the desired direction. To turn the aircraft about the vertical axis using the rudder pedals, opposite inputs are made to the left and right rotors that result in the corresponding rotor discs tilting in opposite directions. In order to climb the power lever (as now called in the BA609 versus a collective lever) is raised and it results in the simultaneous and the same amount of pitch increase in both of the rotor blades that allows the aircraft to vertically ascend. Accordingly, by lowering the power lever the pitch is simultaneously decreased for all rotor blades and the aircraft vertically descends.

When the BA609 is in airplane mode with the left and right nacelles at zero degrees the pilot commands the aircraft to rotate about the lateral axis using the elevator and moving the cyclic stick forward or aft. When the pilot wants to roll the aircraft about the longitudinal axis using left or right cyclic, it is accomplished by using the flaperons. In order to yaw the aircraft about the vertical axis, differential collective pitch is used and the need for a rudder is eliminated. A larger amount of thrust (more pitch) is obtained on one of the rotors as compared to the opposite rotor. Thrust is obtained by raising the collective lever which increases the pitch equally on both the left and right rotors (Figure 3).

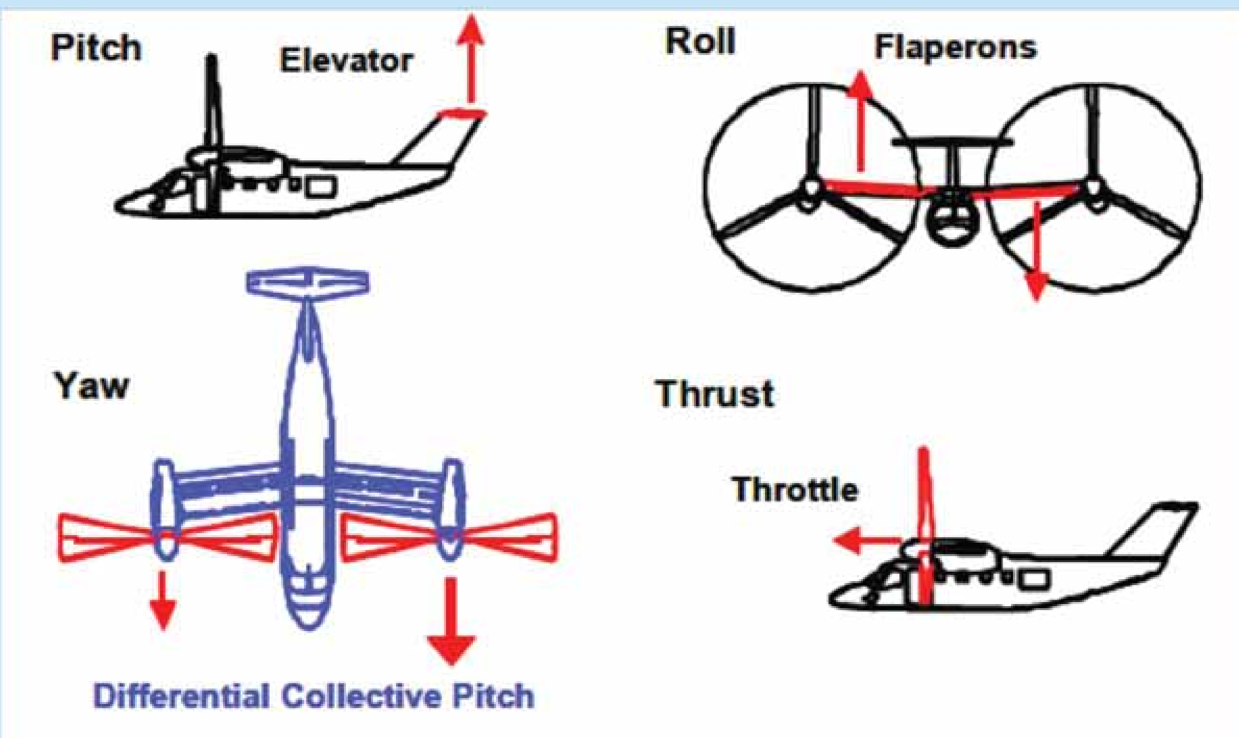


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Figure 3. BA609 Primary Controls in Airplane Mode

When the aircraft is flying with the nacelles at an angle between the airplane and helicopter modes, a combination of the controls must be used simultaneously. This is accomplished by using complex flight control algorithms that are within the software of the three FCC's (Flight Control Computers). Next, we will discuss the primary flight control system and what major components are used to operate and control the rotors and flight control surfaces during flight.

ROTOR AND CONTROL SURFACE COMPONENTS

Fly-by-wire aircraft designs for the flight control systems on the V-22 and BA609 are similar by the fact that they are both designed to have triple redundancy. What this basically means is that if a component has failed or has been determined to not be operating within the prescribed limits that are being monitored by the three FCCs, it will automatically be deactivated and one of the remaining components will take its place for control or operation. This increases the reliability of the overall system and safety margin for operating the aircraft.

The major components necessary for control and operation are the FCCs, rotor actuators and control surface actuators. In order to ensure the necessary reliability, enormous amounts of testing are conducted. During the early stages of developing the aircraft, over 1,000 hours of hydraulic system operational testing were completed before the rotors actually turned on the first BA609 aircraft. The operational testing was conducted in what is called the Bell Xworx Vehicle Software Management Integration Lab (VMSIL) located at the Bell Helicopter facility located in Arlington, Texas. Any software changes made during the flight test or operational phases again require verification using the VMSIL and then on the aircraft before the software will be released for remainder of the aircraft (Fenny and Schultz, 2005).

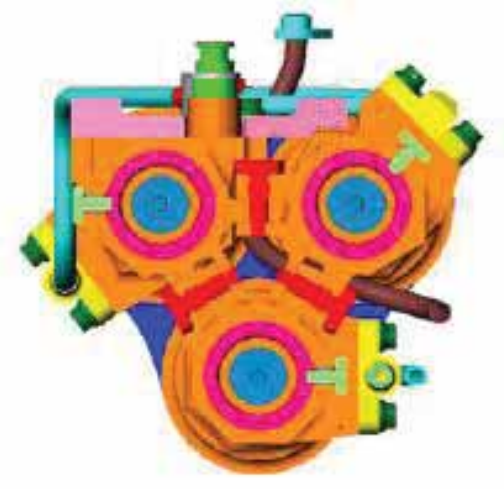

Figure 4. Cross Sectional View of Longitudinal and Collective Actuators

As previously stated, there are three FCCs that receive input signals following movement of the cyclic stick, power lever or rudder pedals by the pilot. There are also three separately isolated hydraulic systems that correspond to the number 1, number 2 and number 3 FCCs. The elevator is operated by three hydraulic actuators. This is also true for the left-hand and right-hand flaperon control surfaces. Each of the single actuators is also controlled by a different FCC and a different hydraulic system that again makes the systems triple redundant.

For controlling the pitch of the rotor blades, each of the rotor systems uses two actuators that are referred to as the collective and longitudinal triplex actuators. This is a major difference when compared to the V-22 design that uses three duplex actuators for controlling each rotor assembly. As shown in figure 4, each of the actuators for the BA609 contains three actuators that are housed within one assembly and this is where the term triplex originates.

CONVERSION MODE OF OPERATION

One of the most unique characteristics of the BA609 that allows the aircraft to transition between the helicopter and airplane modes is the converting of the left hand and right hand nacelles. This is what truly places the aircraft within the powered-lift category and allows the aircraft to operate like a helicopter and then fly at forward airspeeds comparable to a twin engine turboprop aircraft. When the aircraft is converting between the two modes, both the helicopter and airplane controls are being simultaneously used at the same time. The actual rotation of the nacelles, also referred to as pylons, is accomplished by using a hydro-mechanical actuation system that is called the Pylon Conversion System (PCS). The nacelles are rotated by using a switch that is mounted on the power lever. By pushing the switch forward the nacelles will come down and by pulling it aft the nacelles will come up. The normal speed of rotation for the nacelles is 2 degrees per second and there is an emergency mode that only allows the nacelles to be rotated up at 8 degrees per second. This can be accomplished by using additional effort and overcoming a detent in the aft position of the switch.

The system consists of one conversion actuator (Figure 5) for each nacelle and a mechanical cross shaft that connects the two actuators between the two nacelles. The mechanical cross shaft system is referred to as the Interconnect Drive Train (IDT). The provision for the IDT was incorporated in case one of the conversion actuators fails to properly operate and then it can be manually controlled by the opposite conversion actuator. The IDT is made up of aluminum torque tubes that have U-joints and sliding splined shafts. These design features allow for the bending and temporary misalignments that can take place during flight and are typical for standard rotorcraft designs.

Each conversion actuator incorporates a primary brake and a backup brake that are hydraulically operated. They are used internally to the actuator gearbox to prevent rotation of the telescoping ball screw and hold the nacelles at the selected position. Each of the conversion actuators has a quantity of three resolvers that provide pylon position information to the FCCs. Once again, this is in support of triple redundancy.

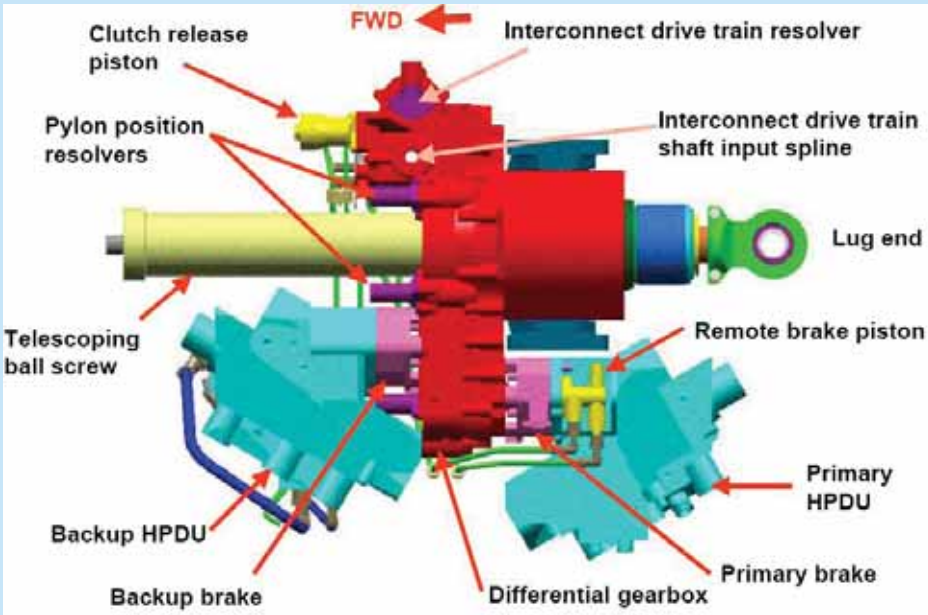

Figure 5. BA609 Pylon Conversion Actuator

The PCS allows the nacelles to be rotated a total of 95 degrees, from 5 degrees aft of being vertical (helicopter mode) to being horizontal (airplane mode). One of the reasons that the nacelles are allowed to rotate aft of vertical is so that the aircraft can be slowed down through the use of aerodynamic braking following a run-on landing. Run-on landings are accomplished similar to fixed wing aircraft and done when the aircraft gross weight and/or ambient conditions do not allow a vertical landing to take place. Of course the nacelles are kept at an angle above 45 degrees during a run-on landing in order to prevent the rotor blades from contacting the ground (Fenny and Hart, 2000).

HYDRAULIC SYSTEM

The hydraulic systems are primarily used to provide pressure for operation of the control surface actuators, rotor actuators, pylon conversion actuators, and landing gear actuators. The hydraulic system is similar to the V-22 in that there are three separate systems and all of the pressure and return lines used for distribution are made of titanium tubing. One major difference is the fact that the V-22 hydraulic systems operate at 5,000 pounds per square inch (psi) and the BA609 hydraulic systems operate at 3,000 psi. A decision was made during the initial design planning stages to use the 3,000 psi systems due to two factors. One reason was that an extensive amount of pre-existing data was already available concerning hydraulic component reliability for civil aircraft. The second reason was the availability of compatible ground carts and support equipment at civil airports. The standard for civil aircraft is 3,000 psi hydraulic systems and the introduction of a 5,000 psi system would have been very costly and require the introduction of new ground carts and support equipment specifically for use by the BA609 aircraft.

The preferred hydraulic fluid used for the BA609 hydraulic systems is manufactured in accordance with specification MIL-PRF-87257 with an optional fluid per MIL-PRF-83282. The MIL-PRF -87257 fluid was chosen due to the increased safety advantages over other fluids typically used. It has a lower operating temperature and is more flame retardant. Most civil helicopters use hydraulic fluid per the MIL-H-5606 specification and many commercial airplanes use Skydrol PE-5 hydraulic fluid as compared to the newer military airplanes that have shifted and are using hydraulic fluid per the MIL-PRF-83282 specification. The production BA609 aircraft will be delivered with the MIL-PRF -87257 fluid and the operators can then choose to replace it with fluid adhering to either the MIL-PRF-83282 or MIL-H-5606 specifications. Seals are installed within the aircraft's three hydraulic systems that are compatible with any of the three specifications (Fenny and Schultz, 2005).

CONCLUSION

The BA609 aircraft is a highly anticipated concept with its ability to take off vertically and fly in airplane mode at a maximum cruise speed of 275 knots and it has flown up to 333 knots as part of flight test demonstrations. It will have a maximum takeoff weight of 16,800 pounds, a useful load of 5,500 pounds and be able to fly up to 25,000 feet with a pressurized cabin that can handle up to nine passengers for the standard commercial configuration (AgustaWestland, 2011). Several civil versions that are being marketed include configurations that support air medical and search and rescue in addition to corporate and commercial variations. Government configurations include search and rescue, medical evacuation and emergency medical service. The ideas of using the aircraft for Homeland Security operations and surveillance have also been discussed.

According to the International Civil Aviation Organization (ICAO, 2004), "The powered lift aircraft will increase our airspace system capacity through simultaneous, non-interfering operations by fixed-wing and vertical flight aircraft". The aircraft can also reduce runway and airport occupancy congestion that alone costs the U.S. economy billions of dollars each year.

