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PHILOSOPHY STATEMENT

Cornelius Lanczos, a mathematician working in the field of applied analysis, expressed the history of mathematics in three phases:

1) A given physical situation is translated into the realm of numbers,
2) By purely formal operations with these numbers certain mathematical results are obtained, [and]
3) These results are translated back into the world of physical reality (1988, p. 1). [1]

Formal papers, in subjects related to aviation, roughly follow the same course. However, there appears to be a weakness in aviation research, that being the omission of the third phase.

It is not good enough that conclusions are drawn, if those conclusions fail to improve the system observed. Clearly, the observed have a say in implementing the conclusions of research, but their failure to implement the conclusions drawn by the researcher may be more indicative of a lack of understanding than a lack of desire. Researchers tend to peer into complex systems as through a soda straw, forming formal opinions on the finite without understanding the complete system. Industry, ever mindful of the complete system, may find research irrelevant, because it makes much to do about nothing.

The editorial staff, to include those listed as consulting editors, is committed to the improvement of all individuals within the aviation community. We seek to enhance existing systems bearing in mind that small improvements must not upset the delicate balance between too little and too much help. We also seek to promote safety, not by lip service, but by demonstration in how we execute our studies and how we report our findings.

We feel that the best way to translate results back to the physical world is to incorporate the viewpoints of people around the globe. Without the influence of a worldwide community, we deny the significance of diversity, and ignore the perspectives of gifted scientists from different countries. It is our hope that each reader will feel the same.

[1] Lanczos, C. (1988). Applied Analysis. Mineola, NY: Dover Publications, Inc.

EDITOR’S NOTES

Formal Papers

To identify factors useful in the development of college aviation curriculum, Fanjoy and Young focused on *glass cockpit* training from the viewpoint of the line pilot. One hundred and ten highly experienced airline, corporate, and military pilots were surveyed before and after a flight simulator training session. Along with issues relating to the automated flight deck training, transition between old and new technology aircraft are discussed, as well as recommendations for developing a glass cockpit pilot training course.

The Stewart and Dohme article discusses the findings from a transfer of training study conducted in the U.S. Army’s Initial Entry Rotary-Wing training program. Sixteen of 46 U.S. Army officer trainees learned to hover in the Automated Hover Trainer before training in the UH-1; the remaining thirty served as controls. Instructor Pilots, blind to the conditions, evaluated their performance. Results demonstrated that AI-based adaptive training, when combined with proficiency-based instruction, could save time and resources in training the basic hover maneuvers in the UH-1 aircraft.

The current national discussion on what forms flight training should take in the future, to improve Aeronautical Decision Making abilities, is addressed by Bertrand. This article provides new information gained from a survey-based study. The study surveyed extremely experienced flight instructors to investigate background information connected with the development of scenario training models.

Maintenance errors are a key cause of aviation mishaps. Research efforts are focusing on how background factors influence safety outcomes. The Fogarty study set out to validate a structural model wherein psychological strain is depicted as a major contributor to maintenance errors. Based on a survey administered to 150 maintenance personnel, the findings showed the effect of safety climate on errors is at least partially mediated by individual level factors, such as psychological strain.

The Li and Harris article examines the reliability and applicability of the Human Factors Analysis and Classification System in the Republic of China (R.O.C.) Air Force: a military, collectivist, high power-distance culture. It also examines inter-rater reliability.Analyzing 523 accidents occurring in the R.O.C. Air Force between 1978 and 2002, the findings of this research highlighted critical areas of human factors in R.O.C. military aviation in need of further safety initiatives.

Inspection and maintenance errors have a formidable impact on the safety and reliability of air transportation. Surveillance, auditing, and airworthiness directives are a part of the quality assurance function of an airline. Iyengar, Kapoor, Dharwada, Greenstein, and Gramopadhye identified the process measures for these work functions based on human-factor principles, utility of data being captured, and working around mental models of the quality personnel. Following this identification phase, two surveys were conducted to validate the process measures. The results of the first survey are presented. The results of the second survey are awaited.

