The Law of Primacy and the Utility of a Jet Transition Course

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ABSTRACT

Regional jet carriers have established Pilot Pathway Programs providing partnership opportunities with collegiate aviation programs in order to fashion pilot training at the undergraduate level. These partnerships provide aviation students early screening for employment with regional airlines and provide the university needed access to airline training material to fully prepare these students for success during regional jet carrier hire training. One of the main issues with normal FAA recommended pilot training and licensing progression is the emphasis on single pilot operations. The regionals operate aircraft requiring a cockpit crew. The challenges of the transition to a multi crew environment are discussed. Deficiencies noted during regional jet carrier new hire training are also discussed, along with traditional undergraduate aviation curriculum. The design, benefits, and goal of a jet transition course will be presented.

Keywords: law of primacy, pilot training, aircrew, regional airlines

INTRODUCTION

According to JetBlue's Director of Business Partner Training standards, a jet transition course (JTC) should be multi-faceted and seek to identify and lay the appropriate foundation for core competencies unique to air carrier and high altitude turbojet operations. In a non-regulatory environment, elements key to such foundations are broad, limitless, and often subject to the best interpretation, perception, and instinct of the person, authority, or agency questioned (Michael J. Hildebrandt, personal communication, January 23, 2013).

Pilot Pathway Programs (PPP) are partnership agreements between airline carriers and universities that allow undergraduate aviation students to begin pilot screening with the university's regional jet airline partners. This early screening process prepares the student for guaranteed jobs as first officers and, upon meeting all the screening requirements, guarantees participating students with follow on interviews with the regional's affiliated national or major carrier. Conversations with Pilot Pathway Program airlines have identified areas frequently deficient in and/or missing from the past experiences of those who encounter challenges during Qualification Training as presented in Table 1 (Appendix).

The JTC was designed and implemented to address these deficiencies and plays an integral role in the preparation of undergraduate students for the demands and pace of training set forth by multi-pilot regional jet carrier operations. Additionally, the course will prepare students for success during the newly directed Air Transport Pilot Certification Training Program (ATP-CTP) (Federal Aviation Administration [FAA], 2013).

Working with our PPP partners, the above pilot deficiencies have been addressed and the curriculum for the JTC has been developed with the assistance of the training directors of the university's PPP partner airlines. Training tools such as emergency cards and Quick Reference Handbooks (QRH), and computer based training software have all been adopted from the PPP partners in an effort to bridge the gap in knowledge and training as noted with the deficiencies in Table 1.

PPP partners such as GoJets and ExpressJet are remarking that while many pilots are looking for jobs today, a significant concern is the lack of qualified pilots. Many pilots have reciprocating or turboprop time, with no FMS time, and have not flown in several years. These are a few of the characteristics of the pilots that have not performed well during the demands and pace of regional jet carrier new hire training. PPP partners see the untapped potential of the undergraduate aviation students and recognize the opportunity to fashion the quality they receive when the student has completed their undergraduate training. The students do not have to be fully trained, they just have to show an aptitude for learning and that they are familiar with the operation and the concept of a crew in the cockpit.

THE TRADITIONAL ROADMAP TO THE AIRLINES

Prior to the JTC inclusion in the Aviation Operations and Flight Operations curriculum, student progression began with the Aviation Science for the Private Pilot Course and ended with a hiring opportunity at a regional jet carrier. This is a typical stair-step approach to pilot progression as depicted in Figure 1 (Appendix).

The following brief course descriptions will provide an insight into the concepts and areas of focus with this stair-step approach to pilot training at the collegiate level (Jacksonville University, 2013).

Private Pilot Course

Students are provided basic concepts of aircraft operation, performance, aerodynamics and design. Federal Aviation Regulations (FARs) and other types of flight publications needed for private pilot operations are introduced. Basic weather theory and reports and elements of flight physiology, in the context of flight safety, are covered. Cross-country navigation techniques are covered including pilotage and dead reckoning, teaching the student how to use the fundamental tools of air navigation including radio navigational aids. The student is fully prepared to take the FAA Private Pilot Airplane knowledge test at the completion of this course.

Instrument Pilot Course

This course provides a detailed study of instrument flight control techniques, radio navigation and instrument flight operations; a study of the FARs and air traffic control (ATC) procedures related to instrument flight; an examination of the avionics and navigational aids for instrument operations; and a review of weather information with regard to instrument flight. The student is fully prepared to take the FAA Instrument Rating knowledge test at the completion of this course.

Commercial Multi-Engine Course

This course provides a continuation of aeronautical science studies and addresses aerodynamics, flight standards, weather, regulations, navigation, systems and physiology, and analysis of instrument procedures and airspace as applied to the commercial environment in single and twin-engine aircraft operations. The student is fully prepared to take the FAA Commercial Pilot Airplane knowledge test at the completion of this course.

Commercial Single Engine Add-On Course

At the completion of the Commercial Multi-Engine Course, students complete additional training required to add a Commercial Single-Engine Rating. At the completion of the course, the student qualifies to take the FAA flight check for the addition of a Single-Engine rating to the Commercial Pilot Certificate.

Certified Flight Instructor (CFI)

This course provides psychological foundations to understand the concepts of teaching and learning. The course applies psychology of learning to enable flight and ground instructors to provide for maximum growth and development of their students. An in-depth study of technical subjects, weather, and airport operations are covered as applied to teaching and learning. At the completion of this course, the student is prepared to take the FAA Fundamentals of Instruction and Flight Instructor Airplane knowledge tests.

Certified Flight Instructor-Instrument (CFII)

This course prepares a certified flight instructor to teach instrument training to student pilots. Using a student taught / instructor guided format, the student will practice teaching courses of instruction on instrument flight control techniques, the ATC system, instrument regulations, Instrument Flight Rules (IFR) navigation, weather, physiology, communications, and overall instrument flight operations. The course prepares the student for the FAA Certified Flight Instructor – Instrument knowledge test.