No new skills are required by the Aircraft Maintenance Technician (AMT) to maintain the BA609 but instead there is an increase in the overall number of skills needed to maintain the aircraft as compared to traditional helicopters. The increase in the number of skills is mainly due to the presence of composites, fly-by-wire technology, digital avionics and cabin pressurization. As our technology continues to advance, so must the technical capabilities of the AMT.

REFERENCES

AugustaWestland (2011). Retrieved from http://www.agustawestland.com/product/ba609

Dubois, T. and Huber, M. (2011, February). New Rotorcraft 2011. *Aviation International News*. Retrieved from http://www.ainonline.com/news/single-news-page/article/new-rotorcraft-2011-28355/

Federal Aviation Regulations. (2011). Part 1, Paragraph 1.1 for General definitions. Retrieved from: http://www.faa.gov/Regulatory_and _Guidance_Library/rgFAR.nsn/

Fenny, C.A., and Hart, K.E. (2000, May). *Design & Development of a Pylon Conversion Actuation System for a Civil Tiltrotor Aircraft*. Paper presented at the American Helicopter Society 56th Annual Forum, Virginia Beach, VA.

Fenny, C.A., and Schultz, D.P. (2005, June). *Design & Development of the BA 609 Civil Tiltrotor Hydraulic System Architecture*. Paper presented at the American Helicopter Society 61st Annual Forum, Grapevine, TX.

Gerzanics, M. (2008, July). Tilting at Success. *Flight International*, 174(5146), 82-84. Retrieved from http://web.ebscohost.com/

ICAO. (2004, April). *Addressing the Future Challenges of the Operation of Powered Lift Category/Tiltrotor Class Aircraft in International Air Navigation*. Working Paper A35-WP/103 presented at the ICAO 35th session to the Executive Committee.

Schafer, J. (2007). Principles of Flight. *Helicopter Maintenance* (39-55). Englewood, CO: Jeppesen.

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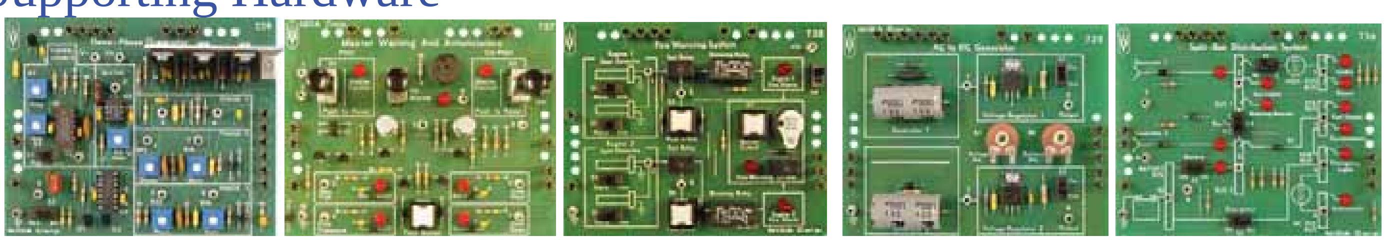
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Imbedding FAA Orals and Practicals into FAR 147 Classrooms

Karen Roberts

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During my attendance of an assessment seminar, "Assessment: Navigating the Shoals Without Running Aground", the presenter Douglas J. Eder of Southern Illinois University Edwardsville told a story about Orca whales training at an aquatic park. These Orcas were trained to swim over a pole in the water by offering a reward of fish for every time they swam over rather than under the pole. Gradually, the pole is raised higher and higher until eventually, the pole is out of the water and the Orcas have learned to jump out of the water as well. Still, of course, with a reward of fish. Mr. Eder summed up the story with three simple statements about the Orca training: "They must see the bar. The bar must be steady. There must be fish."

"They must see the bar"; this got me thinking. Do our A&P students see the bar? And what is the bar? It seems, sometimes, that students are mostly concerned with simply earning a passing grade and eventually the certificate. To them, that's the bar. As a teacher, I think knowledge of the subject is the bar and the grades and the certificate are the fish. So how can I show them the bar? Well, I thought by using the FAA's bank of oral and practical questions for the airframe and powerplant tests in the classroom as an assessment tool. Essentially, this is what you have to know (the bar) in order to get the grade/certificate (the fish). Which got me thinking again. If oral and practical questions were used in the classroom as assessment tools, why couldn't that be counted as credit towards the certificate? It turns out there are Part 147 schools that do imbed the Oral and Practical exams into their courses by the FAA allowing the school an exemption to FAR 65.75. These exemptions granted by the local FSDO state that the school is allowed to "administer Oral and Practical test as an integral part of the AMT educational process rather than upon student's successful completion of the mechanics written test." This statement is common amongst each of the exemptions to FAR 65.75.

According to the Federal Aviation Administration's Automated Exemption System, there are currently four Part 147 schools (one of which is under a program suspension) where this practice is in use. The earliest of which was granted in 1997. Furthermore, in recent years there have been five other Part 147 schools that were also allowed this exemption, but either their exemptions have since expired or the program no longer exists. Using the FAA Public Norms Online Reports on Airman Testing Standards, in 2009, the four schools that are currently using this exemption had average scores on the written exams of 86% on the Airframe, 86% on the General and 85% on the Powerplant, which is slightly higher than the national norm for that year. In 2009, the national averages on Airman Knowledge Tests (written exams) were, 83.65% on the Airframe, 83.72% on the General and 82.02% on the Powerplant.

Aside from FAR 65.75 and the exemption, there is substantial evidence as to why it would be educationally beneficial for the Orals and Practicals to be used as embedded assessment tools rather than as a comprehensive final assessment. This includes (but is certainly not limited to) issues of goal setting, feedback and study habits. Another aspect of using the idea of embedded assessments is that the Oral and Practical questions can be considered a qualitative assessment tool. And in educational institutions, where quantitative grades are required to be used, there becomes this problem of how to quantitatively grade a qualitative assessment. There are promising grading methods to account for this.

Oral and Practical exams, when offered at the end of all the courses, can appear to students as a rather large, long-term goal. Driscoll explains that there is a difference between setting short-term goals and long-term goals and that short-term goals, can actually improve motivation and performance (as cited in Schunk & Gaa, 1981). Before students in FAR 147 schools are eligible to take the Oral and Practical exams, they are required to spend 1150 hours in general and airframe classes and/or 1150 in general and powerplant classes for the intended rating. This equates roughly to 28.5 weeks, of 40 hours per week classroom instruction before a student is allowed to take the Os&Ps. (Even when a student acts on FAR 65.80, this only eliminates approximately 8 weeks off this interval.) In a class operating under the FAR 65.75 exemption, students have the opportunity to accomplish portions of the Orals and Practicals integrally through out the program, lessening the amount of time between when the content was presented and when their learning is assessed.

The testing items included on the Orals and Practicals cover 1150 hours worth of instruction. This can easily be viewed as a large goal. Os&Ps typically take no less than a full day of testing when the Airframe and Powerplant are done together. When students are allowed to work towards smaller, more specific goals, this can lead to more relevant learning strategies and consequently higher output (Locke, Shaw, Saari & Latham, 1981). The Os&Ps are broken into the 3 ratings of the mechanics certificate, the general section includes 12 subject areas, the airframe section includes 17 subject areas and the powerplant includes 15 subject areas. For each subject area, the student is asked, at the least, 3 oral questions and assigned 1 practical project. Some practical projects can combine subject areas together, but for the oral questions; that amounts to at least 132 questions; 36 general, 51 airframe and 45 powerplant. And that's assuming that the students answer them all correctly. Hattie and Timperley (2007) state that students may choose to blur goals together, picking and choosing the goals they can perform and ignoring the others. This is an undesirable effect of large comprehensive exams because this can leave large gaps in the knowledge base of the students. Under the FAR 65.75 exemption, the imbedded oral questions and practical projects offer the students smaller and more specific goals by spreading the subject areas out over the courses.

A third aspect of goal setting is the orientation of the goal (Locke et al., 1981). What the students see as their goal, whether it's performing a practical project or answering an oral question, this will influence their level of performance and efforts to achieve the goal. When students are faced with performance goals, they will look for favorable judgments or avoid negative judgments, but when students are faced with learning goals, they will look to increase their understanding and competence (Dweck, 1986). In a Part 147 school, where the Os&Ps are offered at the end of the program, passing them is a performance goal. The student is solely interested in knowing whether they pass or fail; whether they receive their certificate ratings or not. If the student passes, typically, any further opportunities for instruction come in the form of on-the-job training. If the student fails, they can either wait 30 days to reapply for the tests or obtain additional training in the areas they failed and retest prior to the 30 days. But offering the Os&Ps as imbedded tests through out the program can provide the students with additional chances to receive instruction on the subject area during the course. When given the opportunity, students will persist in their efforts until their goals are met (Driscoll, 2005).

Offering the Os&Ps as a comprehensive final assessment only provides the student with a pass or fail grade. Providing the student with comments about their performance or comprehension is more effective than simply issuing a grade (Crooks, 1988). In the traditional Part 147 program, where the Os&Ps are offered after the completion of the courses, other than a pass or fail, any feedback the student may receive is given outside of the classroom, and the additional instruction required to retake the exam, simply singles out only the performance or comprehension the student needs to receive a passing grade. If not careful, the person giving the additional instruction can fall into the trap of "teaching the test". Feedback "is most powerful when it addresses faulty interpretations, not a total lack of understanding" (Hattie & Timperley, 2007, p. 82). Operating under the FAR 65.75 exemption, any failure of an oral question or practical project happens while the student is still enrolled in the program where teachers can still use class time to address the deficiency. "If students lack necessary knowledge, further instruction is more powerful than feedback information" (Hattie & Timperley, 2007, p. 91).

Using the Os&Ps integrally through the courses, can give the teacher the opportunity to provide feedback in the form of further instruction, whether it's more in depth or simply a different strategy than used originally. "When feedback is combined with more a correctional review, the feedback and instruction become intertwined…" (Hattie & Timperley, 2007, p. 82). If Os&Ps are failed, and were taken after program completion, receiving this form of feedback/instruction, means that students will have to find teachers that are willing to take time outside of the classroom to provide such. On the contrary, under the FAR 65.75 exemption, if a failure occurs, the student and teacher are still in the classroom environment, which provides the perfect setting. In the classroom, the student not only receives this form of feedback, but the instruction with it should also provide the student with information about how to proceed. It is important to demonstrate to the student where they are and where they are going (Hattie & Timperley, 2007). After completion of the program, the additional instruction that is provided in the event of a failure may not match the current knowledge level (where they are) of the student. There is a big difference in filling the gap between the current level of understanding and the desired level of understanding (where they are going) and simply jumping it. And as mentioned before, "teaching the test" can come dangerously close to this.

Under the FAR 65.75 exemption, embedding the oral questions and practical projects makes them part of the coursework, taking 132 oral questions and 44 subjects for practical projects and spreading them out over the courses of the program; rather than giving them all together over the span of 1 to 2 days. Gibbs & Simpson (2004-5) explain that students use coursework rather than exams to organize their work patterns (as cited in Kniveton, 1996), with exams leading to cram sessions where little attention gets paid to semester long lecture/lab notes. And Vos (as cited in Gibbs & Simpson, 2004-5) found that subjects with less frequent assessments have students who study less. Therefore, oral questions and practical projects used as assessment tools during the course can lead to students devoting more study time over the length of the class. Furthermore, Gibbs & Simpson (2004-5) note that students orient their efforts around what counts the most and for students in Part 147 schools, passing their Os&Ps means receiving their certificate to work.

Another advantage that coursework has over exams, is that grades received on coursework are better indicators of learning than that of grades received on exams, but the trick becomes to develop coursework that promotes learning without generating large amounts of grades to be calculated (Gibbs & Simpson, 2004-5). In most institutions, final grades are required and typically are derived from averaging the grades received on the coursework throughout the course. But as Masters and Mislevy (1993) point out, instead of issuing grades based on incorrect ideas, credit should be given for what they do know, for their current level of knowledge. This implies that through out the length of a course, rather than issuing a grade for each assessment, the teacher could track the progression of the student until course completion, then issuing a grade based on their final position. Since most courses in the Part 147 curriculum include at least two of the required subject areas, there would be no fewer than eight oral questions and two practical projects to evaluate a student's progress over through out the course; an ample amount of chances to evaluate the student's progression. However, evaluating a student's progression through the course material can be a qualitative assessment at a time when a quantitative assessment is needed.

John Biggs (1992) combines levels with the categories in SOLO (Structure of the Observed Learning Outcome) taxonomy (Biggs & Collis, 1982). The categories A, B C, D and F are further divided into levels A1, A2 A3, B1, and so on. (Since the Federal Aviation Administration uses 69% (D) as a failing grade, the categories of D and F are omitted from the remainder of this discussion.) Rather than grades being averages from the oral questions and practical performances, this method of grading looks at what kind of knowledge the student has about the subject and how well they exemplify that knowledge (Biggs, 1992). This allows the student's performance to be expressed as a level on a continuous scale rather than an accumulation of percentage points. Then, when the student is unhappy with their grade during a course, their question will be "What can I do to get to the next level?" (learning goal) instead of "How can I earn some extra credit points?" (performance goal).

For category A, there should be a recognizable sense that the student can apply the knowledge and generalize it to more specific contexts. This A&P student should be able to troubleshoot systems and hypothesize probable causes in design and function of more model specific systems than the general systems used in the classroom. This may look like the performance of an experienced AMT. For category B, the student should have a firm grasp of all parts of the subject but may not have a clear sense of how they adhere together. There is no attempt at generalization. This student can possibly explain how the parts in a system work, but maybe not how they work together. And last, category C students know declarative information about the parts however cannot express the knowledge of how the part operates much less how it works within a system. Here, there is little evidence of anything, other than that which was given.

Where the categories are exemplifications of what the student knows, the levels show exactly how well they know it, with 1 being the best and 3 the worst within the category. This part, no doubt, relies heavily on the experience of the teacher and in some respects may be considered subjective. Also, if required by the program's institution, the levels can help break down a letter grade to percentage grades. John Biggs (1992), uses three levels, which may be the easiest way to split up a ten point spread when using the typical 90-100 = A, 80-89 = B and 70-79 = C scale. Level 3 may indicate retelling and minimal arguments. Level 2 might show good coverage and some judgment about the subject. And level 1 would be the most optimal performance of the category.