Saleem and Kleiner wrote on the laboratory experiment performed to understand the effects of visual conditions on pilot performance, workload, and situation awareness for both VFR and IFR flights. Eight VFR-only pilots and eight IFR-rated pilots performed landing approaches during daytime, nighttime, favorable weather, and deteriorating weather conditions using a medium-fidelity flight simulator. Few differences were found between or within each of the two pilot groups, in terms of objective flight performance. However, key differences in workload and situation awareness were exhibited.

The purpose the Sheremeta and Weitzel study was to identify the factors that influence the job performance of the Dispatcher. To determine factors that may enhance or hinder the performance of the Dispatchers, 19 Dispatchers were interviewed from both a major carrier and a low-cost carrier. The results suggested that Dispatchers want stronger management support and improved technology in the workplace.

Human factors training is mandatory for flight crews in the United States, yet it remains optional for non-flight labor. Lu, Przetak, and Wetmore examined the level of threat from non-flight error affecting aviation safety. The non-flight error was found to be the most significant direct hazard affecting airline safety. The discovered accident causes were categorized into ten groups associated with 36 root factors. Using Fault Tree Analysis a more cost-effect safety training for non-flight workers is provided.

Upon completion of a two-part exercise, pilots using GPS navigation significantly lowered their navigational awareness rating, while pilots navigating by pilotage raised theirs. These results, based on findings from Casner's study, call into question unqualified beliefs and claims that advanced avionics systems enhance pilots' navigational awareness and pointed to a need to teach pilots about the potential human factors pitfalls associated with advanced avionics systems.

NASA publishes the data of almost every astronaut from the United States, the former USSR and its subsequently independent states, Europe, Australia, and Asian. Analysis of this data conducted by Cokley, Rankin, and Söhnlein revealed the most likely characteristics of the members of the first communities in space. They contemplate these communities as "audiences," just as earthbound communities have been grouped into audience, or "market," segments by media companies.

Quilty's paper identifies important skills and capabilities required of individuals employed in airport operations and management positions. One hundred six airport managers and airfield operations personnel responded to a survey seeking the identification of skills and traits deemed important for entry level airport operations personnel. The results from this study add to the body of research on aviation management curriculum development.

Developmental

The United Nations and its bodies, such as the International Civil Aviation Organization, have acted as arbiters in politically contentious issues. Both Organizations have proven their viabilities and sustainabilities in their roles as managers of international relations, demonstrating objectivity, discretion, and judiciousness. Abeyratne's article draws on the various instances of dispute settlement by ICAO, demonstrating the role played by diplomacy in the Organization's position as the specialized agency of the United Nations addressing issues of international civil aviation.

Rankin and Ewald discuss the services available to the airport industry through AirportNet, the e-government website of the American Association of Airport Executives. Through the AirportNet, local governments, policy makers, lobbyist, suppliers, vendors, and others are linked together through this airport management website.

Book Reviews

Hansen reviews "Aircrew Security: A Practical Guide" by Clois Williams and Steven Waltrip.

This book concerns post September 11, 2001 security issues facing aircrews and flight attendants on commercial aircraft. Flight-crew members, airline passengers, and readers, interested in aviation security will find this book informative and thought provoking.

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Formal Papers

Training Development Papers

Book Review

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Formal Papers

Flight Deck Automation: Line Pilot Insight for Improved Initial Pilot Training

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Abstract

The difficulty associated with transition from round-dial to "glass cockpit" flight instrumentation has received significant airline industry attention over the last decade. Collegiate aviation curriculum designers have carefully monitored airline training in this area for insights to flight automation course development. This paper addresses glass cockpit training from the perspective of line pilots in an attempt to identify factors useful to college curriculum development. Study participants included one hundred and ten highly experienced airline, corporate, and military pilots who were surveyed before and after a flight simulator training session conducted in preparation for an employment interview with a major airline. Although only a few study participants reported problems in completing automated flight deck training, most reported ongoing concern with line operation of such systems, particularly during the approach and landing phases of flight. Although pilots in the study sample reported regular use of automated flight modes during most phases of flight, they expressed concern over a perceived deterioration in psychomotor skills essential to manual flight operations. Issues related to the transition between old and new technology aircraft are discussed in this paper, as well as recommendations for glass cockpit pilot training course development.