Most students complete their traditional undergraduate flight training during their senior year at the university. Once complete with their CFII rating, the students may begin flying at our Part 141 contracted flight school as a line flight instructor. Students begin their tenure as a flight instructor with an average of 220 flight hours. Prior to the FAA Circular 61-138E, pilots would have to acquire 1500 flight hours to be eligible for the Air Transport Pilot (ATP) certificate (FAA, 2013). With the issuance of FAA Circular 61-138E, students that have acquired their flight training at a Part 141 approved school at an institution of higher education and meet other associated requirements stated within the circular may receive a restricted ATP certificate, allowing them to be hired by a regional carrier with only 1000 hours (FAA, 2013). While 500 hours of flight experience is eliminated from the pilot's logbook, this experience is not a factor in creating the deficiencies noted in Table 1 (Michael J. Hildebrandt, personal communication, January 23, 2013).

ADDRESSING THE DEFICIENCIES

At this point, students have a basic understanding of aeronautics and aircraft systems. In order to address the deficiencies noted in Table 1, we must enable students to develop an advanced level of understanding of these concepts. The course progression is similar to the traditional course progression with the addition of the JTC as depicted by the dashed line in Figure 1.

Advanced Aircraft Systems II

In order to enroll in the JTC, students must meet the course prerequisites; this progression is depicted in Figure 2 (Appendix). This begins with the Advanced Aircraft Systems II course. The course studies systems currently in use in advanced jet transports. The model used for the course is the Boeing 777 (B777). Students study these systems in a building block approach. First the principles of the generic system are introduced which may be applicable to any transport category aircraft. Then airline quality training materials are presented focusing on the B777. These materials include computer-based training (CBT), aircraft systems manuals and study guides and flight management systems trainers (FMST). The CBT and the FMST are available for individual self-study and practice. Any jet transport aircraft could be used, but the B777 introduces several systems not available in regional jet or small transport category aircraft. Some of these systems are: a fuel dump system, a fly-by-wire flight control system, an electronic engine control system, electronic checklists, advanced engine autostart system, advanced engine-indicating and crew-alerting (EICAS) system, worldwide satellite communications (SATCOM) system, autothrottles and autoland system. The large range, massive fuel capacity and the fact that this aircraft is a widebody promotes other necessary discussion items such as overweight landings, heavyweight operations, overwater, international and intercontinental routes and procedures, long range communications and augmented crew operations.

Crew Resource Management

The students then progress to a course in Crew Resource Management (CRM). This course provides a challenge for facilitators who teach in the college or university environment due to the nature of pilot training in the United States. Introduction to CRM exposes the student to a crew environment in which they have no practical experience. Many countries use *ab initio* training for future airline pilots based upon the multi-crew concept from the very beginning of flight training. Under the Multi-crew Pilot License (MPL) model, the end product is an airline pilot, contrary to typical training within the U.S., where the training allows him/her to qualify for the airlines as one of many career choices. Therefore, training in the U.S. is based upon the single pilot model (Helmreich & Foushee, 1993). The pilot is trained from the beginning of his/her aviation experience to solo as a gateway to further training and advancement. The licensing advancement further encourages solo flight with pilot in command decision making and critical thinking coupled with dual instruction given in a hierarchical environment (flight instructor/pilot in command vs. student). The aircraft and flight training devices (FTD) they fly and use in training are designed to be flown by one pilot. The students are trained to accomplish all necessary duties on their own with emphasis on command decision-making, which is in line with the privileges of the licenses they possess. While this type of training can be augmented using single pilot resource management (SRM), for CRM to be effective, a crew environment must be introduced. An FTD of multi-crew aircraft is a very useful tool for this function. The Bombardier CRJ700 FTD is used at Jacksonville University for this activity. A study of accidents and incidents involving a multi-crew environment is also invaluable in this pursuit. Fortunately, many accurate accident re-creations are available on multimedia sources using actual cockpit voice recordings or transcripts and flight data from the ill-fated aircraft's data recorders as well as from formal accident investigation reports. The FTD can be used for such crew related activities as checklist accomplishment, crew briefings, abnormal and emergency procedure accomplishment and related navigation exercises. None of these activities are reliant upon single pilot activities as previously taught. The rule of primacy can be emphasized here, as this is the first exposure for most students to these activities in a multi-crew environment. This is a transitional phase of training because the student now thinks and acts as part of a crew. This provides the baseline for future pilot development within the industry. It is helpful for the faculty member charged with this initial training responsibility to have FAR Part 121 airline operating experience.

The classroom environment is used in CRM for the study of accident recreations and presented in conjunction with subjects necessary for CRM study. These subjects include critical thinking, decision-making, leadership, checklist management, situational awareness, communication, planning, automation dependency, human behavioral factors, stress, conflict resolution, advocacy and assertion, threat error management and emotional intelligence. The operating premise, supported by FAA and NTSB statistics, is that human factors are still responsible for the majority of air carrier accidents and incidents (Wiegmann & Shappell, 2001; FAA, 2004b). Further, one component of human factors study, emotional intelligence, emphasizes that self-awareness and self-management of our emotions as well as the recognition of emotions in others and our skill in managing that awareness are necessary and better arm the individual to operate in a multi-crew and multi resource environment (Cherniss, Goleman, Emmerling, Cowan, & Adler, 1998). CRM training not only involves pilot-to-pilot interaction but also includes interaction with other resources, such as other crewmembers, dispatch, ATC, weather services and other supporting personnel and agencies.

Advanced Aircraft Systems III

The students then move on to the Advanced Aircraft Systems III course. The aircraft used in this course is the same one used in the JTC, the Bombardier CRJ700. In addition to aircraft system and FMS study and practice on FMSTs, the student is able to see the cockpit operation of switches and the results of systems integration. An example is the procedure of establishing the electrical and environmental systems when presented with a dark aircraft. This activity involves an understanding of the electrical system, starting with the battery switch and ending with the aircraft being powered by the auxiliary power unit (APU) generator. The accomplishment of flows and checklist items not only utilizes and reinforces knowledge from the previous courses, but implements experiential learning so necessary to aviation systems study (Pourdehnad, 2000). The FMS in the CRJ700 is different from the B777 FMS in several ways, but the exposure to different systems, both aircraft and FMS, is representative of a career in the airline or corporate aviation industry.

Jet Transition Course

Upon completion of the Advanced Systems III course, the student's undergraduate flight training culminates with the Capstone course for Flight Operations majors, the JTC. This course covers the application of advanced systems knowledge and crew resource management skills in the operations of a jet aircraft. In addition, the course also gives students an understanding of FAA Part 121 regulations, high altitude flight theory, and advanced aerodynamics.
The Bombardier CRJ 700 FTD and Flight Management Systems Trainer (FMST) are used exclusively for this course (Jacksonville University, 2013).