Designated Maintenance Examiners (DME) are only required to report to the FAA whether a student passes or fails the Oral and Practical portions of the test. The score sheet used during the test is kept by the DME, therefore, data that could indicate a difference in scores between students taking Os & Ps at the end of the program versus integrally throughout the program is difficult to collect. In addition, there could be other differences in schools programs such as curriculum organization and available resources that would seemingly have effects on grades. Upon employment, interviews with co-workers of the students may reveal possible differences in their levels of competency that could show some correlation to the type of testing they went through as well.

Regardless of the lack of evidence to prove or disprove the theory that students who take the Os & Ps integrally throughout their program turn out to be better Aviation Maintenance Technicians, there is an impressive amount of educational research that advocates for integral assessment rather than comprehensive final assessments. Exemptions from FAR 65.75 are granted by the local FSDO upon a school's request and subsequent review of the program and proposed changes and there has already been precedent set by other Part 147 schools that have been approved for the exemption. However, examination of the supporting research raises the question; "Should this be the exemption or the rule?".

REFERENCES

Biggs, J. B. (1992). A Qualitative Approach to Grading Students. *HERDSA News, 14*(3), 3-6. Retrieved from http://teaching.polyu.edu.hk/datafiles/R45.pdf

Biggs, J. B. and Collis, K. (1982). *Evaluating the Quality of Learning: the SOLO Taxonomy*. New York: Academic Press.

Crooks, T. J. (1988). The Impact of Classroom Evaluation Practices on Students. *Review of Educational Research, 58*(4), 438-481.

Driscoll, M.P. (2005). *Psychology: Learning for Instruction 3rd Edition*. Boston, MA: Pearson Allyn and Bacon.

Dweck, C. S. (1986). Motivational Processes Affecting Learning. *American Psychologist, 41*(10), 1040-1048.

Gibbs G. and Simpson C. (2004-5). Conditions Under Which Assessment Supports Students' Learning. *Learning and Teaching in Higher Education*, Issue 1.

Hattie J, and Timperley H. (2007). The Power of Feedback. *Review of Education Research, 77*(1), 81-112. doi: 10.3102/003465430298487

Locke, E. A., Shaw, K. N., Saari, L. M.,& Latham, G. P. (1981). Goal Setting and Task Performance: 1969-1980. *Psychological Bulletin, 90*(1), 125-152.

Masters, G. N. and Mislevy, R. J. (1993). New Views of Student Learning: Implication for Educational Measurement. In Norman Frederiksen, Robert Mislevy, & Isaac Bejar (Eds.), *Test Theory for a New Generation of Tests* (pp. 219-242). Hillsdale, N.J.: L. Erlbaum Associates.

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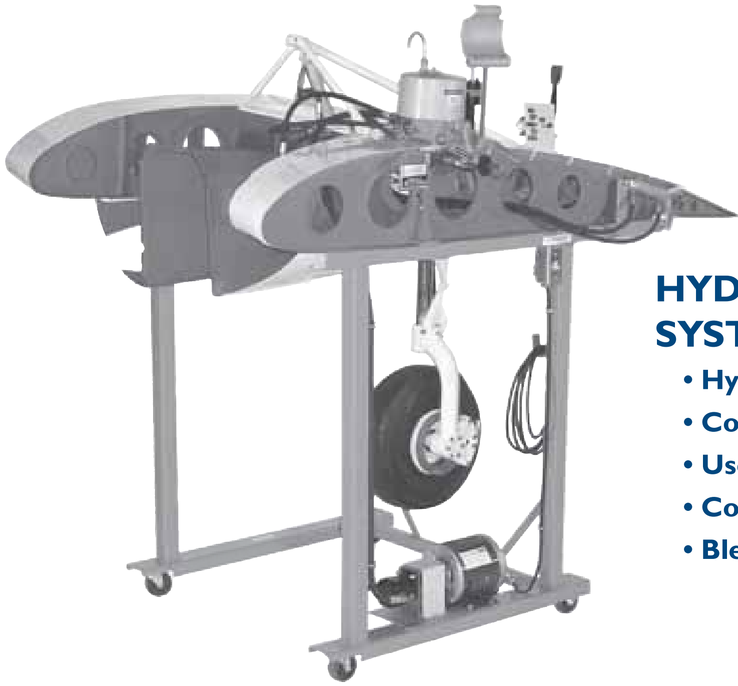

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Lean Enterprise: Investigating its Effectiveness in Part 147 Aviation Maintenance Technician Schools

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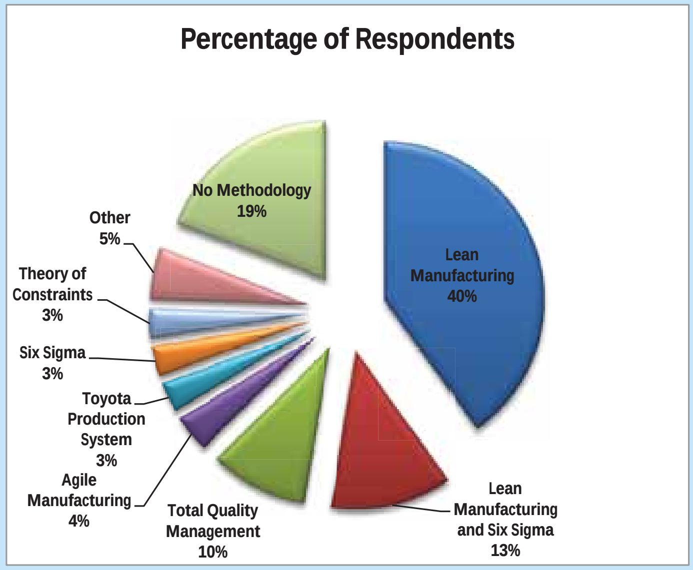
ABSTRACT
In an effort to reduce waste, the aviation industry is spending millions of dollars on Lean Enterprise training. Over the past decade the aviation industry has come to realize the importance of lean and the necessity and urgency of lean training. As a direct result of lean improvements, the industry is reorganizing production lines and modifying operations for optimum efficiencies. The intention of this study is to review lean practices in Part 147 Aviation Maintenance Technician (AMT) schools. By analyzing data from a nationwide Part 147 AMT School survey highlights the level of lean standards in Part 147 AMT schools. The focus is to evaluate where AMT schools are in the lean process and how to support students with "teach by example" surroundings. With the introduction of a simple, low-cost tool from Lean Enterprise "6-S", illustrates how AMT schools can identify and eliminate waste to improve instructional effectiveness.

Lean Enterprise: Investigating its Effectiveness in Part 147 Aviation Maintenance Technician Schools

When people hear the term "lean" some may think it is just the latest buzzword for continuous improvement. After all, there have been several methods proposed to industry for process improvement. Industry Week/Manufacturing Performance Institute (IW/MPI) polled U.S. manufacturing firms in 2006. Out of the 745 respondents, lean manufacturing was the most common method implemented by manufacturers.

The results shown in figure 1 illustrates that lean methodology is used in over 53 percent of manufactures with an increasing trend to combine lean and Six Sigma methodologies. Industry Week goes on to summarize the manufacturing industry as "leaner and meaner" (Blanchard, 2006 p.14). The leaner statement is obvious, the meaner comes from what is seen as the aggressiveness of U.S. manufacturing companies attacking waste, both internally and externally, requiring suppliers to get-on-board with lean and cut the waste out of processes used to support manufactures.



Source: Industry Week/Manufacturing Performance Institute

Figure 1. Improvement methodology in use by manufactures

Womack and Jones in their book *Lean Thinking* (1996) recommend you know and understand a key phrase used in the Japanese language "*Muda*". It sounds awful as it rolls off your tongue and it should, because "*muda*" means "waste," specifically any human activity which absorbs resources but creates no value. Muda is found in many forms, from obvious mistakes that require rework, overstocked inventories piling up, and unneeded process steps and or unnecessary movement of employees or goods all contribute to wasted resources. Any group of people in downstream activity standing around waiting because an upstream activity has not delivered on time, and goods and services which don't meet the needs of the customer. Fortunately, there is a powerful antidote to muda; lean thinking (p.14).

Lean originated and grew out of the Toyota Motor Company as part of the Toyota Production System. Toyota was slow to break into the U.S. automobile industry with its poor quality cars and high production costs during the late 1950s and throughout the 1960s. After years of work identifying "muda" and developing ways to eliminate it, Toyota identified seven types of waste eating away at profits and adding time, and cost, while diminishing product quality. The lean consultant gurus of today commonly refer to this list as the "Seven Deadly Wastes". The seven wastes are:

1. Waste from overproduction
2. Waste of time waiting
3. Transportation waste
4. Processing waste
5. Inventory waste
6. Waste of motion
7. Waste from scrap and rework

As a direct result from lean efforts put forward by Toyota Motor Company, we relate the name Toyota with quality automobiles. Lean methodology that was launched on the manufacturing floors of Toyota Motor Company more than 60 years has not only spread across the globe; it has spread across varying industry manufacturing lines to include the aviation industry and supporting enterprises and supply chains (Hill, 2007). One of the main tools that the Toyota production system developed and proves to be a core-value-tool in the lean philosophy is 5S. The 5S system is based on five Japanese words that begin with the letter "S", the 5S philosophy focuses on effective work place organization and standardized work procedures. The 5S simplifies your work environment, reduces waste and non-value activity, while improving quality, efficiency, and safety.

Lean may have its roots in the automotive industry; but, today, lean has a substantial stake in the aviation industry. Terry Bryan, co-director for Boeing's Lean Aerospace Initiative is more to the point on lean and in the industry stating "Improving processes and reducing costs are the keys to the future success of the aerospace industry. If you don't find better ways to do business and become leaner, you're probably not going to be around much longer" (Ramey, 2004, p.2).

Boeing found itself in a serious struggle trying to compete with Airbus in an industry that had grown beyond Boeing's capacity in 1997. Boeing's designs were decades old compared to Airbuses' newer designs. Boeing's manufacturing operations were out dated and inefficient in comparison.

> Amid unprecedented demand for new planes, Boeing tried to double production overnight. But parts-supply problems and shortage of workers forced the company to shut down its 747 and 737 assembly lines. Some customers fled to Airbus, and Boeing's commercial-airplane division was smacked with a $1.6 billion loss, even though it sold a record $24.5 billion worth of jetliners (Holmes, 2001, ¶ 4).

"Today, you find a world-class manufacturer still on the journey with lean enterprise. Boeing is embracing lean principles, reducing waste, and the cost that result from it. Reducing waste is the key in lean, and one of the predominate process utilized is "5S: The principal activity that is used to create and maintain an organized, clean; high-performance workplace" (Ramey, 2004, p.3).

Japanese Term	English Term	Definition
Seiri	**Sort**	Eliminating unnecessary items from the workplace
Seiton	**Set In Order**	Focuses on efficient and effective storage methods
Seiso	**Shine**	Clean and make repairs to area and equipment.
Seiketsu	**Standardize**	Standardizing best practices
Shitsuke	**Sustain**	Defining new status quo and standards

Table 1. Translation and Definitions of 5S

RESEARCH PROCESS OUTLINE

With the aviation industry successfully embracing lean methodology, our research focus is on how we compare with the aviation industry lean practices in our Part 147 Aviation Maintenance Technician (AMT) schools. Are we teaching students in classrooms and laboratories environments comparable to aviation industry's lean standards? The intention of this study is to review our lean practices in Part 147 AMT schools. The focus of this research is to evaluate where Part 147 AMT schools are in the lean process, in our laboratories, support equipment settings, and how we can support and prepare our students with "teach by example" lean surroundings. The research analysis was accomplished by developing a short multiple choice survey, using a free software survey generator program written and developed by Virginia Tech University. We choose to e-mail the research request to all Aviation Technician Education Council (ATEC) school members' departmental administrators listed on the ATEC Members web page. 103 schools were e-mailed the research request. With the sensitive nature of some of the survey questions dealing with the condition of school's facilities, it was decided to design the online survey to be blind to all respondents and any affiliation to their schools. This was directly addressed in the e-mail along with a brief outline of the research process. We invited the departmental administrators of each school to forward the request to their faculty for participation. At the bottom of the e-mail research request, we included a hyperlink to the automated survey. Initially some recipients of the research survey had difficulties logging in to the survey. In addition to the difficulties opening the survey, approximately 20 e-mails were returned for delivery errors. The survey questionnaire was active for four weeks resulting in 41 responses. During the research request period, we received a few calls from AMT Schools asking for more information on lean and how to apply it. The calls were encouraging considering the unexpected low number of respondents from the research survey. The callers' questions were addressed and recommendations for more information given.

FINDINGS:

The online survey found, of the respondents, 61% have never heard of lean as illustrated in figure 2. If lean is all about eliminating waste in manufacturing industries, how would the seven wastes relate to an educational based industry training students to maintain aircraft? The following are a few examples on how the seven wastes were seen to apply during lean process implementation at Southern Illinois University's Aviation Technologies Department.

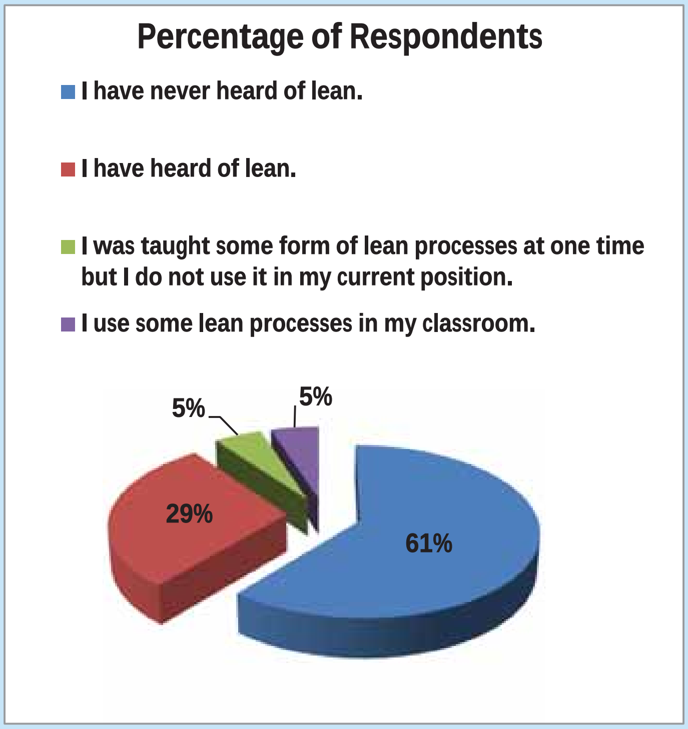


Figure 2. How familiar are you with tools and processes used in lean?