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Flight Deck Automation: Line Pilot Insight for Improved Initial Pilot Training

As newly certified pilots gain experience and prepare to enter service with the aviation industry, they eagerly anticipate the prospect of flight in the latest automated aircraft. Modern "glass cockpit" flight decks also draw great interest from line pilots in transition and offer an exciting outlet for established computer skills and evolving expertise in advanced aircraft. Technological advances associated with advanced flight instrumentation provide more efficient aircraft operation while reducing the potential for pilot error and task saturation. However, pilot complaints of rushed/inadequate automated flight deck training, reports of automation accidents/incidents, and the potential for loss of basic stick and rudder skills provide cautionary reminders for those charged with training pilots of modern aircraft. This paper presents the results of a survey of line pilots regarding their perspectives on glass cockpit systems training and a self-assessment of their current flight skills. Factors identified during this study provided insight for the development of glass cockpit training curricula.

A number of researchers have attempted to identify factors that impact glass cockpit training (Javaux, 1997; McCrobie, et al. 1997; Roessingh et al. 1999; Sarter & Woods, 1992; Wiener, Chute, & Moses, 1999). Their findings suggested that a basic cognitive disconnect occurs between pilots and the automated flight deck. Wiener et al. (1999) surveyed almost 300 Boeing 757 pilots and Sarter and Woods (1992) surveyed 135 Boeing 737 pilots to assess their mastery of flight deck automation. Both studies suggested that mode awareness and gaps in automation knowledge are important factors that can lead to improper interaction with automated flight systems. Highly experienced pilots report particular concern with mode confusion during critical phases of flight (Dornheim, 1995; Huettig, Anders & Tautz, 1999; Javaux, 1997). Mode awareness and confusion problems seem to be generated by poorly trained mental models of how automation works as well as incomplete or ineffective feedback from automated systems. Researchers noted that pilots commonly complain about automation training that is structured for rapid course completion and that only addresses basic procedural considerations (Funk & Lyall, 1999; Roessingh et al., 1999). Researchers suggested that to be effective, training must address how such systems operate, why they operate that way, and appropriate decision processes for automation "surprises." Javaux (1997) suggested that flight automation problems derive from the complexity of interactions between flight deck automation and pilots. His list of tasks that highlight interaction between the flight crew and automated systems included intentional engagement/disengagement of automated modes, awareness of automatic mode transitions, prediction of automatic mode transitions, and prediction of mode effect on aircraft operation. Human operators depend upon feedback regarding these transitions to either successfully operate or monitor flight operations. Feedback, however, is not routinely considered in flight deck design (Norman, 1990). Many aspects of flight automation were designed purposely to be transparent to the human pilot. When things do not go well, however, the lack of feedback to pilots may set up an incorrect response or absence of response by the human crewmember.

A common complaint regarding automation development is that systems designers fail to use a *human-centered* approach to automation. Billings (1991) suggested that effective automation design must keep the pilot actively involved in automation operation, provide a constant flow of automation information, be designed for easy monitoring, have predictable automation actions, provide automation that is able to monitor and correct human mistakes, and help the pilot understand the intent of the automation. Insufficient flight automation training (coupled with policies that mandate maximum use of automatic flight modes) may lead to pilot complacency and over reliance on automation, inefficient use of flight automation, an incorrect mental model of automation function (which can lead to incorrect response), and/or a deterioration of manual flight skills. Mosier, Skitka, Dunbar, and McDonnell (2001) noted automation errors often result from a human tendency to take the most expeditious course of action when problem solving. Errors in flight performance typically occur due to inaction or failure to consult additional sources of information/feedback. In addition, Javaux (1999) suggested that a reduced exposure to malfunctions during flight and minimal theoretical foundation provided during training lead to implicit learning acquired through automated flight operations. The result is a potential for incorrect or inadequate response when encountering an unusual flight situation. Huettig et al. (1999) suggested that a common *monitoring behavior* occurs with incompletely trained glass cockpit pilots. In such instances, automated flight drives an increased decision activity workload while taking the pilot further out of the loop to address real time unusual activity.

