The Current Status of Advanced Cockpit Technology (ACT) Education within Collegiate Aviation: A Preliminary Outlook

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Abstract

Several studies in the past have examined the preparedness of collegiate aviation to meet the demands for the upcoming NextGen (i.e., automated) cockpit. Such research revealed a conflict as to the current prominence of advanced cockpit technology education. The purpose of the study was to explore current tendencies in the education of advanced cockpit technology (ACT) within collegiate aviation by analyzing present-day course catalogs and/or program descriptions located in their university websites. The results for both aviation accredited universities and regular aviation programs indicate a noticeable increase in the teaching of ACT. Using unobtrusive research methods, the study found that 90% of aviation programs show clear evidence of either acquiring a Technically Advanced Aircraft (TAA) or having a specific course with theoretical and/or practical applications of advanced cockpit technology. These conclusions support the idea that collegiate general aviation (GA) training is undergoing the required technological transition that larger air carriers and corporate pilots underwent years ago.

Introduction

Research regarding the status of advanced cockpit technology (ACT) education within collegiate aviation has been performed with inconclusive results. Although some studies suggest that the teaching of such technology using Technically Advanced Aircraft (TAA) is becoming more widespread (AOPA, 2005; Casner 2009) another study found that 73% of pilots are still receiving their flight training with the use of analog instruments (Di Renzo, &Bliss, 2010). In addition, Fanjoy and Young (2004) completed a U.S. survey of four-year flight training institutions and found that, although most flight training program administrators agree that advanced cockpit education is an important element in preparing the future professional pilot, only 51% offer comprehensive training in this area. The majority of these institutions cited cost and curriculum priorities as the reasons for their lack of implementation in their universities and deferral of such training to future airline employers (Velázquez, 2013). Recently, Leonard (2013) found that only a small amount of ADS-B training is currently taking place in the United States, and "the training that is taking place is non-standardized and limited due to the perception that ADS-B is only to be used as a traffic advisory tool" (p. 79).

Review of Literature

According to the Federal Aviation Administration (FAA), a TAA is one with, at least, (a) an IFR-certified Global Positioning System (GPS), (b) a moving map display, and (c) an autopilot (Fiduccia et al., 2003).Most TAA manufacturers add features above those required by the FAA definition. The Aircraft Owners and Pilots Association (AOPA, 2005) argue the majority of active fleet sales to flight training providers, including university programs, have been TAA. However, Casner (2003b) found that airlines continue to struggle with training pilots transitioning from the general aviation training cockpit notwithstanding the fact that the introduction of advanced cockpit automation during early piston-engine training "pays large dividends when later confronted with the task of mastering automation found in jet fleet" (p. 2). Di Renzo and Bliss (2010) suspect advanced cockpit technology education is not as widespread as many think. In addition, Chidester et al. (2007) found that 85% of FAA Aviation Safety Inspectors (ASI) had not received formal education in TAA.

AOPA (2005) argues that with the advent of innovative automation technology the adoption of new piloting techniques is necessary since the pilot now becomes more of a *systems manager*. TAA instrumentation frequently "provides more data than most pilots know what to do with so there is another need for training" (AOPA, 2005, p. 29). Casner (2003b) argues that although the FAA testing contains specific knowledge and flight requirements for the evaluation of topics such as aerodynamics and weather, within their practical test standards (PTS), no such requirements have been put in order for the evaluation of these new critical and emerging piloting skills. The lack of formal training outlines and FAA guidance might be influencing the incorporation of ACT education in collegiate aviation.

The introduction of advanced cockpit education raises additional issues in the educational and human factors sectors. The FAA (2008) argues that students should be taught when to use these levels of automation and when not to. Although advanced cockpit technology increases situation awareness, it can also present a serious hazard if the system malfunctions and the pilots are unprepared (FAA, 2009). In addition, workload seriously increases if pilots mismanage the automation machine (AOPA, 2005). Thus, the proper sequencing of training or timing of TAA education is also a concern within the flight training industry (AOPA, 2005). Researchers at MTSU (Craig et al., 2005) studied such dichotomy by having a group of pilots undergo ab-initio TAA training and compared their success, measured in flight time required to reach certain milestones, e.g., solo flight, certificate completion, etc., versus those who had already received training in airplanes with analog instrumentation. The MTSU initial findings reveal that TAA ab-initio students take longer to solo for the first time but subsequently reach other highlights earlier than students trained with analog instrumentation.