JET TRANSITION COURSE LABORATORY

The JTC was never intended to be comparable to a type rating in a specific aircraft. Nor was it intended to produce a fully trained regional jet pilot. If the goal was to create a fully trained regional jet pilot, it would take a lot longer than eight weeks at the collegiate level, which is the duration of the jet transition course. The goal is to provide students with exposure to the regimen of airline training they should expect as a new hire and provide them the skill sets to maintain the pace of training and the pace of execution that is expected, rendering them an enlightened airline candidate (Ziskal, 2013).

The Advanced Systems courses and the CRM course provide the students with a benchmark of systems knowledge that will allow them to succeed in the JTC. When they enroll in the JTC and finally get into the FTD, the focus is strictly on flying the aircraft, learning the profiles, and becoming familiar with the aircraft. The FTD is the laboratory where CRM principles and advanced systems knowledge previously learned can be put to use in a crew environment. The JTC is the capstone and culminating experience of all their collegiate flight training at the university.

The JTC takes CRM to a whole new level for students. To this point, students have been acting as pilot in command (PIC) in single-piloted aircraft. The transition to a crew concept has several practical implications, to which the students have received no exposure. Specifically, the student's lack the experience of checklist use as a crew, cockpit leadership, and task delegation (Ziskal, 2013). This is the student's first exposure to a challenge and response method of conducting a checklist. The checklists and the profiles refer to the pilot flying (PF) and the pilot monitoring (PM), or pilot not flying (PNF). Someone with prior captain experience should demonstrate the role of captain in order to employ the law of primacy during the initial sessions in the FTD (Ziskal, 2013). If measures are not taken so that the instructor teaches the procedure or maneuver correctly the first time, the student may recall their learning incorrectly as he or she recalls the learning experience during a real-time requirement to execute the learned behavior (Flight Standards Service, 2009). In addition, having an experienced line pilot in the cockpit introduces the student to the more realistic timing and pace of line operations.

Once a foundation of CRM has been established, and students understand the pace of execution expected, two student first officers may be assigned in the FTD. While the FTD cannot create the same leadership hierarchy that exists in reality in the cockpit, students can role-play and be assigned to carry out the duties as captain and first officer during subsequent FTD sessions. During normal and abnormal operations, the PF will initiate procedures, discuss his/her intentions, and after obtaining the PNF's input, decide upon a course of action. In practical terms, the benefit of this method of operation is that first officer candidates learn to think like a captain.

During the course of training in the FTD, a scenario may be associated with the hydraulic or a fuel system, which requires the student to have an elementary working knowledge of the system in order to solve the problem at hand. Using the FTD allows the instructor to walk the students through the problem, illustrating the ability to solve the problem by following each progressive step on the emergency card and the QRH. Emphasis is placed on the FP to solely focus on flying the plane while the other student is taking care of the task at hand relative to the PNF duties. The pilots then work together to bring the event to a successful conclusion. The regional airline partners do not require that the students be qualified first officers upon completion of the course. The key learning objective with the JTC is that students are exposed to the aeronautical decision making process while working in a crew environment. They learn from the beginning how to solve problems using the regional partner's emergency card and QRH, and how to execute the procedures at the pace expected at the airlines (ExpressJet, 2012).

The regional Pilot Pathway Programs require that their institution of higher education partners have a jet transition course in their curriculum. This has provided the university access to regional airline training materials, which further enhances the realism of the FTD sessions (ExpressJet, 2012). The scripted lessons are very similar in content as the actual new hire training at the regional airline. The scripting of the lessons takes them from gate to gate, beginning with the pre-start checklist, taxi for takeoff, and a normal takeoff and climb-out. Because the Advanced Qualification Program (AQP) concept is incorporated into the training regime, students are trained to proficiency (FAA, 2006). Once proficiency is demonstrated, the lesson moves on to new areas to be covered negating the requirement to revisit a procedure or maneuver fully understood. The students have to know all the profiles prior to each FTD session. If they show up for class and they do not know the profiles, they do not fly the flight and come back when they know them.

A unique feature of using an FTD for training is that it can store and recall snapshots of flight profiles. A snapshot is a record of particular flight characteristics with specific altitude, airspeed, geographic location in space, and aircraft configuration that can be accessed from the FTD software. These snapshots of profiles can place the FTD and its aircrew instantly at 35,000 feet to demonstrate high altitude characteristics, such as a ‘behind the power curve’ demonstration or the ‘coffin corner’ demonstration of high and low airspeed limits. Then the aircraft can be snapped to a new geographic position and altitude in preparation for a new maneuver, all with the click of a mouse. This feature is ideal because scenarios the students can expect to see in regional training may be presented in the classroom, and then recreated in the FTD. Students may see similar events in their basic aircraft training or during Line Oriented Flight Training (LOFT) (ExpressJet, 2012). Other than the obvious ability to save time, the greatest benefit of the snapshot capability of the FTD is that the students can be trained to handle specific situations that they may never otherwise initiate themselves in a real aircraft.

The FTD is also a great tool for demonstrating the problem of automation dependency (Ziskal, 2013). Quite often the students are presented with a situation that demands a sense of urgency, to the point where both the pilots are inclined to manipulate system switches or enter commands in the FMS, while neither one of them is flying the aircraft, as can be seen in Figure 3 (Appendix).

One such profile requires the students to perform a takeoff out of Denver with a climb to 8000 feet. A change of departure instructions is initiated by ATC at the same time as a new heading is assigned. Due to the urgency of the directions of ATC, both students feel obligated to enter the new directions in the FMS. While distracted with the FMS, the aircraft continues to fly on its previously commanded heading, straight towards the mountains to the west. Things start to happen fast, and the first indication that the aircraft and crew are heading toward the high terrain is when the students hear the aural warning of the Ground Proximity Warning System (Ziskal, 2013). This is a perfect example of how a simple, unexpected task can lead both crewmembers to lose situational awareness. In addition to illustrating how easy situational awareness can be lost by both crewmembers, the pace at which events occur is also accelerated. The students have made a tremendous leap from their aircraft of a maximum airspeed of 150 knots to an aircraft that cruises between 400 and 500 knots.