1. **Waste from over production**. We may not actually produce products to stock up on the shelves; however, we continuously accept products and equipment as donations that are not part of our curriculum, which contributes to unnecessary inventory.
2. **Waste of time waiting**. Students waiting for an aircraft, piece of equipment or for the proper supplies needed for an assigned lab project.
3. **Transportation waste**. If you have to tow aircraft around to make room to work on them, you are wasting resources and time while placing extra wear and tear on equipment.
4. **Processing waste**. Making a straightforward process or project unnecessarily complex sometimes just because it has always been that done that way.
5. **Inventory waste**. Excess inventory not only obstructs classrooms and laboratories, it occupies precious space, and wastes energy looking for needed items among surplus inventory.
6. **Wasted Motion**. Requiring someone to leave the training area to get a required tool, part, or needed equipment during labs, wastes energy and time.
7. **Scrap-rework**. Students may work several weeks on a lab project with little or no in-progress inspections, discovering later the project is not within the specifications and requires it to be totally reworked.

Maybe not all of the seven wastes situations described relate directly to all programs as stated, but you can see how the seven wastes can be applicable within a Part 147 AMT school. A favorite tool used to help identify and reduce wastes from our school's programs is the 5S system. A popular derivative of 5S is 6S, with the additional step added for safety. The added focus on safety in our environment is always a good practice, so the 6S philosophy was adopted. During discussions and evaluations of the 6S philosophy, Southern Illinois University's composite laboratory will be used as a case study as the 6S philosophy was implemented.

SORT

The first "S" of the 6S tools used to lean-out an area is Sort. It is best to accomplish this lean activity with all "stake holders" present. In this case study, both professors that utilize the composite laboratory, one for Structures Repair Course and the other for Advanced Composite Materials Course, were involved during the sort. The sort process addresses waste associated with over production and inventory waste. A Lean 6S instructional block of training was added to the Advanced Composite Processes Course allowing the opportunity for students to take part in the lean process. The easiest way to start the sort process is to pull everything out of the cabinets, desks, lockers, and corners to a central location. It's amazing at what you can find leftover from years of instruction by the various professors and the obsolete materials and equipment donated to the program from well meaning supporters. Next, you must decide what is essential to teach the course and what is not. As you sort through items, a good practice is to tag unnecessary items; this stage of sort is termed a "red-tag" event. The tags are made-up for the occasion documenting institutional requirements. Some information to record might be the item name, quantity of item, reason tagged, disposition if required, and final action to be taken. The interesting part now is deciding what is essential and what gets red-tagged. What worked best in our case study was a simple statement asked as a item is held up. "Do we need this to teach our courses?" It is a type auction as you look at specific needs of each course and the value of each individual item. When you have identified an essential item, it needs to be confirmed where it is used and when it is used. During the sort three areas were established and marked for collection. The first, an area assigned for items deemed essential for the courses taught. The second, for items not needed and considered junk or trash. During the sort several containers of expired resins, sealants, and chemicals were identified as no longer needed resulting in over a cubic yard of hazardous materials, subsequently, requiring special handling and coordination with the University. Lastly, the third area is for red-tagged items. A temporary storage area for red-tagged items may be required for offering up any red-tagged items of value that may be of use in other courses. Other items found to be red-tagged were obsolete equipment marked for return to the University. If this sort process sounds familiar, you might have seen a program on The Learning Channel (TLC) called *"Clean Sweep"*. In the TLC television show, they have Organizational Specialist to help homeowners to sort through piles of belongings brought outside to the yard. Next, they place each item in one of three areas, a keep area, which is always resorted twice, a yard sale area, and a giveaway/throwaway area. While the sort action is going on outside during the program, the cameras periodically cut to a team of craftsmen and designers inside of the homeowners' house remodeling for added storage and functional design. In real life, however, the craftsman is you and any remodeling efforts comes out of your budget.

SET IN ORDER

The second step in the 6S process is "Set in Order", the equivalent to the remodeling stage adding storage and functional design. Now that what is essential to teach courses is identified, it needs to be organized at or near the point of use to reduce transportation waste and waste of motion. This process results in what you need, where you need it, and when you need it. This is normally where you would look to get buy-in with the people performing the task. In a University setting with students for a semester at a time, it can be more challenging when it comes to getting buy-in. Therefore, it became a learning opportunity with the students. At all eight workstations in the composite laboratory, teams of two students per station were tasked to arrange the needed items for the course in the tool drawer's for best fit and function. After sharing and discussing the reasons for each station's choices of placement, the students attained a well-organized, universal layout. Next, with previously purchased foam each team traced the tool layout on the foam and cutout the outlined areas for tool placement. The universal layout between draws and the high visibility with the foam cutouts makes it easy to inventory each drawer at the end of the class. A similar shadowing process without the foam is used for the occasional special tools that are required, stored in the shop box. During set-in-order phase it was discovered that the composite resin and catalyst is stored in a locker on one side of the room and the mixing area and ventilation was located on the other side. By replacing the locker with an approved fire cabinet and locating it right next to the resin mixing station, a savings in time from the unneeded movement and eliminated the potential of spills during transportation. Several visual controls were created to help ensure control where items are to return. Students should be able to walk into a laboratory area and know

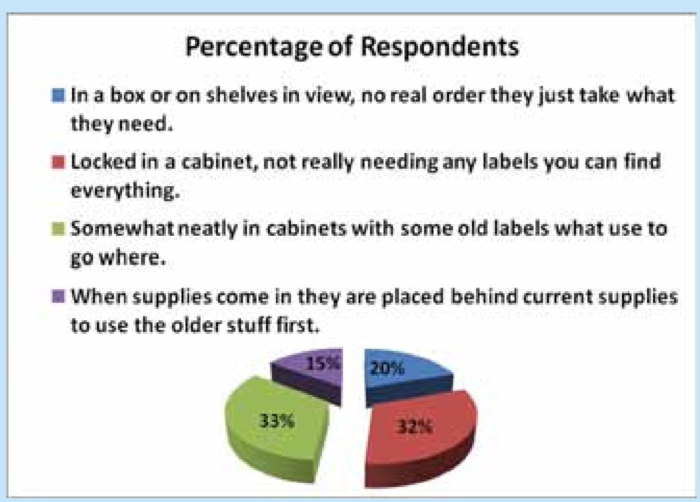


Figure 3. How are consumables stored in laboratory settings?

where things go. If you search the internet for “5S” you will be inundated by a completely new marketplace that offers all kinds of labeling and marking items for 5S implementation. In the research survey, the question “How are consumables stored in lab settings?” was asked. This question was looking for the storage systems that might be in use. Over 50% of respondents replied they do not use any type of organization with supplies as shown in figure 3. The response indicates a possible waste in time and potential overstock, resulting in inventory waste. By arranging consumables in a manner identifying where each item should be can help eliminate inventory waste and energy wasted looking for needed items. During labeling of each part bin an option used quite often in manufacturing is to add a minimum and maximum stock on hand amount to the label. This can help manage critical item inventories. Part storage and co-mingling of two different parts in one container are serious problems in the aviation industry. The same size and type of bolt with varying lengths stocked one next to another can find its way misplaced in a similar parts’ bin. This simple mistake can lead to serious circumstances on aircraft. One method used to combat the problem is alternating bolts, washers, and nuts bins in each row. In this case, keeping similar items such as bolts with different lengths from being right next to each other reduces the probability of co-mingling of unlike parts. An easy time saver in any laboratory setting is to outline and label where the broom, dustpan, and trash can are to be located. This can help eliminate the “Where do I get this?” or “Where does this go?” questions from students at the end of class and can save your sanity as well as wasted time. Simply put, set in order is a place for everything and everything in its place.

SHINE

Once you have removed the clutter and junk in your work areas and identified where everything belongs, the next step is to clean the area and equipment. This is the stage where you give the attention to the faulty equipment you have been meaning to get to or the equipment you found during the Sort phase. Putting the equipment in top shape saves unexpected down time during instruction. Students may also notice changes in equipment and facilities if regularly maintained. If Shine is overlooked in an area, it could in time, lead to equipment failure and or loss of a resource. Paint and repairs in the area shows pride in the program to students and potential students. Shine is a step that needs reinforcing to maintain. In Standardize, we will look at ways, to ensure the shine phase of 6S continues to be polished.

STANDARDIZE

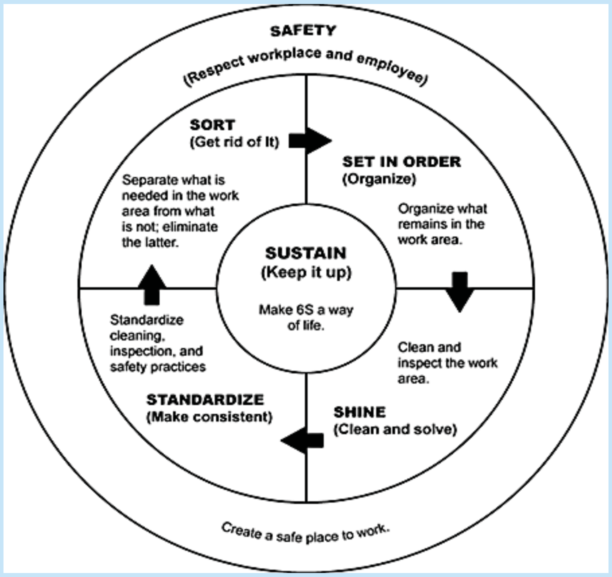
Without standardizing, a work area can deteriorate returning to previous conditions. Standardize is developing a periodic housekeeping checklist. Its purpose is to ensure that all the previous steps of sort, set in order, and shine are maintained. This is not something that has to be done daily. You may choose to do this inspection once a week, very two weeks, or even once a month. Whatever schedule chosen keep in mind the intent is to ensure that all the hard work put into the 6S process up to this point is continuing. After completing the 6S process in the composite laboratory a standard practice was established to identify a student at the start of each class as the Tool Control Monitor (TCM). At the end of the class session everyone must remain until the TCM verifies inventory and laboratories condition. The responsibility is eventually assigned to each student not only giving the students experience in standardizing in the 6S process, but also giving them more experience as a leader.

Figure 4 illustrates research survey responses relating to Standardization in storage areas. The responses revealed that 71% of the responses found items easy to locate in their storage facilities. Any out-of-sight storage area can easily become a magnet for clutter. This is key to reduce wasted time looking for equipment and to safely store equipment. A simple way of getting organized and standardized is by using an area map. Posting a simple map or some type of display showing what the item is and where it’s located in the storage room. As you walk in you can quickly find what you are looking for and have a chance it might get back to where it belongs. Why not make it simple to locate a piece of equipment?

Figure 4. How is equipment stored in storage areas?

SUSTAIN

The fifth of the 6S process is Sustain. Simply put, we are not trying to use a checklist to ensure compliance with the established plan of lean. Instead, we’re trying to sustain the process by motivating and encouraging our or students. We want students to practice using established shop standards to develop organizational habits, and the best housekeeping skills. The goals are that they will continue these practices throughout their career. Students need to be aware of what we are trying to achieve and why. They need to understand the concepts and the individual techniques used in lean. People need to feel that their efforts are recognized, positive reinforcement helps fulfill these needs. If 10 minutes is needed to restore the laboratory to established standards then 10 minutes should be allotted. Empower students with responsibility to ensure the work place continues to be organized, clean, and above all, safe. Pride in a job well done reinforces standards and leads to good habits.



United States Environmental Protection Agency.
Retrieved from http://www.epa.gov/lean/tookit/ch5.htm.
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Figure 5.
Safety the Sixth "S" of the 6S Process

SAFETY

The sixth and largest "S" in lean is safety. Having respect for our workplace and students. It encompasses the entire Lean process as shown in figure 5. Safety should be one of our highest priorities. We want to insure that our students use the proper Personal Protection Equipment (PPE) when handling chemicals, hazardous waste, and using power tools. In our case study, it is the rule, 100 percent of time in the Composite lab everyone must wear safety glasses. Anytime resin is mixed the proper PPE will be worn. The Material Safety Data Sheets (MSDS) must always be current and available, it's not only a good practice it's the law. If equipment becomes unserviceable it should be removed or made inoperative and tagged as such until repairs can be made. These are just a few ideas of what is needed to respect our workplace and our students. Safety is a constantly evolving process that we can't afford to take lightly. Figure 6 illustrates the research survey responses relating to safety standards. Of the respondents 80% stated that fire extinguisher locations were clearly identified. Of respondents, 73% stated that on the first day of class they give a tour to identify where, and how to use safety equipment. Tours of safety equipment and procedures should start off every semester. Only 66% use flammable lockers to store flammable chemicals. All flammables should be kept in OSHA approved flammable lockers for safety and visibility. Only 51% have one central location for first aid and hazardous response equipment, one can only hope the other 49% have multiple locations. Only 49% have the required MSDS's available for quick access in the laboratory areas. We definitely have room for the sixth "S" improvement.