Research Methodology

Purpose of the Study

The purpose of the study was to gain a better understanding of how, and if, flight training institutions were incorporating advanced cockpit technology education today, given the conflicting research conclusions in recent publications. To accomplish such task, a review of collegiate aviation programs was completed. The current study analyzed university catalogs and program descriptions for course availability on subjects such as Technically Advanced Aircraft (TAA) and/or Advanced Cockpit Technology using an archival design and unobtrusive research methods. Archival research data may be gathered from numerical records, verbal documents, or visual artifacts such as websites (Vogt et al., 2012). In addition, any evidence on the availability of TAA, flight training devices (FTD) and/or simulators for the purpose of ACT education was also recorded. The study was guided by the following research question:

- Are flight training institutions, within collegiate aviation, incorporating advanced cockpit technology (ACT) education in their curriculums? If so, how?

Study Population

A total of twenty (20), ten aviation-accredited and ten non-accredited, programs were randomly selected using a Random Integer Generator (RIG). The aviation accredited programs were assigned a number from 1 to 29, the total of aviation programs offering flight training. The ten accredited programs were selected from a list of aviation accredited flight education programs found in the Aviation Accreditation Board International (AABI) website. The other 10 programs were selected using the University Aviation Association (UAA) list of member institutions. The same process was used with the institutions listed as UAA members, that is, institutions were assigned a number between 1 and 106. It is important to note that the random selection of institutions was done, in both cases, by specifying a sampling frame or unit (i.e., the list of UAA member institutions and the list of AABI accredited programs). In addition, numbers were chosen without replacement meaning that if the institution number was repeated the researcher moved on to the next selection.

These samples were compared to ascertain any differences between the advanced cockpit technology education offered in accredited programs and that found in non-accredited aviation institutions. As specified earlier, during sampling, it was important to establish the universe to be sampled from (Babbie, 2010). Equally important, was to distinguish between units of analyses and units of observation. The units of analyses were the various university catalogs and/or program brochures while the units of observation were the course descriptions or outlines of type of equipment used.

Sampling is an important issue in any research. When collecting qualitative data, researchers often refer to reaching the saturation point to know when to stop collecting records (Vogt et al., 2012). The concept is crucial when conducting archival research such as this one. The saturation point is the moment when it is no longer useful or productive to continue collecting data; “the point at which the yield in useful data does not justify the effort to collect more of it” (p. 200). During the initial analysis of AABI-accredited institutions it became clear these programs had already made efforts towards the education of ACT. After this discovery, the focus was shifted to compare the aviation-accredited programs with the non-AABI accredited.

Data Analysis

In order to find a pathway to analysis, the first stage consisted of pre-coding. When available, the different course catalogs and/or program descriptions were explored to understand the strategies used by universities to educate on ACT. Subsequently, all of the relevant information from these sources (e.g., catalogs and/or program descriptions) were separated and entered individually into a computer-aided qualitative data analysis software called QSR NVivo (version 10). The use of such qualitative analysis software allowed for a second stage of coding where themes began to emerge (i.e., specific TAA equipment, topics covered within ACT courses, etc.).During this stage, manifest coding, a common technique in content analysis, was used to determine the level of institution engagement in the education of ACT. During manifest coding, a researcher objectively codes the contents of a document (Babbie, 2010). Figure 1 shows a word query tag cloud illustrating the prominence of specific words within the sources analyzed (e.g., catalogs and program descriptions). The relative font size indicates which words were used most commonly throughout the sources. The most frequently used words were *systems*, *flight*, *navigation*, and *glass cockpit*.

Figure 1. Tag cloud helps visualize word query.

The word glass cockpit was also further researched to explore connections of the phrase within the documented sources. In Figure 2, a *Word Tree* regarding the mentioning of glass cockpit within university course catalogs and/or program descriptions reveals that programs are frequently using the Garmin G1000 as their preferred method for glass cockpit education. In addition, the aircraft mostly used for these purposes is the Diamond airplane. Finally, in some instances, the glass cockpit is provided as training software in ground course laboratories, FTDs and/or simulators.