THE LAW OF PRIMACY

E. L. Thorndike was a pioneer in educational psychology and developed multiple laws of learning in the early 20th century, one of which is the law of primacy (FAA, 2009). “Primacy, the state of being first, often creates a strong, almost unshakable impression and underlies the reason an instructor must teach correctly the first time and the student must learn correctly the first time (FAA, 2009, p. 2-11).” Simply stated, what is learned first is learned best. In addition, the task must not be learned in isolation, it must be taught as applied to the overall performance of the task, and the experience should be positive, functional, and lay the foundation for what is to follow (FAA, 2009).

The crux of the law of primacy is that the instructor may present procedures and techniques in such a manner as to establish a foundation of proper habit patterns (FAA, 2009). This is the premise of the JTC. Therefore, it is the flight instructor’s responsibility to train proper habit patterns from the beginning, rather than backtracking to correct faulty habit patterns after the fact (FAA, 2009). According to the principle of primacy, it is important for the instructor to make sure the student gets it right the first time (FAA, 2009). The law of primacy applies to four specific elements of the JTC, (a) training enhancement strategies, (b) the human-systems integration element, (c) team performance as applied with crew resource management, and (d) airspeed calibration.

TRAINING ENHANCEMENT STRATEGIES

Improvements in training enhancement strategies have greatly enhanced the quality of flight training available at the undergraduate level. It is not uncommon to find sophisticated, high fidelity flight training devices on campus. This provides the student the optimum train-like-you-fly environment. However, in order to capitalize on the law of primacy, flight instructors must ensure that the training tools are without error in order to fully capture the initial training moment. The hardware and software elements of the FTD must be set to facilitate the training event without flaw in order for the law of primacy to take effect. This includes the up to date manufacturer's pilot operating handbook, QRH, and emergency checklists. Digital analysis of the simulation video and data flight replay, ATC simulation, and the high fidelity visual presentation of the external environment all provide essential elements of the initial jet experience in a controlled classroom environment. The key distinction between the classroom environment at the undergraduate level and the initial new hire level is that more time may be taken at the undergraduate level on a one-on-one basis. This provides a higher quality level of instruction, which focuses on training to proficiency as opposed to a pass-fail system common during new hire training.

Human-Systems Integration

It is essential to establish the human-systems integration element of the law of primacy from day one. This element is the most essential of the three elements mentioned for it provides the catalyst for creating a synergistic relationship between both crewmembers in the last element of CRM, human error management. The aircraft students will be flying as regional new hires have the most sophisticated avionics in the industry today. Multiple electronic components on the flight deck provide the crewmembers all the information they need to safely operate the aircraft under varying conditions. However, in order to efficiently utilize the avionics and flight management systems, the students must learn how to operate the equipment correctly the first time. As with many of the avionics systems, there may be multiple ways to set up the electronics, displaying the data in multiple configurations. The JTC provides the instructor the opportunity to demonstrate the correct way to set up the electronics in order to provide the student pilot the most efficient avionics configuration in the least amount of time. This also provides the instructor the opportunity to operate these systems within a crew environment. This is a key element of the JTC as it relates to the law of primacy. The course is primarily designed to emphasize operation in a crew environment, with a lesser emphasis on aircraft systems knowledge.

Team Performance

The effects of the law of primacy culminate with the student learning how to combine the training strategies of the FTD with the newly acquired automation management techniques in order to create a synergistic relationship with their other crewmembers through the use of CRM.

Decision-making is now a shared responsibility with other crewmembers, and students must have this process demonstrated to them properly rather than allowing them to develop their own processes or flows. Presenting decision making scenarios to the crew allows the instructor to demonstrate how to go through the decision making process as a crew, emphasizing what the crewmembers need to be looking for, what information they need, and what information will be produced through the process. All other aspects of CRM are addressed as a crew to successfully make the paradigm shift from the single pilot mentality to that of a crew. Situation awareness takes on a whole new meaning, as the crew now shares the workload. This is a difficult transition for young aviators, and care in instruction must be taken to provide the students the new skills required to provide leadership on the flight deck and, perhaps a more difficult task for some, to accept the responsibility of duties delegated by the captain. Assertiveness is a facet of CRM emphasized at this point in training. Students are encouraged to vocalize their questions or concerns with other crewmembers. Students are taught how to address flight deck anomalies in a professional manner, along with how to exercise command presence during communication.

Airspeed Calibration

Airspeed calibration provides the student the mind's eye sight picture of the velocity of the aircraft. Up to this point, the student has cruised at a maximum of approximately 150 knots indicated airspeed. This is a mere fraction of the speeds traveled in the high-speed regional jets flown today. Applying the law of primacy, the instructor may present the student with canned flight profiles at specific airspeeds and altitudes to provide the student with a benchmark of how fast the aircraft is travelling. Additionally, this allows the student to develop a perspective necessary to plan climbs, descents, and airspeed restrictions. In addition, to augment a facet of CRM, adaptability/flexibility, the instructor can demonstrate how to configure the aircraft from these multiple scenarios providing the students many new benchmarks of aircraft performance. These new benchmarks of performance now become just another component of the crew's combined situational awareness.

LAW OF PRIMACY EXAMPLES

Examples of the application of the law of primacy used to address the four previously mentioned elements of the JTC and the Table 1 deficiencies are given below. Also included are the relevant industry accidents/incidents, which facilitate the highlighting of aircrew training system deficiencies. It has long been the practice of airlines and the industry to examine their training programs as a result of each accident/incident or safety and violation trends. Some of the sources include company initiated Line Oriented Safety Audits and FAA Aviation Safety Action Program reports (FAA, 2004).

Checklist management/accomplishment

Students are introduced to challenge and response dialogue and expanded checklists in normal procedures of aircraft operation. The cadence of timing and the chronology and flow of checklists is modeled upon airline procedures. The QRH and expanded abnormal checklist are integrated with EICAS use. When distractions and increased workload management events such as a runway change are introduced, proper checklist discipline can be explained and reinforced.

The accidents of Northwest 255, an MD-82, 1987 (complete omission of the taxi checklist) in Detroit and Air Florida (Palm) 90, B737-200, 1982 (incorrect positioning of the engine anti-icing switch) in Washington DC, are examples of incorrect checklist usage, which were presented in CRM and can be used to reinforce this first introduction to multi-crew checklist accomplishment (National Transportation Safety Board [NTSB], 1988a; NTSB, 1982).