Pilots of automated flight decks describe training in automated operations as procedurally focused and insufficient to reduce the impact of in-flight surprises that regularly occur. However, most airlines mandate maximum use of flight deck automation for operational efficiency and safety. Frequently, the result is that pilots who are new to an automated flight deck lack confidence in automated systems operations, particularly during critical phases of flight. Such pilots may not have made the adjustment from active control of the aircraft, based upon a broad range of feedback, to passive monitoring of aircraft operations using minimal, but targeted feedback. This study was designed to identify issues associated with a transition to automated flight deck operations that might be useful in designing advanced flight training curricula.

Methodology

The population for this study was 110 highly experienced airline, corporate, and military pilots who were completing flight simulator training in preparation for an interview with a major airline. Training was conducted from August to November 2003 and consisted of a 15-minute pre-brief session followed by a one-hour session in a "round-dial" Boeing 727 training device. The training profile consisted of a short orientation to the instrument panel, a takeoff, a complex departure procedure, rate climbs and descents, holding scenarios, and descent/vectors for a precision instrument approach. Additional instrument approaches were accomplished to complete the hour of training.

A biographical survey was administered to participants prior to training. Data collected included: age, gender, total flight hours, and method of initial flight training. In addition, glass cockpit and round dial aircraft experience were assessed. Finally, subjects with automated flight deck experience were asked to rate aspects of their training and level of familiarity with various modes of automated flight systems. Several open-ended questions were presented during the survey to address participant concerns with automated flight deck training and suggestions for improvement. Upon completion of the survey and training period, a Likert-scaled instrument was administered to determine participants' perception of their performance during the flight simulator session. Items evaluated included: instrument crosscheck proficiency, flight within established control tolerances, smoothness of control, and knowledge of instrument procedures.

Results

For survey purposes, glass cockpit aircraft were defined as having an electronic flight instrument system and integrated instrument displays that operated in conjunction with a programmable flight management system. The average total flight time of all participants was 5,583 hours and ranged from 2,200 to 16,000 hours. When asked about their initial method of flight training, 39% of the pilots reported training through collegiate aviation. Other respondents reported flight training with fixed base operators (28%), training centers (18%), and military flight schools (15%). The participants in this study were employed by regional airlines (55%), major airlines (15%), corporate aviation (11%), military aviation (11%), and charter/instructing/miscellaneous (8%). Average glass cockpit flight time for the 75 participants (68%) with glass cockpit experience was 1,915 hours. Thirty-five participants (32%) had negligible time in glass cockpit aircraft (less than 5 hours). Data collected from those participants with negligible glass experience were not considered in study findings.

Pilots in the study sample were asked what they liked best about their prior glass cockpit training. The challenge of learning advanced automation and glass cockpit technology was cited most often (35 pilots). Many felt that this challenge was a major highlight in their professional careers. The new display technology and innovative methods of instruction were also identified as best-liked aspects of training. A few respondents indicated that the increased emphasis on situational awareness and the use of specialized flight training devices during training were especially helpful during the transition to glass cockpit instrumentation (Figure 1).