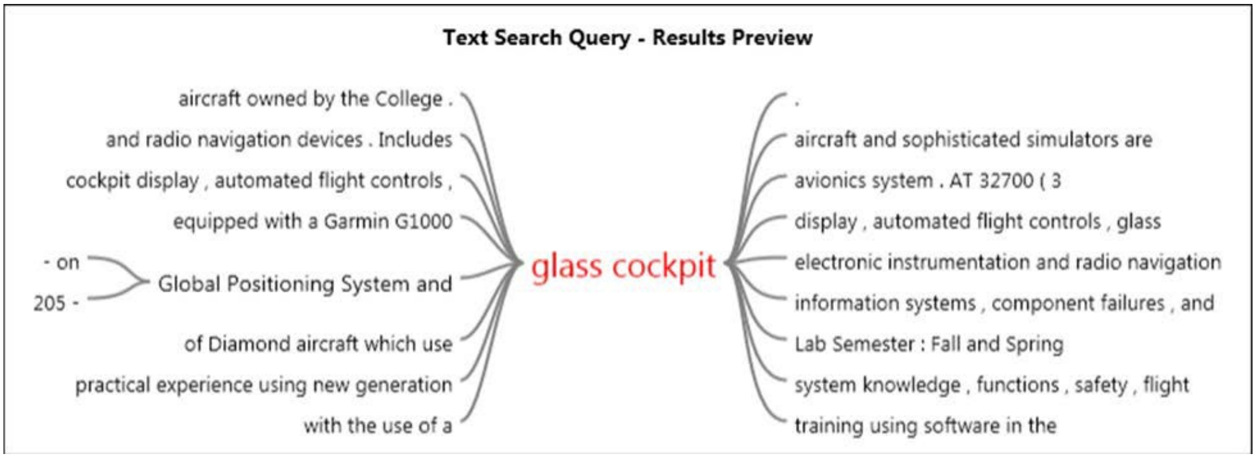

*Figure 2.*Word Tree regarding the mentioning of glass cockpit within university course catalogs and/or program descriptions.

The following information originates from the sampled AABI accredited university programs. Table 1 indicates the university name with the accompanying airplane and equipment currently being used to teach advanced cockpit technology. The information was obtained directly from the course catalog and/or website's program description. The absence of any specific information does not necessarily indicate real-time absence of the component. Thus, for future research the author intends to survey university programs to gain a deeper understanding of the information contained or missing from such sources. Non-accredited aviation institutions were also sampled. Table 2 contains the same information for non-accredited aviation institutions.

In comparison, 70% of AABI and non-AABI accredited aviation programs reveal through their course catalogs or program descriptions the availability of ACT education. Flight training institutions may also provide ACT education through specific-type courses. These courses may contain ground, FTD, simulator, flight instruction or a combination of these. Table 3 shows the information for AABI accredited institutions that possess such course(s) along with a brief overview of important advanced avionics or NextGen topics contained within them. Non-accredited aviation institutions were also sampled. Table 4 contains the same information as Table 3, only for non-accredited aviation institutions.

The analysis of AABI accredited universities revealed that 80% possess a specific and separate course where they either teach the theoretical applications of such technologies or provide hands-on training with FTDs, simulators, or airplanes. Only 60% of the sampled non-AABI accredited universities showed such a course.

Finally, a cluster analysis was accomplished using the NVivo software. Figure 3 illustrates a cluster analysis diagram of coding similarities.