Altitude Selection on the Mode/Flight Control Panel

After a history of altitude violations, airlines developed a reliable method of setting a new target altitude involving both pilots (Hutchins, 2000; American Airlines [AA], 2014; Wagener, & Ison, 2014). The accepted procedure involves the PNF receiving and acknowledging the new clearance from ATC and setting the new target altitude on the Mode/Flight Control Panel (MCP/FCP). The PNF then leaves his/her hand near the altitude selector, pointing to the new altitude until it is verbally acknowledged by the PF. This method of involving both pilots, even during an introduced distraction, has reduced altitude violations significantly and is different from the single pilot environment (Helmreich & Merritt, 2000).

FMS Usage

After accidents/incidents involving input and execution of data significantly altering the flight path of the aircraft by one pilot leaving the other pilot out of the loop, it was recognized in the airline industry that lateral and many times vertical alteration or modification of the flight path had to involve both the PF and the PNF. An example of this scenario was demonstrated in the case of American Airlines 965 enroute to Cali, Colombia, where selection of ‘R’ in 1L of the FMS took the aircraft over 90 degrees from the intended flight path (Ladkin, 1996). Previously it had been acceptable to have the PNF receive flight modifications from ATC or set up a procedure in the FMS and execute these changes as a way of helping the PF manage the workload, sometimes with unintended results due to the fact that the PF was not in the loop. Another generic example of FMS mismanagement: a PF heard the clearance and input and executed the data into the FMS without acknowledgement of the PNF, essentially operating in a single pilot environment. The current industry established procedure is that the PF or PNF may input the data into the FMS if the autopilot is engaged, or the PNF inputs the data if the PF is hand flying. Prior to execution, the non-inputting pilot verbally agrees with the data input before the modification is executed (AA, 2014). In order to employ the law of primacy, this critical method of altering the aircraft’s flight path needs to be introduced correctly into the crew environment the first time the student is introduced to the FMS. When the FMS is being operated, if the instructor sees both heads looking at the FMS instead of one pilot addressing the FMS and the other monitoring the aircraft as illustrated in Figure 3, immediate corrective action should be taken.

Mode Confusion

Operation of the MCP/FCP is similar in a crew environment to the operation of the FMS. The Air Inter 148 accident helped highlight subtle differences in MCP/FCP presentation and understanding (Bureau d'Enquêtes et d'Analyses [BEA], 1993). The conclusion of the mishap investigation report was that the vertical speed and flight path angle settings were confused. The steeper than required descent resulted in controlled flight into terrain (CFIT). Involving both crewmembers in the operation and verification of the MCP/FCP settings and functions is essential and is established airline practice which can be introduced from the beginning of MCP/FCP usage, again employing the law of primacy (AA, 2014).

Operation of Speed Brakes

Speed brakes are an established way of increasing the descent in turbine powered jet transports without increasing speed, especially when confronted with tight altitude crossing restrictions. They can also be used for increased rate of speed reduction. Without warning annunciations, when the throttles are increased, it is easy to forget that the speed brakes are still deployed, especially in a prolonged descent. Aircraft such as the B777 have this warning, while others do not. If the speed brakes are inadvertently left deployed, aircraft performance is affected, sometimes with tragic results. It is widely acknowledged through simulator recreation that the B757 that was AA 965 would have cleared the mountain ridge if the speed brakes had been retracted after the ground proximity warning was received (Larkin, 1996). Two procedures can be introduced to students who have not flown an aircraft configured with speed brakes. The first procedure is to leave the hand that deploys the speed brakes on the speed brake handle until the speed brakes are retracted. This retraction thus takes place before the hand is moved to the thrust levers or changes the airspeed on the MCP (if autothrottles are used). The second procedure involves the escape maneuver when warned by the enhanced ground proximity warning system (EGPWS) if the aircraft is so equipped. Most airline procedures call for an oral callout of speed brake retraction or verification thereof as part of the escape maneuver. The JTC provides students with speed brake operation for the first time in their aviation careers.

Autopilot Operation

After the Eastern Airlines 401 accident involving inadvertent partial disconnection of the autopilot with no aural or visual warnings, the FAA mandated that autopilot disconnection be announced to the crew in some fashion (NTSB, 1984). Many airlines further require the verbal annunciation of “autopilot off” or something similar so that both pilots are aware that the aircraft is being manually flown. This procedure can be introduced in the student’s first crew experience involving a complex aircraft so that there is never any confusion as to who or what is controlling the aircraft.

Crew Responses to Emergencies and Abnormal Situations

When faced with a simple distraction or a time critical emergency procedure, one fact remains constant: someone has to fly the aircraft (Mudge, 1998; Coetzee, Schepers, & Barkhuizen, 2002). The three highly experienced and well-trained crewmembers of Eastern Airlines 401 were so involved with an inoperative light bulb that no one noticed that the aircraft was no longer at the altitude previously held by the autopilot. This accident highlighted a breakdown in crewmember duties and responsibilities (NTSB, 1984). Every crewmember, not only the captain, must verify who is flying the aircraft at all times. A simple annunciation of “You fly, I’ll fix” is a good mental trigger. If the captain does not delegate who is to fly and who is to work the checklist or address the distraction, the first officer should inquire. Scenarios can be introduced to reinforce this behavior. These can range from a simple passenger problem involving a lengthy flight attendant conversation with the cockpit, to a situation involving one pilot working with a long abnormal procedure. In each case, one pilot is distracted. The other pilot must take it upon him/herself to mentally be the aircraft operator. Ideally, these duties should be announced and discussed: "You fly the aircraft and I'll work the problem with the QRH". "OK, the autopilot is on, we are maintaining FL 330 and proceeding direct XYZ, my aircraft". Accomplishment of an abnormal checklist necessarily involves a separation of duties. The time can be lengthy if the procedures are complicated and interrelated. This was the case with Qantas Airlines 32, an Airbus 380 returning to Singapore (Australian Transport Safety Bureau, 2010). The first officer was faced with fifty-eight different procedures to be accomplished before a landing could be attempted. The accomplishment of these procedures consumed almost an hour. The only time the PF should be involved in the procedure is when the PNF is going to accomplish a checklist item which will drastically alter the operation of the aircraft. Some examples include throttle reduction to idle, fuel switch shutoff, fire handle activation, and aircraft depressurization. These actions must be verified by the PF so that he/she is prepared for the result and also as a double check that the correct fuel switch/thrust lever/fire handle is addressed. During the flight of British Midland Airlines 092, the accident involved the shutdown of the incorrect engine, leaving the aircraft powerless (Air Accidents Investigation Branch, 1990). If introduction of these distractions can be presented in such a way that each pilot questions and verifies who is flying the aircraft, this behavior will become engrained in the young pilot's psyche (Morrison & Chein, 2011). In this way, a link in the accident chain may be broken through the employment of the law of primacy.