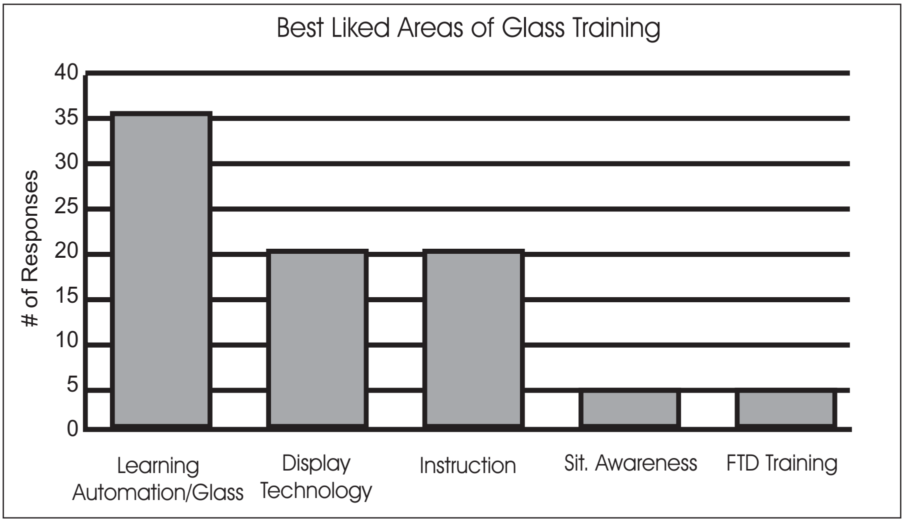

Figure 1. What did you like best about your glass cockpit training?

Study participants were queried about those areas they liked least during glass cockpit training. While some pilots indicated *method of instruction* was their most liked area of training, the same area was reported as overall least liked area of training (20 pilots). Other pilots (15) found training course formats frequently inadequate. Some pilots (12) felt threatened by a new system that was radically different from their prior experiences. A few pilots reported problems with the transition to a new instrument display (7) and difficulty in adjusting to computer-based training (5). In addition, some pilots (12) identified the flight management system (FMS) as especially difficult to master (Figure 2).

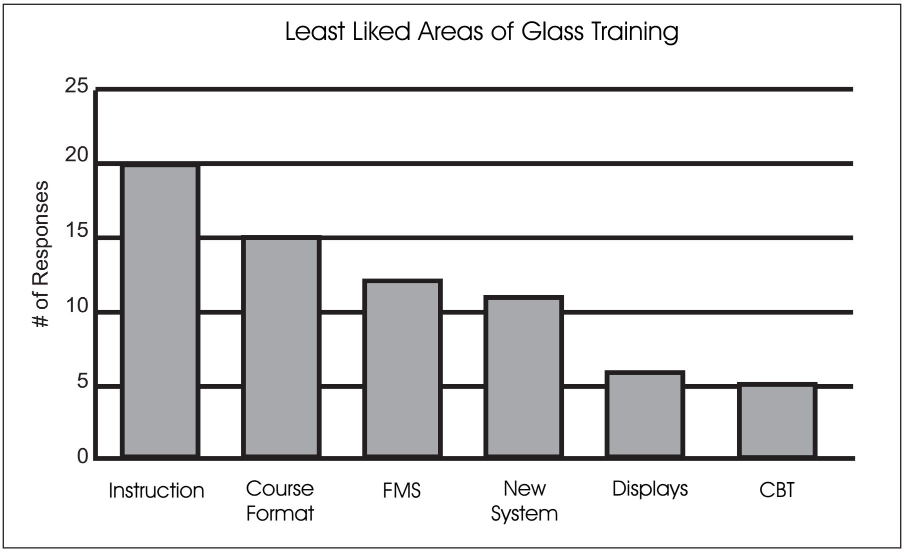

Figure 2. What did you like least about your glass cockpit training?

Prior to the simulator training sessions, pilots were asked what areas of round dial operation most concerned them. This question focused on pilot confidence in their abilities to conduct flight operations using raw data. A majority of the respondents (43) were concerned with their current scan proficiencies. They felt comfortable locating primary flight information that was contained in a single display unit, especially those that had been flying glass for some time, and had doubts about their abilities to effectively interpret flight data from multiple sources in a typical round dial aircraft. Some respondents (23) were concerned with the transition back to round dial aircraft and a different operating philosophy. A few pilots (9) were concerned with precision *manual* aircraft control during basic instrument flight maneuvers, such as changing/holding altitudes and headings, entering holding patterns, and completing a basic precision instrument approach. Many pilots (36) did not indicate an area of concern in response to this question (Figure 3).