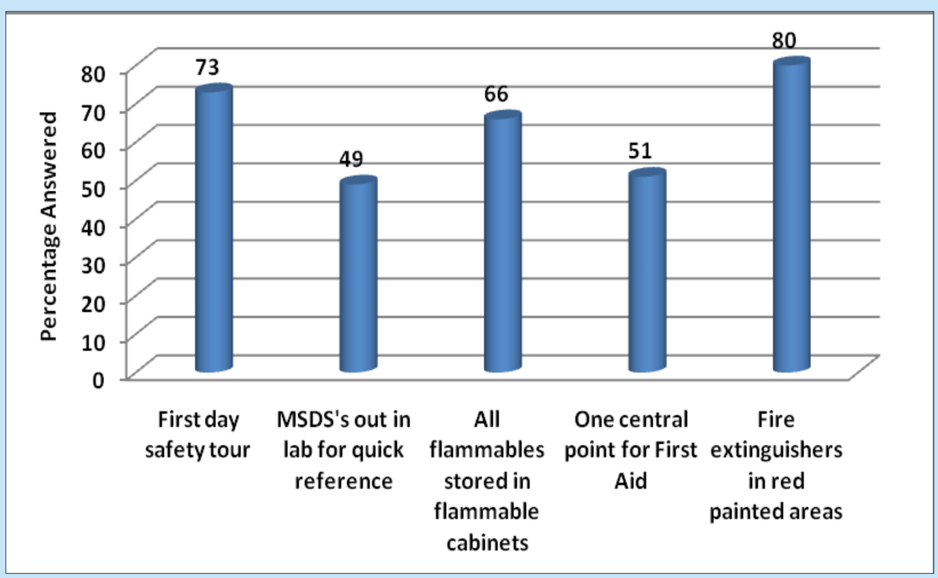

Figure 6.
Which statement(s) best describe your classrooms or laboratories?

CONCUSSIONS

The Lean process uses a system designed to reduce wasted resources, time, and to help optimizing a company's productivity. The aviation industry is committed to lean mythology and has success with it in the past 20 years. It's not just Boeing embracing lean, it is just about any company working within aerospace today. Lean mythology is successful in any type business, manufacturing, suppliers, and yes even Education.

The research within Part 147 Schools shows lean would clearly benefit our programs. The survey shows that 61% of the respondents polled had never even heard of lean, and only 10% have heard of or had any experience with lean. The seven wastes are within our programs in one form or another. If we evaluate how we do business by using the lean process tools, like others in aviation industry, I am sure we will found wastes draining your resources, reducing our instructional effectiveness, and needlessly occupying our limited storage spaces. The implementing of the lean process 6S is relatively inexpensive but its rewards can be impressive. The opportunity to instill the lean process in the Composite laboratory and in our students has increased productivity, and safety while making both an even more valuable asset. The students know what needs to happen and were everything needs to return to. Feedback from students has been positive as potential employers mention lean in job interviews, students are able to talk about the use and benefits. They come to the realization it's not just a buzz word it's the aviation industries' life style. We must teach by example these desired traits our industry supports. We need to ensure that our men and women have one more valuable tool called "Lean" shadowed in their toolbox.

REFERENCES

Blanchard, D. (2006, October). What's working for U.S. manufactures. *Industry Week*, 255, 49. Retrieved from http://www.industryweek.com/articles/census_of_manufacturers_--_whats_working_for_u-s-_manufacturers_12720.aspx

Henderson, I. (2007, March). 5s Training - The Lean Manufacturing Housekeeping. *PHS Management Training*. Retrieved from http://www.training-management.info/5s.htm

Hill, S (2007). The word of the day: Lean has become an end-to-end business process. *Manufacturing Business Technology*. Retrieved from http://www.mbtmag.com/index.asp?layout=articleprint&articleid=ca6479510

Holmes, S. (2001). Boeing goes lean. *Business Week*. Retrieved from http://www.businessweek.com/print/magazine/content/01_23/b3735098.htm?chan=mz

Katz, J. (2007, May) Lean choices. *Industry Week*, 255, 14. Retrieved from http://www.industryweek.com/articles/lean_choices_18426.aspx

Lean and Environment Toolkit (2007). *United States Environmental Protection Agency Lean Manufacturing and Environment*. Retrieved from http://www.epa.gov/lean/toolkit/ch5.htm

Minerd, D. & Seide, S. (Executive Producers). (2007). *Clean Sweep* [Television series]. Maryland: Discovery Communications LLC.

Ramey, C. (2004). Consortium is keen on lean [Electronic version]. *Journal of Boeing Integrated Defense Systems, 2(3), 3*.

Womack, J., & Jones, D. (1996). *Lean Thinking*. New York: Simon & Schuster

Annual Conference, Orlando. FL April 2011

Several venders attend the conference every year to present their goods or expertise to schools and to share information on many subjects dealing with current educational issues. This is a great place to view and try out many of the teaching aids and lab equipment available. The items on display ranged from engine cut-a-ways to teaching software. So if you did not get to attend the conference this year you missed out on many opportunities to gather information on all types of new teaching materials. Thanks to all of the vendors for their support and help with putting on the conference each year.

April 2011 Annual Conference, Orlando. FL

Integration of Aeronautical Engineering Principles and Concepts into Second Year Aeronautical Engineering Technology Course:

Goals and Proposed Actions

J. Hedden and S. Dubikovsky

ABSTRACT

In 2009, the Aeronautical Engineering Technology (AET) program at Purdue University received ABET accreditation. The accreditation is assurance that a college or university program meets the quality standards established by the profession for which it prepares its students and has accredited some 2,900 programs at more than 600 colleges and universities nationwide. In addition to national recognition, the accreditation allowed the Aviation Technology Department to add the 'Engineering' term to the "Aeronautical Technology" degree offered by the program which in turn provided additional academic and employability value to the degree. The accreditation came with stipulations of compliance that need to be resolved. Full ABET accreditation requires the program to increase the amount of aeronautical engineering 'concepts and principles' currently being taught and to enhance the curriculum to provide a higher degree of engineering comprehension for the students. All applicable courses in the AET plan of study are required to modify and/or enhance their curriculum to include these attributes. This Instructional Development Project (IDP) is initiated to meet ABET's requirements to enhance the curriculum, in the Aircraft Materials II (AT208) course, to include relevant aeronautical engineering concepts. The enhancements will be utilized for this semester as well as subsequent classes in the future.

INTRODUCTION

Since the 1970s the American economy has moved away from producing goods to providing services. About 85% of non-farm workers are employed in service-providing industries such as construction, transportation, and utilities (Griswold, 1999). Along with the workforce shift has come changes in the educational initiatives for workers. No longer is a useful worker one that is trained in a single aspect of his or her profession but rather one that is multi-disciplined, has good communication skills, knows how to solve problems and works as a team player to achieve a common goal.

Global competition has increased the educational demand put on the American worker and shows no signs of slowing down. Even service-providing jobs are susceptible to offshoring (Moncarz, Wolf, & Wright, 2008). Jobs that used to require a high school diploma now require a college degree. The level of education in that degree has risen proportionately also. Higher order math and communication skills are required by the industries to satisfy their ever increasing need for talented workers. High schools and universities have responded to this need by teaching higher order subjects earlier in a student's career and demanding more and more each succeeding year.

To meet the global challenge of competency in the workforce, universities have 'raised the bar' and now expect more from their students and require them to attain higher levels of sophistication. To that end, this project is directed at helping post-secondary students in the aeronautical technology realm attain a higher level of competency to meet the challenges of the workforce in the 21st century. ABET has accredited some 2,900 programs at more than 600 colleges and universities nationwide (ABET, 2010).

NEEDS ANALYSIS

A 'needs assessment' is considered to be a systematic exploration of the difference between the desired status of something and it's actual status and is usually associated with organizational and/or individual performance (Dick, Carey, Carey, 2009). When conducting a needs assessment, considerations need to be paid to accurately defining the status of the current situation and also the desired status to establish a clear goal and achieve desired results. A typical needs assessment asks the following questions:

- What is the actual level of performance now? -the actual status
- What level do we want to achieve? –the desired status

- What changes in behavior, performance and attitude are expected? –the need

During the last ABET visit, an analysis of the current level of aeronautical engineering curriculum was undertaken and the results suggested the current AT 208 curriculum needed more aeronautical engineering principles and concepts to satisfy ABET requirements. It was suggested that 20% more static engineering concepts concerning strength of materials and load factors be integrated into the curriculum. This instructional development project (IDP) is being developed to fill the 20% gap in the curriculum required by ABET and meet the goals of the objectives.

PURPOSE

The main purpose of this project is to develop and integrate an additional (20%) of aeronautical engineering principles and concepts into the curriculum of the Aircraft Materials II course. These enhancements are initiated for compliance with ABET accreditation. Emphasis will be given to applied concepts of static engineering loads and forces used in aeronautical engineering principles.

A secondary purpose of the project is to 'raise the bar' of education and knowledge to meet the needs of the aviation industry, the vision of the university and the need to graduate a more highly skilled class of engineering technologist than in the past. In remarks made during her State of the University 2010 speech, Purdue's President, France A. Córdova, alluded to the quality and education of the incoming students:

> This year's freshman class has the highest SAT scores in our history – up nine points over the previous year…and up 32 points over the beginning of the decade. Also increasing is the enrollment of students within the top ten percent of their high school rank (Córdova, 2010).

With top performers coming to the program, challenging curriculum will be needed to keep these individuals motivated and the addition of aeronautical engineering concepts into the AET program will help meet that challenge.

OBJECTIVES

The objectives were created to match the purpose of the study and are as follows:

- The course will have 100% compliance with the engineering requirements for ABET.
- The course curriculum will contain 100% of the engineering principles and concepts required by ABET.
- The classroom curriculum will include 20% additional aeronautical engineering concepts.
- Increase aeronautical engineering concepts and principles in the lab by 20%.
- The course improvements will increase the engineering knowledge and capabilities of the learners by 20%.

TARGET POPULATION

The representative group for this project will be comprised mostly of third and fourth semester, undergraduate students in the Aeronautical Engineering Technology (AET) program at Purdue University who are registered to take Aircraft Materials II (AT 208) course. These students have passed Aircraft Materials I, understand the basic process of working with aluminum sheet metal and basic riveting fundamentals and should have the entry level mathematics skills necessary for this course. The gender makeup, of the target population, is mostly male students with 2 or 3 females in the class. Historically, males have dominated this population in industry however; females are demonstrating an eagerness to compete with men and have proven they can function quite well in AET. Many times women feel intimidated by males in a particular field, and look elsewhere for opportunities, but the young women in AET stand side by side, shoulder to shoulder with the males in the class and produce as good if not better products than their male counterparts.

PROJECT MANAGEMENT PLAN

The management plan for this project includes collaborating with the engineering faculty members to identify and develop aeronautical engineering curriculum consistent with the requirements of ABET and the aviation industry. A team teaching approach will be utilized for the purpose of integrating the necessary engineering concepts into the class curriculum and presenting them to the group. One of the authors of this paper will present the aeronautical engineering concepts and principles needed to bring the curriculum up to 100% compliance in lecture. His many years of experience as an industrial engineer will serve the project well and provide the class with the additional knowledge necessary to achieve the goal. The following Table 1 lists the objectives, needs, activities, and assessment questions of the project and is predicated on approval of both the Aviation Technology department of Purdue University and ABET itself.

Table 1

Needs	Objectives	Activities	Assessment Questions
1.0 The course is not 100% compliant with ABET standards and needs to have aeronautical engineering principles integrated to meet those requirements	1.0 The course will have 100% compliance with the engineering requirements for ABET	1.1 Collaborate with engineering faculty to determine which engineering related concepts will be integrated 1.2 Meet to finalize integration of appropriate engineering principles and concepts for ABET compliance	1.0 What % does the course need to comply with ABET requirements?
2.0 The course curriculum lacks sufficient engineering concepts to meet the ABET requirements	2.0 The course curriculum will contain 100% of the engineering principles and concepts required for ABET	2.1 Integrate the chosen engineering principles into the curriculum for the classroom portion of the course 2.2 Integrate the chosen engineering principles into the lab projects	2.0 What % of engineering principles does the course need to possess?
3.0 The classroom curriculum lack the engineering principles necessary to meet all the ABET requirements	3.0 The classroom curriculum will include 20% additional aeronautical engineering concepts	3.1 Team teach the newly identified engineering concepts using traditional methods of pedagogy 3.2 Introduce new engineering concepts using a variety of instructional strategies	3.0 How much of an increase in engineering principles is needed for compliance?
4.0 The lab curriculum lacks required engineering principles and concepts for ABET certification	4.0 Increase aeronautical engineering theories and principles, in the lab projects by 20%	4.1 Introduce the previously identified engineering principles and concepts into existing lab projects 4.2 Develop new lab projects to include practical aeronautical engineering projects.	4.0 What % of engineering concepts needs to be increased in the lab projects?
5.0 The course lacks assessment items to evaluate retention of engineering principles by the learners	5.0 The course improvements will increase the aeronautical engineering abilities of the learners by 20%	5.1 Develop assessment items and instruments to determine effectiveness of program improvements 5.2 Develop a formative and summative means to assess the overall effectiveness of the project	5.0 How much will this project improve the engineering capabilities of the students?

ACTIVITIES

The activities outlined above comprise the essence of the project and include the basic premise of introducing improvements into a program which include:

1. Collaborate with faculty
2. Identify new concepts
3. Develop ideas
4. Implement concepts
5. Assess the results.

The process starts with both authors meeting before the semester begins to talk about the different types of aeronautical engineering principles to interject into the class curriculum. There are a series of planned meetings to keep the collaboration process moving. It will be a challenge not only to create and develop the materials and curriculum for the course but also to apply effective collaborative efforts to keep lines of communication open and working. As Winer and Ray (1994) state in the Collaboration Handbook, "Collaboration is a process that gets people to work together in new ways. The process doesn't end but spawns new collaborative ventures." After the semester starts, the collaboration, development and integration process will be ongoing, evolve continuously and carry on until the end of the semester. A weekly collaboration time will be established to allow both authors of this paper to meet and exchange ideas.

The exactness of the integration process has not yet been fully determined meaning the specific engineering practicum have yet to be paired with the unit of instruction in the course. Some of the units of instruction, such as aircraft paint and markings, will not include any engineering enhancements because of the nature of the subject. Most of the integration of engineering concepts will center on the 'sheet metal repair' units of instruction. The activities will cease at the end of the semester with the completion of the project.

BROCHURE AND WEBSITE

The brochure produced for this project was created for informational and recruitment purposes and is intended for a target audience comprised of prospective students in high school, community college as well as adults looking to change their career paths.

The website created for this project was created to provide relevance to the course by providing career information concerning aeronautical engineering positions in the aviation industry. The site contains information regarding the description of the position, the educational requirements for the job and additional websites with employment opportunities. It is the intent to keep updating and expanding the website to include more information relating to careers in aeronautical engineers. Go to http://at208.weebly.com to view the website.