Timing, Descent Planning and Workload Management

One of the most difficult transitions a pilot makes in his/her aviation training is when first faced with a turbine powered aircraft which cruises three time faster and flies four times higher than the pilot has ever flown before. This presents the instructor with the opportunity to employ the law of primacy while instilling habit patterns that will keep the student ahead of the aircraft. An example of timing might be the mating of a checklist with an event, such as taxi checklist accomplishment while taxiing, and the lineup checklist approaching the hold short line. Workload management can be emphasized by accomplishing the descent checklist, including the approach briefing, before the top of descent (TOD) is reached. This activity thus requires the acquisition of the information about the weather and current landing procedures at the destination airport and the calculation and setting of the approach speeds. These items ideally need to be accomplished before the descent is started so crossing restrictions and increased ATC instructions and changes, as well as checklists, can be dealt with effectively. So what determines the TOD point? In a single engine propeller aircraft, it might be when the airport is in sight. In a turbine aircraft at cruising altitude, it is over one hundred miles from the airport. If the student can be taught to calculate the TOD, then he/she can address the items necessary for landing before the TOD and remain well ahead of the aircraft. When manually calculated, this point can be a check on the automation to verify the accuracy of the FMS calculated TOD point. There is a formula which applies to any modern turbine powered transport: altitude to be lost in thousands of feet multiplied by three, add six to ten miles for the FAA mandated speed restriction below 10,000 feet, and add two miles per ten knots of tailwind, or subtract two miles per ten knots of headwind. Example: cruising at FL330, landing at an airport with an elevation of one thousand feet. Thus the altitude to be lost is 32,000 feet, which in thousands is 32. So the calculation starts with 32 x 3, which is 96 miles. Then add the distance for slowing at 10,000 feet to 250 knots. If the aircraft is descending at 280 knots, add about six miles, if over 300 knots add ten miles. In this example we will use the CRJ700 descent speed of 280 knots, so we add six miles, resulting in 102 miles. If the GPS readout shows that there is a fifty-knot tailwind at FL330, we must add another ten miles (two miles per ten knots of tailwind). Thus the final figure is 96+6+10, resulting in a TOD 112 miles from the destination airport. In time, this descent takes about twenty to twenty-five minutes. If the crew has not given much thought to their approach and landing, and they are approaching thirty minutes from their destination airport, they are going to be behind the aircraft. This timing and workload management exercise is one which every pilot of a turbine powered aircraft will use every flight and can be taught from initial exposure.

Attitude Instrument Flying

Along with speed calibration comes the pitch, power, airspeed relationship of turbine-powered aircraft. If a student used to flying propeller driven aircraft with a low cruise speed is given a takeoff and climb in the CRJ700 FTD and then told to level at seven thousand feet, the 250 knot restriction will be exceeded almost all of the time. This is because a corresponding power reduction must accompany the reduction in pitch. With primary training emphasizing the pitch-power-airspeed relationship in the JTC, speed calibration can begin. At that seven thousand feet altitude and 250 knots there is a given attitude, thrust setting (usually an N1 reading) and on aircraft with moving thrust levers, an associated thrust lever position. If the correlation between pitch, anticipatory thrust lever movement and airspeed is introduced, this enhances pilot cognition by training working memory, and now we have a pilot whose mind is operating at the speed of the aircraft (Morrison & Chein, 2011). We can introduced the pilot to a given aircraft configuration and speed and show a corresponding attitude and thrust setting/throttle position. These readings then become targets to achieve the desired result. A smoother pilot who is ahead of the aircraft is the goal. This way of operating a turbine aircraft is transferable to any jet transport aircraft and can be used by the pilot throughout his/her career. A by-product is also verification of aircraft behavior in case of air data input malfunctions or failure. In the absence of an angle of attack indicator, the pilot can revert to known pitch and power settings to produce an airspeed even if the airspeed indications are suspect. The Air France 447 accident over the Atlantic resulted from a pilot-induced deep stall as a result of erroneous overspeed indications due to air data system problems (BEA, 2012). Reverting to basic attitude instrument flying, setting a known power and attitude at their cruise level may well have given the pilots time to resolve the unrelated warnings and airspeed indications they were receiving.

Basic Automation Dependency

As Asiana Airlines 214 in San Francisco and Turkish Airlines 1951 in Amsterdam have shown us we can trust automation right up to the time it surprises us (NTSB 2014; Dutch Safety Board, 2009). If a pilot is so detached from the aircraft operation that their mind is not ahead of the aircraft, they might as well take a seat in first class. Operating an automated aircraft not only requires pilots to know the automation but to recognize and understand when they are not receiving the correct results and system behavior from their inputs to that automation. Developing that “trust but verify” attitude is the challenge for every instructor of a student upon initial training and exposure to flight deck automation. At a minimum, four basic premises should be taught to the student when first introduced to the complicated automation confronted in the JTC. First, the student should treat the automation as any cause and effect relationship. Does the initial input provide the desired results? Is the flight mode annunciator (FMA) showing NAV and is the aircraft responding to that command when the NAV button is pushed on the MCP/FCP? And if not, why not, and how can the situation be corrected? Second, is the automation continually doing what the pilot expects it to do? If not, pilot must recognize and correct the situation, even if it means downgrading the automation. For example, if the autothrottles are continually retarding when they should not, then the pilot should disconnect them and place them in the desired position. Third, the best automation mode is the mode that provides the desired results. It can be full automation or completely downgraded to hand flying. Quite simply, the pilot must make the aircraft respond with whatever mode achieves that result. Finally, the instructor must ensure the student understands that the automation will never replace him/her as the final authority in operating the aircraft. This complements the need to always maintain basic pilot proficiency. Students need to know from the beginning of their automation training that they cannot allow their basic flying skills to deteriorate. They may have to fly a damaged aircraft someday where the automation has failed and their pilot proficiency is needed.