Table I

AABI Programs and their current equipment for ACT education

University	Equipment and Description
Arizona State University (ASU)	Single--Engine Cessna 172 (GIOOO)
Embry-Riddle Aeronautical University (ERAU) Daytona	The entire C-172 and Diamond DA 42 Twin Star fleet is e:tuipped with Garmin GI000 includes the ADS-B onboard collision avoidance system.
Florida Institute of Technology (FIT)	No specific information on equipment was found
Inter-American University of Puerto Rico (IUPR)	No specific information on equipment was found
Middle Tennessee State University (MTSU)	All DA40s have the Garmin GIOOO suites and the latest eight have the GFC Automated Flight Control System and Garmin's Synthetic Vision Technology.
Purdue University	Recently upgraded its fleet of airplanes to include an Embraer Phenom 100 jet and 16 Cirrus SR-20G3 single engine aircraft. The planes and their corresponding simulators are equipped with a Garmin GI000 glass cockpit avionics system.
Rocky Mountain College (RMC)	Flight training is conducted in Piper and Beechcraft aircraft O\vned by the College. Glass cockpit aircraft and sopl:isticated simulators are used in training.
Southern Illinois University at Carbondale (SIU)	Flight Training Device (FTD) lessons using the GIOOO FTD.
St Cloud State University (SCSU)	No specific information on equipment was found
University of North Dakota (UND)	(GIOOO) in the Cessna 172S. The Piper Seminole is IFR equipped with dual Garmin GNS 430 GPS units and a two-axis autopilot.

Table 2

Non-AABI Programs and their current equipment for ACT education

University	Equipment and Description
Bowling Green State University (BGSU)	No specific information on equipment was found
Central Washington University	PC lab for computer-based training, two Frasca 141 single engine FTDs, a Frasca TrueFlight Baron G58 FTD with Garmin GIOOO glass flight deck, a Frasca 242T which simulates a Super King Air 200, and a Frasca CRJ 200.
Delta State University	Diamond airplanes also feature digital instrument displays, called glass technology, which replace the traditional analog six-pack of round gauges.
Farmingdale State College	No specific information on equipment was found
Indiana State University (ISU)	DA40s and glass-cockpit simulator.
Liberty University	The majority of aircraft used by the SOA are equipped with Garmin G1000 Navigation Systems (Cessna 172s).CRJ-200 Regional Jet simulator as part of the Advanced Jet Systems course (recommended for the Airline Hiring Agreements).
Texas A&M University-Central Texas	No specific information on equipment was found
University of Alaska at Anchorage (UAA)	Diamond aircraft which use glass cockpit
Utah Valley University (UVU)	All-Diamond fleet
Walla Walla University	Piper Arrow is equipped with a Garmin 500 instrument panel and multi-functional display, MVP 50 digital systems monitor, Garmin 430 WAAS IFR GPS, and modern radio and navigation equipment. Piper Seminole is equipped with autopilot, supplemental oxygen, modern radio and navigation equipment, a Garmin 430 WAAS IFR GPS and MX20 multi-functional display. In addition, a GlOOO Flight Training Device

Table 3

AABI Programs and their current courses for ACT education

University	Course and relevant topics
ASU	*AMT 382 Air Navigation*: Theory and application of modern advanced navigation and flight instrument systems
ERAU	*AS 435 Electronic Flight Management Systems*: autopilot and flight management systems.
FIT	*AVF 3005 Technically Advanced Instrument Flight*: primary flight display, multifunction display and GPS navigation system.
MTSU	*AERO 4230 - Advanced Air Navigation*: Advanced navigation equipment and operation procedures, including international, transoceanic, and polar routes, inertial navigation, GPS.
Purdue	*AT 32700 Advanced Transport Flight Operations*: automated cockpit instrumentation, domestic/international flight operations, and global navigation
RMC	*AVS 205 - Global Positioning System and Glass Cockpit Lab*: hands-on global positioning system and glass cockpit training using software in the classroom and hardware in flight training devices
SIU	*AF306 Intro to Technically Advanced Aircraft Operations*: Technically Advanced Aircraft (TAA) systems, navigation and autopilot
SCSU	*AVIT 205. Aircraft Electronic Systems*: electronics systems including operation of electrical systems and major components, autopilot systems, global positioning systems, flight management systems, multifunction electronic display systems.