CONCLUSION

To meet the challenges of an international industry and keep pace with global competition, STEM (Science, technology, engineering and Mathematics) education must be brought to the forefront of education in the United States and included in all technology course work. Regardless of the area of concentration, STEM concepts and principles must be introduced to students in America at an early age using contextual environments, and applied mathematical situations.

Integrating and implementing engineering fundamentals and concepts regarding statics and strengths of materials into advanced materials courses at Purdue University brings vital components of STEM initiatives into the curriculum. Efficient collaborative efforts employing open dialog among faculty, are necessary to effective integration of engineering principles and essential to the success of the program. Through the efforts of dedicated educators, and the approval of departmental administration, this collaborative endeavor allowed students the chance to expand their mind and approach conceptual ideas from the point of view of an engineer. Understanding the constraints of strength and yield points, combined with the practical knowledge of design and application, provides AET students a dual edged knowledge base and a more complete understanding of the concept of repair procedures applicable to the aviation industry.

REFERENCES

ABET, Inc. (n. d.). ABET, Inc. home page. Retrieved March 13, 2011, from: http://www.abet.org

Córdova, F.A. (2010, February 23). State of the University 2010: Meet the President. Retrieved from: http://www.purdue.edu/president/speeches/StateOfUniversity10.html

Dick, W. Carey, L. & Carey, J.O. (2009). The systematic design of instruction. (7th ed.). Upper Saddle River, NJ.: Pearson Education.

Griswold, D. (1999, September 30). Trade, Jobs, and Manufacturing: Why (Almost All) U.S. Workers Should Welcome Imports. CATO Institute, Trade Briefing Paper no. 6. Retrieved March 13, 2011, from: http://www.cato.org/pubs/tbp/tbp-006.pdf

Moncarz, R. J., Wolf, M. G., & Wright, B. (2008, December). Service-Providing Occupations, Offshoring, and the Labor Market. Monthly Labor Review, 131 (12), 71-86.

Winer, M.B., & Ray, K.L. (1994). Collaboration Handbook: Creating, sustaining, and enjoying the journey. St. Paul Minnesota: Fieldstone Alliance

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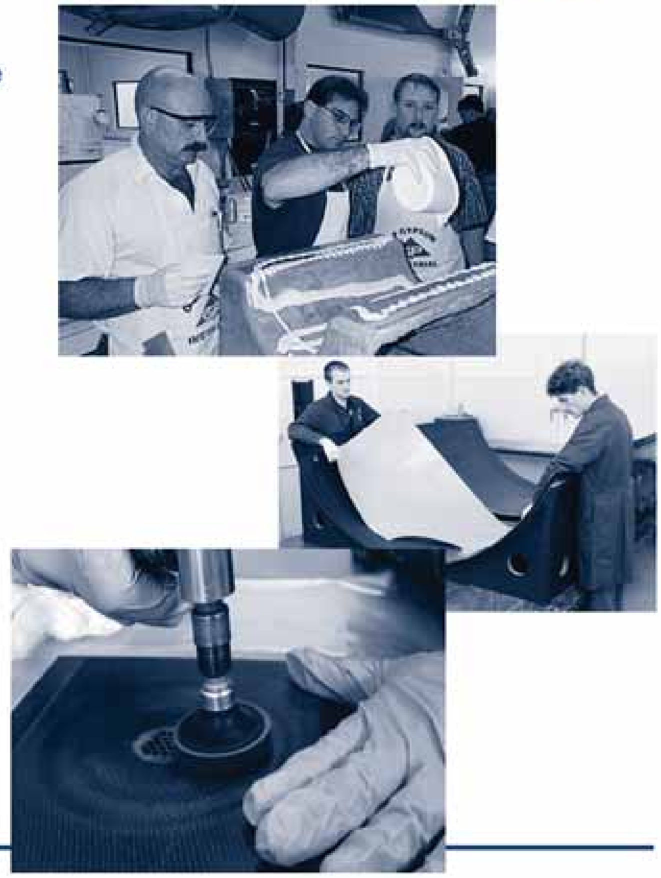

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Teaching Maintenance and Inspection Aspects of the Rotax 900 Series Aircraft Engine at a Traditional Part 147 Airframe and Powerplant Technician School

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ABSTRACT

The Rotax 912 series Aircraft Engine is a 4-cylinder, 4-stroke, high RPM, liquid cooled, lightweight power unit used in a host of recreational experimental and special light sport aircraft. The non-certified 912 ULS 100 horsepower visual flight rules (VFR) only version is the most common. Since the Rotax is substantially different from typical light aircraft reciprocating engines in several respects, additional training above what is offered in a typical Airframe and Powerplant (A & P) curriculum is recommended and in some case required to perform various levels of maintenance on the engine. Rotax approved maintenance courses at several levels are available through a number of factory approved providers. Due to the popularity of these power plants and the recent emergence of the experimental light sport aircraft (E-LSA) and special light sport aircraft (S-LSA) markets, familiarization with these engines and/or addition of factory approved maintenance courses may be viable additions to traditional Part 147 A & P programs. This paper examines some of the engine's characteristics and provides some suggestions for inclusion of Rotax engine familiarization material in such a program.

BACKGROUND

Rotax 912 series engines are manufactured by BRP Powertrain GmbH, an Austrian company which was acquired by Bombardier in 1970. Originally designed for Sea-doo® Watercraft and BMW motorcycles and all terrain vehicles (ATVs), the engines may more closely resemble motorcycle rather than aircraft types in some respects. While the first Rotax designed for aircraft use was certified in 1975, development of the 912 series began in 1984 with the 912F type certified 10 years later and the increasingly popular 912 ULS light 4-stroke light sport aircraft engine more recently (Rotax, 2009). During the course of its evolution to the modern light sport aircraft power plant marketed today, the Rotax endured some growing pains (Cox, 2007), however, the present day series exhibit few problems when properly maintained (Hamilton, 2007). The Rotax 912 ULS currently is in use in a large number of experimental and special light sport aircraft (E-SLAs and S-LSAs), the latter including the popular Remos and Tecnam lines.

Characteristics of the Rotax 912 include 4-cycle operation, liquid cylinder head cooling, use of balance tube connected twin Bing carburetors with embedded starting carburetors (perhaps inaccurately called chokes), a dry sump oil lubrication system, a propeller speed reduction gear box and a magneto type generator for accessory operation and ship's battery charging. While some of these characteristics mirror what is common in motorcycle engines, similarities to typical aircraft engines include battery independent redundant solid state magneto driven ignitions, dual spark plug cylinders and automatic fuel mixture metering for efficient operation at altitude. The engines operate to a service ceiling of around 12,000 feet and at a considerably higher RPM than conventional reciprocating aircraft engines.

The FAA, Rotax and LSA manufacturers collectively have developed guidelines on engine servicing and inspections. In addition to the conditional requirements that the Federal Aviation Administration (FAA) and primarily Rotax may impose for individuals to service and inspect its engines, the light sport aircraft manufacturer may also have specific guidelines as to qualifications for performance of maintenance and inspections on its products. These are generally specified in the manufacturers' maintenance manuals for a particular engine/aircraft and must be adhered to. Certain items may be approved for inspection by the aircraft owner and other generally more complex or airworthiness related ones, by a certificated airframe and/or powerplant technician or a light sport aircraft repairman with the proper training and/or experience. Any modifications to the airframe or its components must be approved and specified by the manufacturer as to what can be performed and how the procedure is to be accomplished. Unlike conventional aircraft in which major alterations or modifications require an approved FAA form 337 Major Repair and Alteration (Airframe, Powerplant, Propeller, or Appliance) form, both major and some cases minor alterations require the manufacturer's, but not necessarily the FAA's approval. Certain repairs may also require manufacturer's approval and documentation as specified in the aircraft maintenance manual or via direct communication with the manufacturer. In any case, a thorough understanding of the applicable aircraft and engine maintenance manuals is paramount to performing required maintenance and inspections properly (FAA, 2006). The intention of this paper is to assist interested FAA Part 147 Airframe and Powerplant Maintenance Schools in the addition of Rotax engine maintenance and inspection familiarization procedures to their programs. It is not intended as an empirical paper or literature review and by no means is a guide to practical application of any maintenance or inspection procedure or a substitute for any material contained in the various manuals published by the engine or airframe manufacturer. The information contained in this paper is not endorsed by Bombardier, BRP Powertrain GmbH & Co, Rotax or any of its subsidiaries.

WHAT PART 147 A & P SCHOOLS CAN DO

Part 147 airframe and powerplant mechanic schools are a primary source of entry level aircraft maintainers in the U.S. (GAO, 2003). While these schools are governed in the topics they must include in their curriculum by the FAA, there is some latitude for adding instruction beyond specified topics included in the regulations. The topics are arranged in Appendices B - D to Part 147.2 and include material that must be taught in the general, airframe and powerplant curricula respectively. Although certain topics are specified, the regulations do not limit the inclusion of ancillary material where time permits (FAA, 2009). It is in this realm and under these guidelines that material relating to unconventional aircraft power plants such as the Rotax 900 series may be introduced. This being said, it should be noted that a revision of the Part 147 curriculum requirements is presently under review by the Aviation Rules Advisory Committee in conjunction with the FAA and revision of the topics and contact instructional time allotted to each of the three categories is subject to change. Specifically, the contact hours of instruction required for the FAA power plant mechanic certification may be reduced from the present 750 to 650 although a total of 1900 hours for the sum of all three categories of instruction is expected to remain (Thompson, 2010).

In the power plant curriculum at Southern Illinois University Department of Aviation Technologies, five courses deal directly with power plant maintenance, repair and inspections. These are the Reciprocating Power Plant; Carburetion, Lubrication and Fuel; Power Plant Testing; and Powerplant Inspection classes. Additionally, the Ignition Systems, Electrical Systems and Propellers classes offered provide additional venues wherein Rotax related material may be covered. The five primary and three secondary power plant courses occupy 21 and 13 credit hours and make up over 600 and 300 semester contact hours respectively.

WHAT TO ADD AND WHERE TO PUT IT

Using a typical A & P curriculum as an example, a discussion of the appropriate areas of instruction to place the additional material follows.

Most of our students begin their power plant courses in the second year of the program. The first of the engine related classes in which the students participate is a Reciprocating Powerplant course. This class teaches construction, operation and timing mechanisms as well as cleaning and inspection of typical aircraft engines. Basic concepts as well as adherence to manufacturer's guidelines are stressed. It is in this course that the characteristics of the Rotax engine could be introduced. Approximately two hours of instructor led discussion and demonstration may be adequate for a basic overview. Included in the instruction could be a discussion of the close tolerances of manufacture including the engine's liquid cooled, high compression, high RPM and twin carburetor distinctiveness permitting the development of 100 horsepower in a 130 lb package. Use of a large graphic of the engine and a typical installation as depicted below in Figures 1 and 2 would afford the instructor the opportunity of teaching the highlights of its construction and operation while giving the students a proper visual overview.

Figure 1. Rotax 912 ULS

Figure 2. Typical Rotax 912 Installation

With permission from the producer, the inclusion a one hour video entitled Rotax 912 Engine Introduction produced by Paul Hamilton and featuring Phil Lockwood and Dean Vogel of Lockwood Aviation describing aspects of Rotax 912 operation and maintenance would be appropriate in this course (Hamilton, 2007). Once initial introduction to the engine is accomplished in the Reciprocating powerplant course, details of its line maintenance can be covered in the various component courses such as carburetors, ignitions, propellers, etc. and inspections covered in the Powerplant Inspection course.

The details of the twin top mounted carburetors can be examined in a carburetors class. These units consist of two Bing-64 constant depression float type carburetors connected by a balance tube at the intake manifolds. They are mounted to the intake manifold body of the engine with a flange secured with clamps that facilitate easy removal. Most installations do not employ filter screens in the carburetor bodies making installation of a gascolator on the airframe firewall and a course particulate filter at the fuel tank-fuel line connection advisable. Installations can be made with or without an airbox; however, for the benefit of a carburetor heat control its inclusion in the installation is recommended (Rotax, 2009). In the Rotax, the cold starting sequence consists of operating a “choke” rather than priming the engine or pressurizing the fuel system as in injector type systems. The “choke” is actually a starting carburetor which injects additional fuel when activated to enrich the fuel-air mixture for cold starts. The throttle must be in the full idle position and the “choke” at full activation for the system to operate properly. As the “choke” lever also increases engine starting RPM, Rotax recommends that the “choke” lever be backed off and the throttle increased to 2200 RPM for warm-up after the engine starts (Rotax, 1998). Part of the installation and inspection process consists of balancing and checking the two carburetors such that the two throttle valves open equally and an equal vacuum level throughout the throttle travel path is achieved on both carbs. This is a multi-step process which consists of an initial mechanical setting of the cables and linkages followed by a pneumatic balancing wherein fine adjustments are made ultimately achieving a smooth idle and run condition. The process is delineated in the Rotax Line Maintenance Manual (Rotax 2009) and several other sources including the article Looking After Your Rotax 912 Series Engine (Beale, 2009) and Reaching Smooth Idle, Parts 1 & 2 (Lockwood, 2004). As the Rotax actually functions as two 2-cylinder engines connected to a common crankshaft, it is imperative this aspect of engine installation and maintenance be carried out (Lockwood, 2004). Additionally, according to the Rotax 912 Line Maintenance Manual, carburetor balance must be inspected, checked, and corrected if necessary at each annual/100 hour inspection and at the initial 25 and 50 hour engine inspections (Rotax, 2009) reinforcing the importance of performing this operation.