Using Automation in Non-Automated Maneuvers

The visual approach seems simple enough in its definition. After all, it is the first type of approach any pilot is taught at the beginning of their primary training. However, a visual approach in a jet transport can be challenging, especially if flown by a pilot who has only been trained to fly precision approaches with electronic guidance. If the electronic guidance is absent, either inoperative or the approach is flown to a runway with no precision guidance, the pilot might rely on visual light guidance such as Visual Approach Slope Indicator (VASI) or Precision Approach Path Indicator (PAPI). If these aids are also absent the pilot can be subject to visual illusions, which may not be recognized before the aircraft is put into an unrecoverable condition such as landing short of the runway. These illusions can be exacerbated by night or rainy conditions. To help achieve a stabilized approach as required by the FAA, a constant glideslope must be flown. This condition can be achieved by programing the FMS to give a constant glideslope on the primary flight display (PFD). The PFD will display a vertical path, augmented with flight director guidance. This result can be achieved on the FMS very easily by selecting the runway, a distance from the runway, and a corresponding altitude. A standard 3-degree glideslope translates to a three hundred foot descent per nautical mile. Therefore, at 1,500 feet the aircraft should be at 5 miles from the runway, at 1,200 the distance should be 4 miles and so on. The speed and therefore the type of aircraft are irrelevant. In other words, this formula works for any aircraft at any speed. Teaching this procedure to pilots upon initial exposure to the automation achieves two important results. The first result is that without outside vertical guidance the pilot can use the automation to set up a stabilized approach. The second result is that any pilot can immediately recognize if the aircraft is deviating from a standard 3-degree glideslope. For example, if the aircraft is 2 miles from touchdown at 400 feet, the aircraft is 200 feet too low. If the student is taught initially that automation can be used to augment a visual approach as well a standard instrument approach, every approach deviation can be recognized quickly and corrected. In the case of Asiana 214 in San Francisco in 2013, the B777 FMS was not used to help achieve a 3-degree glideslope even though the Instrument Landing System (ILS) and PAPI were inoperative. The aircraft flight path was too low when the crew tried to correct and the resulting crash destroyed the aircraft and three passengers died (NTSB, 2014).

Airline Training Methods

In addition to the usual memory items and limitations associated with the study of any aircraft, the JTC gives the instructor the opportunity to show the student *how* to study a modern jet transport based upon airline training materials and methods. This knowledge is applicable to any airline school on any aircraft. At first glance it might appear overwhelming for the student to look at an abbreviated checklist and then examine the expanded checklist. So many checklists and so many items! However, airline operators have developed manuals based upon the manufacturer's recommendations and approved by the FAA, which will help make things easier. The first element to be grasped by the student is that they must understand their duties within a crew environment. In the JTC, emphasis is placed upon the duties of the first officer. Those duties are clearly delineated in the expanded checklist part of the operating manual. Additional help with the execution of these duties is available through the use of flows. These flows are patterns that help with the accomplishment of the specific checklist. There is an after start flow, for example, which then can be verified by making sure these items are accomplished by following the after start checklist. Most of the checklists have these flows associated with them. These suggested flows are found in the operating manual. A helpful way of studying and speeding up the process of checklist familiarization is for the student, and partner in the program if available, to sit in front of a "paper trainer". A paper trainer is nothing more than a series of color poster boards, which resemble the aircraft cockpit layout. Students can practice the flows while having the expanded checklist available without utilizing valuable time in the FTD. Every airline crewmember does this with each new aircraft and seat he/she encounters. This same methodology can be used to introduce the student to systems non-normals, with associated EICAS messages, as a method of tying systems training to cockpit procedures. When it comes to learning how to fly the aircraft, the profile method is used. Each known maneuver, e.g. normal takeoff, normal ILS approach, single-engine ILS approach, has a suggested published profile associated with it, showing suggested speeds and configurations for the maneuver. Even though these are canned suggestions, the profiles are very helpful to assist the student to achieve the desired results from the maneuver. After introduction and explanation of the profile for a specific maneuver, the instructor should suggest that the student "chair fly" the maneuver. Chair flying is simply a mental exercise in flying the maneuver in your mind, much like an actor practicing a script. This exercise helps with the sequence, callouts and configurations needed for successful accomplishment of the maneuver. FMS exercises can also be practiced with sample flight plans for initialization and inflight FMS modifications. FMS trainers (FMSTs) are part of any airline training program and should be part of any JTC. If these training methods are learned in the JTC, real airline training will be much more productive for the student.

Airline pilots like to say that their operating manuals are written in blood. This is really not an exaggeration as the accidents presented above, resulting in changes to procedures introduced here, have resulted in well over a thousand deaths (Degani & Wiener, 1997). The transition to turbine-powered aircraft in the JTC is the largest knowledge/technology jump these students will likely make in their aviation careers. As digital natives who have grown up with video games and the Internet, they are better equipped than previous generations to make this transition. The challenge and also the opportunity of the JTC is to instill sound aviation practices from the beginning and expose these students to initial ways of thinking and acting, which will allow them to stay ahead of the aircraft, trust but verify the automation, and work cooperatively in the crew environment to exercise good decision making, communication, emotional intelligence and critical thinking.

Sterile Period

The sterile period is defined by CFR Part 121 and should be introduced in the JTC (FAA, 1981). This is a further example of the proper application of the law of primacy. The instructor can introduce interruptions from either flight attendant crewmembers or other sources through role-playing during periods of taxi or other times when the sterile period should be enforced. Depending on the airline, the sterile period extends from initial aircraft movement to either 10,000 feet or 18,000 feet. These interruptions and distractions should be dealt with in deference to the Federal Aviation Regulations. From the outset of their careers in multi-place aircraft, the students should be taught not only to respect the sterile period but also to utilize skills of prioritization and workload management necessary in a demanding crew environment in a jet transport. Two accidents stand out as examples from which students can learn the importance of respecting the sterile period. The first accident was Pacific Southwest Airlines 182 in 1978 over San Diego, which prompted the FAA to formalize the sterile period (NTSB, 1978). The second accident was Delta 1141 in 1988 at Dallas-Ft. Worth International Airport (NTSB, 1988b). The voice recorder of this second accident is chilling (AirDisaster.com, 1988).