Table 4

Non-AABI Programs and their current courses for ACT education

University	Course and relevant topics
BGSU	*AERT 3300 - Digital Cockpit Instrumentation*: flight instruction in the use of digital cockpit aircraft instrumentation, including systems differences, flight director, and autopilot use.
Farmingdale	*AVN 424 Advanced Avionics and Cockpit Automation:* automatic flight control and flight director systems, stability augmentation systems, power management systems, flight management systems and auto land/go around systems. Latest technology navigation systems topics including inertial navigation systems (INS), inertia reference systems (IRS), Global Positioning Systems (GPS) including Local Area Augmentation Systems (LAAS) and twice Area Augmentation Systems (WAAS).
ISU	*AVT 3171319 - Technically Advanced Aircraft/Lab:* introduction to advanced avionics, electronic flight instruments, navigating with the use of a glass cockpit display, automated flight controls, glass cockpit information systems, component failures, and emergencies.
Liberty	*AVIA 4351436 Advanced Jet Systems/Training:* This course is designed to replicate an airline "New Hire" class in order to give our students a feel for what to expect once they graduate and join either the airlines or a corporate charter business. Our faculty who teach the course have flown the CRJ-200.
UAA	*ATP A232 Advanced Aviation Navigation:* advanced navigation and flight display systems technology, the theory and operation of Global Positioning System (GPS) and Automatic Dependent Surveillance-Broadcast (ADS-B) navigation equipment.
UVU	*AVSC 1260 21st Century Avionics and Instrumentation*: knowledge and practical experience using new generation glass cockpit electronic instrumentation and radio navigation devices. Includes glass cockpit system knowledge, functions, safety, flight planning, crew concepts, and the use of GPS technology.

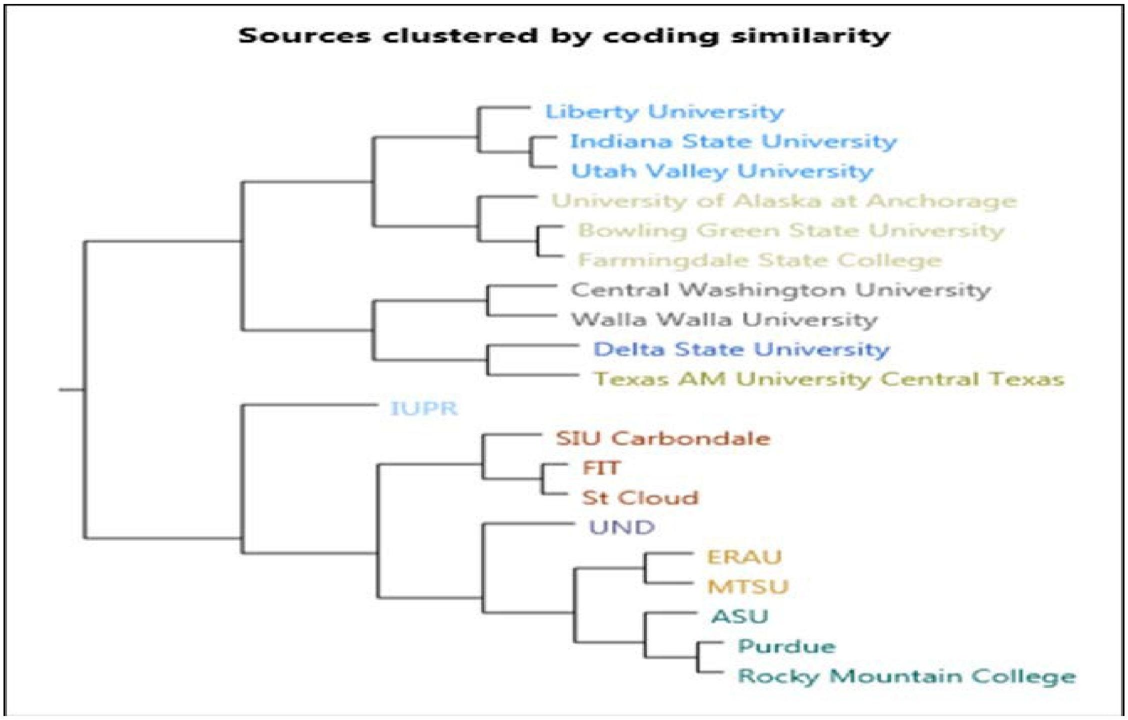

Figure 3. Cluster analysis diagram of coding similarities.