It should be mentioned that the Rotax 900 series runs very well on automobile gasoline, 91 octane or above, as well as 100 low lead (LL) avgas, however, there are some caveats which apply to each fuel type usage. As the Rotax is partially liquid cooled, the engines normally do not run as hot as a typical Lycoming or Continental aircraft power plant. When using 100 LL, lead deposits accumulate on the cylinder heads, valves, connecting rods, etc. as well as spark plugs and a pasty lead residual will accumulate in the sludge and particulate catching area at the bottom of oil reservoir. Rotax recommends that use of 100 LL more than 30% of the time requires a shorter interval between spark plug and oil changes (Rotax, 1998). The shorter intervals are generally at one-half the normal plug change interval and every 50 hours for an oil and oil filter change. While Rotax does not comment on the use of lead scavenger additives such as TCP, some of the other literature suggests that its use may decrease problems associated with the use of leaded fuels (Aircraft Spruce, 2009). Rotax does conclude that field experience has shown that no detriment to the engine occurs with their use (Rotax, 2009). Use of unleaded automobile fuels with gasohol added may create some problems if the percentage of ethanol in the fuel is high enough. Since ethanol has a tendency to absorb water, condensation in fuel tanks may tie up some of the ethanol, which while good to eliminate water from the fuel can lower its octane rating below the minimum of 91 required for proper operation of the engine (Hamilton, 2007). This can also lead to a condition called phase separation of the fuel, which could cause further degradation of fuel system components. One of this paper’s authors noted through an unfortunate personal experience with high (93) octane unleaded automotive fuel not containing ethanol, degradation of some composite fuel tank slosh coatings and adhesives on the inside surfaces of the fuel tanks. It appeared possible that this damage may have been caused by the effects of unknown additives in the fuel. Providentially the degradation was noticed early and repairs affected before serious damage threatening the integrity of the fuel tanks occurred. While the octane rating and presence or absence of ethanol in automotive fuels is easily determined, the presence of other additives which may damage particular systems may not be evident until damage is done. As the federal Environmental Protection Agency and others push for replacement of leaded aircraft fuel with an acceptable standardized unleaded, non-ethanol containing substitute (Douglas, 2010), caution is appropriate in the usage of automotive fuels as they may cause damage to the fuel system.

Additional information regarding lubricants for instruction relates to crankcase oil. As indicated previously, the Rotax 900 series engine resembles a motorcycle engine in many aspects. One aspect is the use of a gearbox similar to what constitutes a motorcycle engine transmission to reduce the high engine RPM to a rate appropriate to drive a propeller. Because of both the tight mechanical tolerances utilized in manufacture of the engine and the use of a lubrication system common to both the crankcase and gearbox, regular aviation engine oil is not recommended for use in the Rotax power plant. Instead a non-synthetic petroleum oil, high quality multigrade motorcycle oil (10W 40 or 10W 50) or specially formulated semi-synthetic (Hamilton, 2007) such as Aeroshell Sport Plus 4 is recommended (Aircraft Spruce, 2010).

Oil level check and change procedures in the Rotax also require a different approach than in conventional aircraft engines. The Rotax uses a dry-sump type system wherein the oil is contained in a separate reservoir rather than the engine crankcase. The system does, however, use an oil cooler, a mechanical engine driven oil pump and a fiber filter with a pressure bypass as is the case in typical aircraft engines. Rotax recommends the oil reservoir be mounted on the firewall and the oil cooler mounted in the air stream with the intake and output ports facing upward. The Hamilton Rotax Introduction video also recommends exclusive use of Rotax brand oil filters due to their bypass pressure characteristics and manufacturer's assurance of quality (Hamilton, 2007).

Prior to checking the oil level in the reservoir, the engine needs to be hand cranked in the counterclockwise direction of normal rotation (when facing the power take off or propeller side of the engine) with the oil reservoir filler cap removed until a gurgling sound is heard. This procedure assures any engine oil remaining in the crankcase is returned to the reservoir and to also prevent the introduction of air into the oil lubrication system. The process may take up to 10 or more rotations. When performing an oil change or servicing the system, care should be taken not to permit engine rotation in the direction opposite of normal rotation. Should the lubrication system require service necessitating disconnection of the oil lines at areas other than the top of the reservoir tank, removal or replacement of oil lines, changing of the oil cooler, or total draining of the oil system, the system must be purged as oil is added, again to prevent introduction of air which may become trapped into the system. Procedures for accomplishing these tasks are outlined in the Rotax engine Line Maintenance Manual (Rotax, 2009) and the purging procedure is also demonstrated by a video posted on the Rotaxowners.com web site. Additional procedural Rotax "E-learning" and instructional videos relating to oil and filter changes as well as other maintenance and inspection procedures are also available there (Rotax, 2010).

Although not actually part of the fuel and lubrications topic, a magnetic plug inspection should be performed at specific intervals as described in the line maintenance manual and instruction videos. The Rotax engine has a single magnetic plug which is located on the left side of the engine above the oil filter flange. As is the case in any engine, an excessive amount of metal filings (greater than a 3 mm [0.125 in] clump in the case of the Rotax) adhering to the magnetic plug is an indication of possible internal engine damage or malfunction and should be promptly investigated. As with conventional aircraft engines, the oil filter should be cut open and the element examined for metal filings or other particulates at the change cycle (Rotax, 2009).

The Rotax uses a liquid cooling system for the cylinder heads while conventional air cooling is used for the balance of engine temperature regulation. As is the case in automobiles and liquid cooled motorcycle engines, a radiator, expansion and overflow bottle are employed and all need periodic checks and maintenance. The liquid coolant may be a typical 50/50 (50 percent distilled water and 50 percent antifreeze) antifreeze solution or a waterless coolant such as Evans® may be employed. The coolant type used is designated by the manufacturer. The Rotax cylinder head gauge temperatures generally range between around 160° to 300° F (150° C maximum) and the oil temperature between 120° and 285° F (50° – 140° C). In the event a change is the coolant type is made, the system must be thoroughly flushed and treated in accordance with the manufacturers' directions. Waterless coolants and 50/50 coolants are generally not compatible. Engines will typically run somewhat hotter when waterless coolant is used (Hamilton, 2007).

An ignitions class would be a good venue to discuss the redundant dual magneto solid state ignition while an electrical systems class may be more appropriate to discuss the DC power system. In the ignition system, there are no mechanical contact points to wear out. However, a study of the mechanism is important as an adjunct in proper maintenance and inspection of the system. The energy for the ignition spark is generated in a magneto coil which is co-mounted in the ignition housing at aft end of the engine along with a "light coil" circuit. The 8 light coils generate an alternating current that is rectified and filtered to provide the 12 – 14 volts direct current (DC) to run the aircraft radios, instruments and accessories as well as keep the ship's battery charged. Rotating magnets on the flywheel induce voltages in both the light and ignition coils. There is also a take off to power an electronic tachometer. The AC power from the redundant ignition coils is sent to the electronic ignition module for spark energy processing and that from the light coils to a rectifier-regulator-filter unit to achieve the 12 volt, 250 watt DC energy for battery charging and accessory power. Figures 3, 4 and 5 below reveal the external components of the electrical and ignition systems (Lockwood, 2004).

Figure 3. External Electrical Modules (Lockwood, 2004)

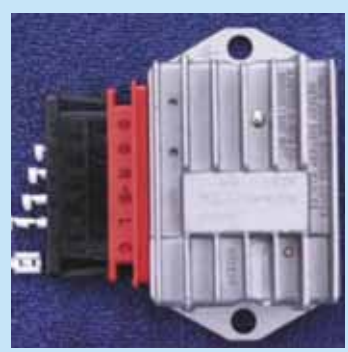

Figure 4. Rectified-Regulator-Filter Module (Lockwood, 2004)

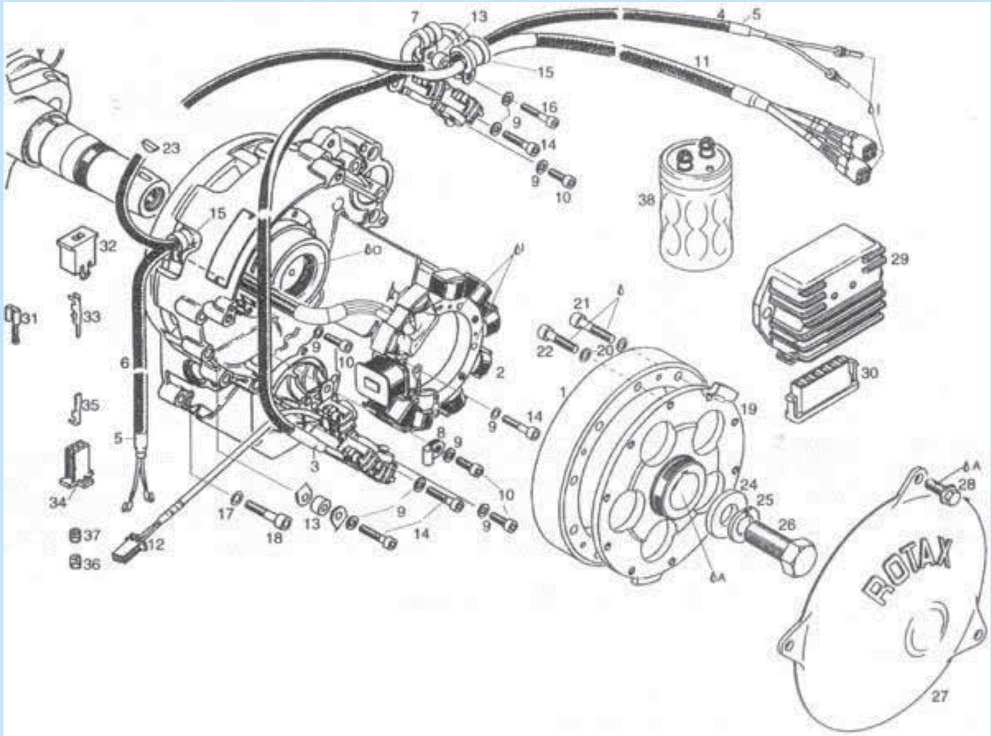

Figure 5. Rotax Magneto-Generator and Associated Parts (Rotax, 2009)

As is the case in a typical reciprocating aircraft engine, the Rotax uses redundant spark plugs, two per cylinder. Plug electrode gaps should be checked and set during replacement or cleaning and at inspection intervals (Beale, 2009). The spark plug heat rating is important, and the plugs should be changed with a direct replacement type typically every 100 hours or every 50 hours if 100 LL fuel is used (Rotax, 2009). Spark plugs for the Rotax are sold at a cost comparable to automotive plugs so frequent changes are an inexpensive portion of maintenance costs. Rotax recommends a heat conductive silicon based paste be applied to the plug threads taking care not to permit the paste to contact the bottom 3 threads or electrode area. Disabling of the ignition system subsequently shutting down the engine is accomplished by grounding appropriate pins on the 6-pin connectors to the ignition modules. Typically this is controlled through a set of toggle switches or a conventional OFF-MAG 1 ON-MAG 2 ON-BOTH ON-START ignition switch. If it becomes necessary to test the ignition system, removal of a plug to check for spark at the electrode while cranking over the engine is not advisable. According to the Hamilton Rotax video, the engine must rotate at about 250 RPM to produce a usable spark of sufficient magnitude to be visible. Hand cranking of the engine by turning the propeller, even with the effect of the gearbox, does not provide sufficient rotation speed to accomplish this. Further, if a plug is not adequately grounded, damage to the ignition coils may occur as the energy generated has to be dissipated somewhere. If this energy does not have a suitable path, it can cause an overload, burning out the excitation coil necessitating an expensive repair. If ignition testing becomes necessary, use of a timing light or other appropriate testing device is recommended (Hamilton, 2007).

A number of types of propellers are suitable for the Rotax engine although usage of different types and manufacturers call for a particular RPM idle setting (Lockwood, 2004). A benefit some three blade composite prop types is a single blade can be changed out in the event of chips or damage rather than replacement of the entire propeller assembly (Warp Drive, 2010). In most cases the airframe and or propeller manufacturer defines how the process is to be performed and it should be followed precisely. Because of the Rotax' high RPM characteristic, a gearbox with a reduction rate of 2.43:1 is required to ensure the propeller tip speed is not excessive. Maintaining the engine idle RPM between 1800 and 2200 is recommended in any case although extremely light weight propellers may permit speeds as low as 1400 RPM. An idle speed lower than 1400 will damage the torsion damper system in the gearbox and would probably result in a rough idling engine in any case (Rotax 1998). The gearbox shares its lubrication oil with the rest of the engine, necessitating the use of somewhat specialized oils as described above. The gearboxes in newer engine models are equipped with an overload clutch to mitigate damage in the event of a prop strike, however, should one occur appropriate inspections of the crankshaft and other engine components are necessary prior to return to service. Checking the amount of torque required to engage the overload clutch is part of the maintenance and inspection procedure (Rotax, 2009).

Figures 6 and 7. Depiction of Dynon EMS-D120 display with engine off and engine running (Hannon and Harrison, 2009)

PUTTING IT ALL TOGETHER

The final areas to combine and review the Rotax maintenance and inspection material together are Powerplant Testing and Powerplant Inspection classes. It is here that students use the knowledge and experience they have gained in the 2.5 to 3 year airframe and powerplant technician program to complete their training.

A powerplant testing class can provide the students with knowledge of the correct procedures and precautions to be observed during engine installation, ground operation and fuel and oil servicing in addition to culmination of the material they have learned in previous training. Troubleshooting and interpretation of instrument readings is also taught in this class. Particularly applicable to the Rotax, the manufacturer recommends a number of installed monitoring instruments to assure the health and well being of its engines during normal operation. In addition to the typical fuel quantity, oil pressure, temperature and hour-meter gauges, two cylinder head temperature gauges and an oil temperature gauge is advised as well as fuel pressure, exhaust gas temperature and electrical system DC voltage output indicators. Provisions are made in the new glass cockpit engine monitoring systems designed for light aircraft such as the Dynon EMS-D120 (pictured below) in installations where electronic monitor system has replaced the older analog steam gauge type instruments (Dynon 2008). Whichever method is used, continued familiarization with the Rotax Engine operators' and installation manuals as well as the line maintenance manual can be stressed here.

In a powerplant inspections class, students can demonstrate their knowledge of Federal Aviation Regulations relating to engines, applications of Federal Aviation Administration Airworthiness Directives, Service Bulletins and proper use of inspection equipment. Generally, Rotax engine installations fall under the FAA Special Light Sport or Experimental Light Sport rules which would include demonstration of adherence to both the engine and airframe manufacturers' guidelines, service directives and maintenance procedures as well as any directives imposed by the FAA. Below is an example of an engine inspection check list portion developed by one of the authors for a Rotax 912 engine (Figure 6).