Stabilized Approach

A final example of the implementation of the law of primacy in the JTC is a recent but high visibility item on the FAA's radar. This agency has identified unstable approaches as the cause of improper landings and overrun incursions (FAA, 2007). The FAA has tasked operators to develop procedures respecting the concept of a stabilized approach. Stabilized means that the aircraft must be at approach speed, the thrust properly set, the aircraft configured for landing and positioned on the proper glide path. For most operators, an example might be that an approach must be stabilized by 1,000 feet, or 500 feet for a visual approach, above ground level (AGL). If not stabilized by these altitudes, a go-around must be initiated. In many airline manuals, there is a required callout by the PNF, e.g. "stable" at 1,000 feet AGL. The introduction of this procedure can be initiated as soon as the first approach is conducted in the JTC. This procedure should be emphasized thereafter, so as to be a part of each student's understanding of the conduct of a stabilized approach.

CONCLUSION

Recent regulations from the FAA on greater training requirements, longer rest periods between shifts, and the continued retirement of aging pilots has accelerated the hiring of pilots by most U.S. airline carriers (FAA, 2012; 2013; Jansen, 2013). As the pool of available pilots decreases, and more are hired to fill shortfalls at the airlines, the demand for qualified pilots will continue to increase. Therefore, it is in the best interest of the airlines to continue their partnership with the collegiate community, providing whatever assistance is necessary in order to produce the most qualified new hire candidates possible. This will help ensure the future business success of the airline. (Michael J. Hildebrandt, personal communication, January 23, 2013).

The former airline pilot pipeline has been sufficiently altered to warrant a look at primary training methods. The time-tested military pipeline to the major airlines has all but evaporated. In the 1970s, the percentage of military-trained pilots going to the majors was in the 80th percentile (Boeing, 2012). The regional system was non-existent and pilots were going from round dial military aircraft to round dial airliners. Most airlines had aircraft equipped with a flight engineer position. This third seat provided a training ground in airline crew operations for the new hire that may not have had the benefit of flying a military multi-crew aircraft. Military aviators were also provided unequalled training and operational experience in equipment and flight regimes not available to the civilian-trained aviator. For the most part, the hundred year training history of the military honed the use of the law of primacy to produce pilots with habits readily adaptable to the aircraft operated by the majors.

There has been a paradigm shift in airline hiring. The majors now and in the future will be filling their ranks from the regional pipeline. Less than twenty percent of the future aviators for the majors will come from the military (Boeing, 2012; Paasch et al., 2013). The regionals will be utilizing collegiate programs to fill their right seats in ever increasing numbers. Regional partners have reiterated the hiring statistics and future projections on every visit to the university during their student recruiting presentations. Because the collegiate programs will be the feeder pipeline for the regionals and then the majors, the training programs at the collegiate level must be up to the task. The military training programs have standardization and the law of primacy at the core of their success. Collegiate programs must strive for the same result. When any task is taught in an environment, which is transferable to the regional cockpit, it must be taught correctly the first time. The JTC provides the perfect laboratory for this experience.

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APPENDIX

Table 1
Noted Deficiencies in Regional New Hires

Automation management and appropriate levels of automation
Multi-pilot flying: Pilot Flying / Pilot Monitoring concepts
Use of highly standardized profiles and callouts
Basic FMS* programming and usage
Energy management and descent planning
Applications of Threat and Error Management

Note. FMS = flight management system.

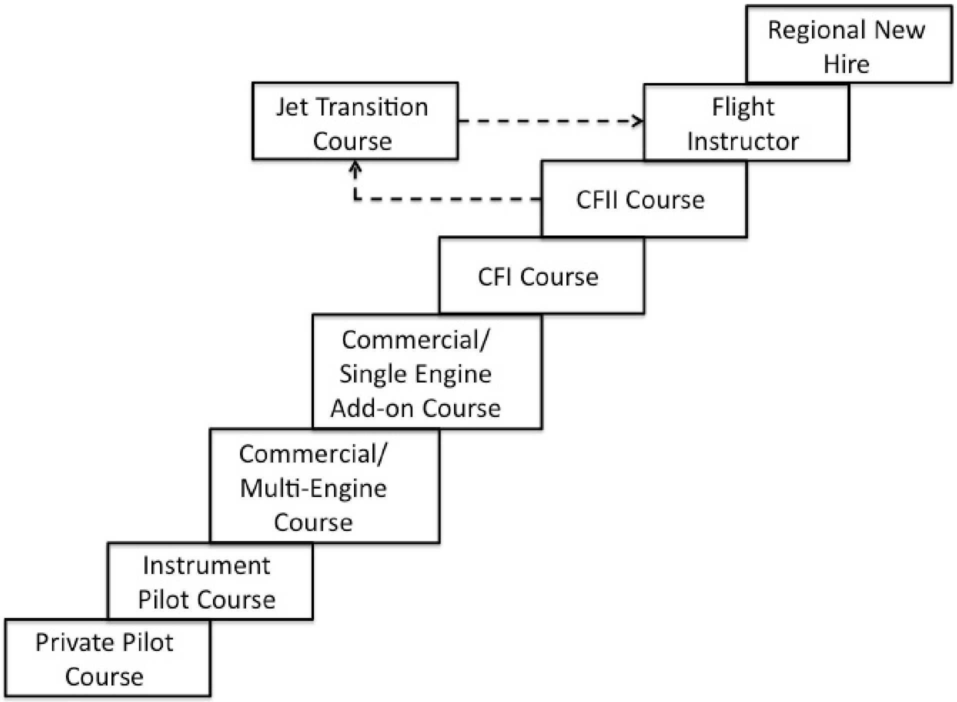

Figure 1. Traditional student pilot progression.

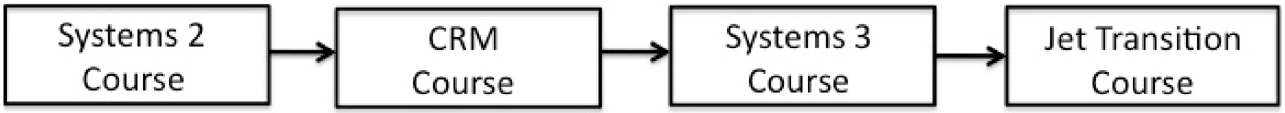

Figure 2. Prerequisites for the Jet Transition Course.

Figure 3. Students in the CRJ 700 Flight Training Device.