The diagram indicates how sources of information have coding similarities, which in turn could suggest similar collegiate strategies for the education of ACT. The programs of Middle Tennessee State University and Embry-Riddle Aeronautical University have the same color (orange) and were therefore coded similarly. MTSU and ERAU were the only two universities with evidence of added safety features to their existing fleet of TAA. MTSU airplanes include GFC Automated Flight Control System and Garmin's Synthetic Vision Technology (SVT) while ERAU's aircraft have the Automatic Dependent Surveillance-Broadcast (ADS-B)onboard collision avoidance system technology. Other similar coded programs were Liberty University with Indiana State University and Utah Valley University. Again, the cluster analysis suggests similar strategies in the offering of ACT education. The nearness of University program names also indicates similar coding. The Inter-American University of Puerto Rico has a different color than all other program names and is located further away from the rest of the group suggesting a different strategy for ACT education.

Conclusion

The study has revealed many positive aspects regarding the current state of advanced cockpit technology education in collegiate aviation. The overwhelming majority of AABI and non-AABI accredited institution possess either a course on the theoretical and/or practical applications of ACT or specific equipment for the training of students in such advanced avionics systems. Fanjoy and Young (2004) conducted an in-depth survey of collegiate aviation programs and found that only 51% had ACTs in place for their students. Although the scope of the present research is smaller, and has been limited to archival methods and content analyses, the growth of such percentage almost 10 years later indicates that collegiate aviation is increasing its level of readiness to prepare the future commercial pilot.

Regarding separate specific-courses for ACT education, 80% of AABI accredited institutions had a course in place regardless of its acquisition of TAA equipment or other glass cockpit technology. Only 60% of non-AABI accredited universities had such a course for their students. These figures will likely increase as we move beyond the 2020 time frame when the FAA mandate requiring aircraft to be properly equipped with ADS-B technology arrives.

The Future of Flight Training

As the present study concluded, an international FAA-sponsored panel of air safety experts had established that pilots are relying too much on automation and that two-thirds of many accidents were attributed to poor manual flight skills or mistakes using flight computers (Pasztor, 2013). In addition, the FAA just completed a key revision of pilot-training rules reflecting some of the report's recommendations, including new requirements for teaching more-effective ways to monitor other crew members and flight instruments. For example, AC 61-98B, *Currency Requirements and Guidance for the Flight Review and Instrument Proficiency Check,* is being updated to include a section on “manual flight after automation failure” (Cianciolo, 2014, p. 12). Notwithstanding, the incorporation of advanced cockpit technology in aviation higher education should continue to rise. With the conclusions of the expert panel, the FAA must now consider acting upon the recommendations and provide the flight training industry with the guidelines necessary to ensure sound incorporation of such technologies in flight education.

As every reader can appreciate, the incorporation of advanced technology education is an area worthy of further research. Many questions still lie ahead, regarding the most effective way to train, the best moment to introduce such technologies, and the effects of automation on basic *stick-and-rudder* skills. Flight training institutions are the first to address these learning concepts thus their current adequacy to meet the demands of the future generation of pilots is essential.

The immediate concern is addressing the preparedness of the future pilot population with said technologies. Learning to fly a TAA will change the flight-training world, and it should pay noticeable dividends to all segments of the industry (AOPA, 2005). Such studies are relevant to government, manufacturing industry, and education to identify training adequacy and expectancy meeting the FAA’s 2020 NextGen mandate requiring all airplanes to be properly equipped with automation technologies.

Recommendations

As previously indicated, the absence of any specific information, within the tables or figures of the present study, does not necessarily indicate real-time absence of ACT education. Thus, the results of the study can be considered exploratory rather than definitive. Future research should study the level of preparedness of collegiate aviation to meet the demands for the NextGen cockpit by conducting interviews of program administrators and/or survey research to cover a wider variety of aviation higher education institutions. Consequently, for future research, the author intends to survey university programs to gain a deeper understanding of the information contained or missing from sources within the present study.

AOPA (2005) accurately claims that students learning cockpit automation must adopt new piloting techniques geared more towards becoming *systems managers*. Educational research is needed in the areas of training for such technologies. Although the FAA has recently incorporated test items to evaluate flying candidates in the use of automation and resource management, what is needed is educational research that proposes or discovers ways to formulate instructional guidelines for the new and emerging paradigm of flying and flight training.

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