Inspection Description	Hours			
Task	50 hr	100 hr	other	Performed by
1. Clean engine	X	X	200	owner
2. Visual engine check	X	X	200	owner
3. Engine leak check	X	X	200	owner
4. Check engine mounts	X	X	200	owner
5. Check engine external parts	X	X	200	A & P
6. Reduction gear check	X	X	200	A & P
7. Check oil level	X	X	200	Owner
8. Change oil and filter	X	X	200	A & P
10. Check cooling system	X	X	200	A & P
11. Change coolant (every two years or)			200	A & P
12. Replace coolant reservoir pressure cap			200	A & P
13. Check and regulation of carburetors	X	X	200	A & P
14. Check control cables	X	X	200	Owner
15. Change spark plugs			200	A & P
16. Check compression			200	A & P
17. Check engine electrical parts	X	X	200	A & P
18. Change rubber parts			200	A & P
19. Check overvoltage relay			200	A & P
20. Overhaul engine (15 years)			1500	A & P

Figure 6. Typical engine inspection checklist in an LSA Airplane

As is generally the case under light sport rules, the manufacturer is at liberty to determine maintenance tasks and who should perform them. In this case, some of the inspection items may be performed by the owner (owner) and others by a qualified airframe and powerplant technician (A&P). The inspection lists and maintenance items generally have one or more caveats advising that FAA or appropriate regulatory agency and/ or engine manufacturer's regulations and guidelines be followed with respect to individuals considered qualified to perform the maintenance and inspection tasks (Figure 7). It is recommended that a separate engine logbook be kept (Beale, 2009) and Rotax actually supplies one with its engines. The Rotax Line Maintenance manual contains a section on performance of inspections and an inspection checklist (Rotax, 2009).

Per Special Light Sport Rules, the aircraft manufacturer is the last word in aircraft maintenance and repair. It is reiterated that the FAA 337 Major Alteration form is not required in performing special light sport aircraft repairs and maintenance, however, manufactures approval along with a method of compliance is.

IMPORTANT :

As far as ROTAX 912 engine installation, inspections and maintenance are concerned, carefully follow the instructions of the engine manual supplied with the engine.

For maintenance and inspections of parts with finished materials or supplied by other manufacturers, such as: propeller, hubs, wheels, brakes, pumps, filters, pulleys, cables, pipes, bolts, rivets, extrusions, fusions, etc., follow the suggestions of the manufacturer, if supplied.

Figure 7. Manufacturer's Caveat Concerning Installations and Maintenance (Rotax, 2009)

SUMMARY

Addition of Rotax engine training material would be an enhancement to any A & P school curriculum. There is a wealth of information available on the Rotax web site and also through a variety of other sources. Depending on the needs and desires of the institution, a greater or lesser degree of material can be introduced. Several organizations offer the factory approved courses in the form of 2 day service and maintenance courses as well as a Rotax technical instructions course (Rotax-Owners, 2010). These courses may be of value for Part 147 A & P instructors in preparing instructional materials.

In the case of institutions certificated by the Federal Aviation Administration under Part 147, integration of Rotax engine familiarization material into systems courses where engine repair and maintenance is covered where desired, may become easier as a result of suggested revisions to Part 147 by the Maintenance Technician Schools Curriculum and Operating Requirements Working Group of the Aviation Rules Advisory Committee (ATEC, 2009). In such cases, FAA guidance as well as curriculum committee or other approval depending on local practice should be undertaken prior to implementation of any course revisions. As these materials are taught, the end result will be better informed and educated airframe and powerplant technicians available to service a popular aircraft engine in the emerging light sport category.

REFERENCES

Aircraft Spruce. (2010). On-line catalog, TCP fuel treatment. Retrieved May 17, 2010 from: http://www.aircraftspruce.com/catalog/appages/alcortcp.php

Aviation Technical Aviation Council (ATEC). (2009). 147 ARAC summary. *Journal of the Aviation Technical Education Council*. 31(1), 32-33

Aviation Technical Education Council (ATEC). (2009). ARAC update. *Journal of the Aviation Technical Education Council*.

Beale, Conrad. (2009). Looking after your Rotax engine. Conair Sports, Ltd. UK

Cox William. (2007). Air elite storm rally. *Plane and Pilot, Pilot Journal*. Werner Publishing. Los Angeles

Douglas, James. (2010). General aviation industry prepares for an unleaded fuel. Av-Stop.com Aviation On-Line Magazine Retrieved May 20, 2010 from: http://avstop.com/news_april_2010/general_aviation_industry_prepares_for_an_unleaded_fuel.htm

Dynon (2008). Pilots guide; EMS-D120 engine monitoring system. Dynon Avionics, Inc. Woodinville, WA

Federal Aviation Administration (FAA). (2006). Certification of repairmen (light-sport aircraft) AC 65-32. U.S. Government Printing Office. Washington

Federal Aviation Administration (FAA). (2009). 14 CFR Part 147 Appendix B, C, and D; general, airframe and powerplant curriculum requirements. U.S. Government Printing Office. Washington

Hamilton, Paul. (2007). Rotax 912 engine introduction. [DVD Video]. United States: Adventure Productions.

Harrison, M. and Hannon, D. (2009). Digitizing a reciprocating engine testing platform. *Aviation Technical Education Journal,* 31(2) 4-11.

Lockwood, Philip. (2004). Reaching Smooth Idle Part 1 and Part II. *EAA Sport Pilot*. Magazine. April and May, 2004.

Lockwood, Philip. (2004). Tips and tricks for the ideal Rotax installation. *EAA Sport Pilot Magazine*, March, 2005.

Rotax. (2009). SI-912-016 R2 selection of suitable operating fluids for Rotax 912 and 914 series. Rotax-Bombardier, BRP-Powertrain GmbH. April 8, 2009

Rotax-Bombardier (2010). History. Retrieved May 6, 2010 from http://www.rotax.com/en/About.Us/History

Rotax-Bombardier. (2009). 912 ULS installation manual. BRP Powertrain GmbH & Co. Austria

Rotax-Bombardier. (2009). 912 ULS line maintenance manual. BRP Powertrain GmbH & Co. Austria

Rotax-Bombardier. (2009). 912 ULS illustrated parts manual. BRP Powertrain GmbH & Co. Austria

Rotax-Bombardier, (2010). Purging of the lubrication system, si-912-018. Video. Rotax owners.com. Retrieved May 18, 2010 from: http://www.rotaxowner.com/index.php?option=com_content&view=category&layout=blog&id=7&It emid=159

Rotax-Bombardier. (1998). 912 ULS operators manual. BRP Powertrain GmbH & Co. Austria

Rotax-Owner.com. (2010). 4-Stroke training courses. Retrieved May 28, 2010 from: http://www.rotaxowner.com/index.php?option=com_content&view=category&layo ut =blog&id=11&Itemid=16

Thompson, Raymond E. (2009). Part 147 ARAC update. Letter to aviation technical aviation council membership, January 29, 2010

United States General Accounting Office (GAO). (2003). GAO-03-317 Aviation safety – FAA needs to update the curriculum and certification requirements for aviation mechanics. Government Printing Office. Washington.

Warp Drive Propellers. (2009). Installation instruction brochure. Warp Drive Inc. Ventura, IA.

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ATEC Update

PRESIDENT'S MESSAGE

When I assumed my role as president, I did so with the desire to see ATEC improve our communications, membership services, and offerings to each member institution. After all, each of us has limited time and resources and will invest them where they do the most good. We are making progress. An ongoing review of the website has been taking place to clean up what is currently available and look to what our next generation website should look like. We added more sessions at the conference that benefit your school as well as the individual instructor. ATEC is also looking at ways to facilitate sharing curriculum in an open source manner with other members while protecting copyright and intellectual property rights.

We continue to hear about the impending shortage of A&P technicians. Hiring is starting to pick up and internships are returning. More than ever, each of us needs to provide the most current and advanced training possible. The Part 147 ARAC may be delayed due to higher priorities within the FAA, but as a group we can still continue to develop and evolve each of our programs. ATEC is focused on providing resources to assist with your growth. You have requested ATEC to provide these services and we are listening.

Your input is always welcome. We need to know your needs so we can serve you in the best manner possible. Best wishes to each of you for 2011.

Ray Thompson

FINANCE/BUDGET

The 2009-2010 ATEC Budget Report was distributed at the conference showing a net surplus of $7,830.15.

While the 2011 Budget (December 2010-March 2011) is tracking well, it is still too early to project a surplus or deficit for 2011.

Aviation maintenance programs nationwide are still in a retrenchment mode but membership is remaining stable. Membership is as follows:

	2009	2010	2011
Institutional	94	70	93
Individual	3	7	7
Industry	19	22	14
Life	9	9	9
TOTAL	125	108	123

ATEC CONFERENCE

Ninety-six representatives from 58 schools attended the 51st Annual ATEC Conference at the Orlando International Palms Resort. In addition, there were 19 exhibitors, 8 speakers and 27 spouses/guests.

See you in 2012 at the Phoenix Fiesta Resort April 14-17 for the ATEC Conference with IA Renewal on April 14, 2012.

The top five conference presentations in rank order were:

1. Understanding and Teaching the New Millenial Students
2. Industry Panel
3. Latest Technologies in UAV
4. Beyond the Technical: Teaching Professionalism
5. Best Practices in Student Recruiting and Marketing

The exhibitors were the highest rated part of the general conference along with the conference facility. The lowest rated part of the conference was the hotel sleeping rooms which had not been updated as promised by the hotel.

ATEC DVDs

The entire (almost 200) instructional materials library is now fully converted to DVD format. They are available on the ATEC website, www.atec-amt.org (click on Instructional Materials) with a downloadable form.

The numbering system for ordering is still the same with a "check" qualifier after the number to signify the DVD format. You can also continue to order video tape format materials if you choose.

ATEC COMMITTEES

A committee membership roster is attached. If you would like to serve on a committee, please let the ATEC Office know at ccdq@aol.com.

ATEC WEBSITE

The ATEC Communications Committee is working with our webmaster to improve the existing site while reviewing newer and better free hosting sites.

As to the content, the committee is interested in input from members on the following:

- What communication technology do you use?
- What content would you like to see on the ATEC website?

Please send your feedback to:

Paul Herrick – afpeh@uaa.alaska.edu and

Tom Hagovsky – hagovsky@purdue.edu

GOVERNMENT RELATIONS

The top issue for the Government Relations Committee is the 147 revision Final Report currently on hold in the NPRM process. There has been further dialogue with AFS-300 about the timeline of the 147 NPRM, now projected to be FY 2012. This NPRM work is on the FAA Dashboard (a weekly updated monitoring system).

Note: While waiting for 147 NPRM, AFS-300 is moving forward and working to test and evaluate "alternative methods of delivery" with an ATEC school. ATEC will continue this work, including follow up 147 guidance development to be in harmony with the new rule once it goes into effect.

ATEC has intervened in several local school and regional issues with the FAA. Members of the GR committee have been able to head off some serious situations. Over the past 6 months, the ATEC Government Relations Committee assisted five member schools with FAA issues that could not be resolved at the local level. For assistance contact Andrew Smith - atsmith@ksu.edu.

SCHOLARSHIPS AND AWARDS PRESENTED

On April 11, at the ATEC Conference, over $25,000 in aviation related scholarships were awarded to students, faculty and schools.

Almost 250 people from ATEC member schools applied for the various awards developed by the Northrop-Rice Foundation (NRF).

The list of winners and their schools are attached.

Plus congratulations to:

Debra Monchilov – Student of the Year Award winner 2011

and

Neal Perkins – Educator of the Year Award winner 2011

JOB OPENINGS

Go to www.atec-amt.org for recent postings. Click on "Employment Postings" on the left hand margin.

ATEC COMMITTEES
2011-2012

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2011-2012 cont.

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CALL FOR PRESENTATIONS

AWARDS

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NOMINATIONS

ATEC CONFERENCE COMMITTEE

Agenda: David Jones
Amy Kienast Linderman

2011
SCHOLARSHIPS AND AWARDS

AERONAUTICAL REPAIR STATION ASSOCIATION STUDENT TUITION SCHOLARSHIP

Drew Decker – Teterboro School of Aviation

AVOTEK BOOK AWARDS

1. Benjamin Rector – Aviation Institute of Maintenance - MO
2. Gerald Finch – Michigan Institute of Aviation & Technology
3. David Crosby – National Aviation Academy
4. Ronnie Tercero – Aviation Institute of Maintenance – Orlando

AVOTEK DALE HURST MEMORIAL SCHOLARSHIP

Donald Lesicka – Spokane Community College

NORTHROP RICE FOUNDATION – INSTRUCTOR AWARD

Gail Y. Rouscher – Western Michigan University

SNAP-ON TOOL CORPORATION – TOOL AWARDS

1. James Buckingham – University of Alaska
2. Ronnie Tercero – Aviation Institute of Maintenance – Orlando
3. William K Henderson – Clover Park Technical College
4. Robert Boyle – Michigan Institute of Aviation & Technology
5. Allison R Hoyt – Tarrant County College

NORTHROP RICE FOUNDATION TUITION SCHOLARSHIPS

1. Kimberly K Olszewski – Del Mar College
2. Edward J Costantino – Pittsburgh Institute of Aeronautics
3. Shane Wineinger – Vincennes University
4. Denis Bulfoni – Teterboro School of Aeronautics

2011
SCHOLARSHIPS AND AWARDS cont.

WING AERO BOOK AWARDS

Sara Lee Torres-Ortega – Del Mar College
Matthew Griffin – Hinds Community College

NIDA CORPORATION SCHOOL TRAINING EQUIPMENT

Blue Ridge Community College – Fred Dyen

ROTORCRAFT ENTERPRISES SCHOOL TRAINING EQUIPMENT

National Aviation Academy – Michael Wisnewski

FLIGHTSAFETY INTERNATIONAL INSTRUCTOR SCHOLARSHIP

Randy Chesley – Utah State University

AMERICAN EUROCOPTER INSTRUCTOR SCHOLARSHIP

Carl J Newton – Hallmark College of Aeronautics

SOUTHWEST AIRLINES INSTRUCTOR SCHOLARSHIP

James H Crocker – Greenville Technical College

AWARD WINNERS

Neal Perkins – Educator of the Year Award winner 2011

Debra Monchilov – Student of the Year Award winner 2011

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