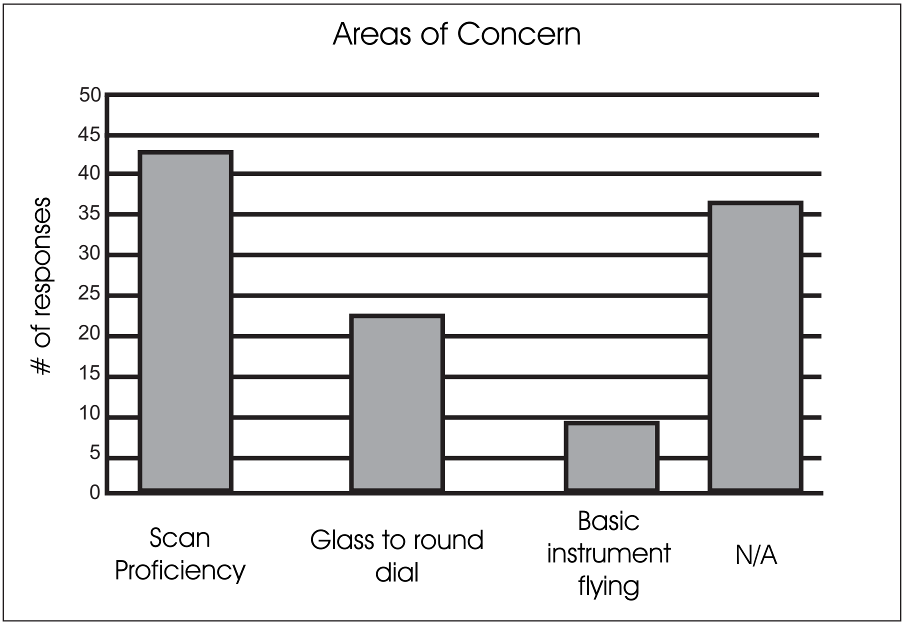

Figure 3. As you prepare for this simulator session, which areas of round dial operation cause you concern?

Respondents were asked to rate the difficulty of the glass cockpit training they received. Qualifications of training providers, course content/methodologies, and timing of initial automated flight deck training were not identified or assessed. On a Likert scale of 1 to 5, with 1 being very difficult and 5 being very easy, most respondents (70) found their flight automation training courses to be at least satisfactory (Figure 4). These ratings seemed to indicate that training courses met the overall expectations of the trainees, despite particular areas of concern identified in an earlier question.

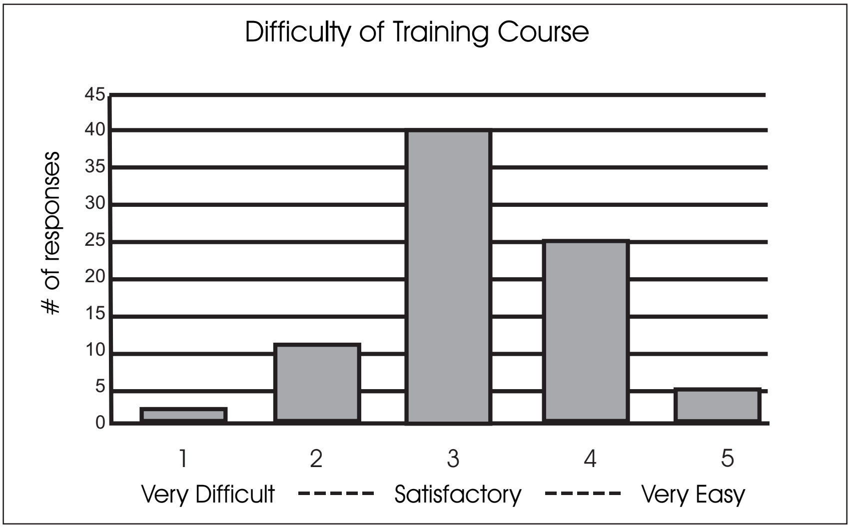

Figure 4. What was the difficulty level of the glass cockpit training course you attended?

Survey respondents were asked to identify phases of flight with which they were most uncomfortable when using automated flight modes. More than one area could be identified, if desired. Although all phases of flight were represented, the approach (33) and departure (21) phases of flight were most commonly identified in response to this question (Figure 5). A few pilots commented separately that the use of flight automation during missed approach was especially challenging. Although aspects of flight deck automation that contributed to discomfort were not identified, open literature seems to suggest programming of the flight management system can be problematic in most flight phases.

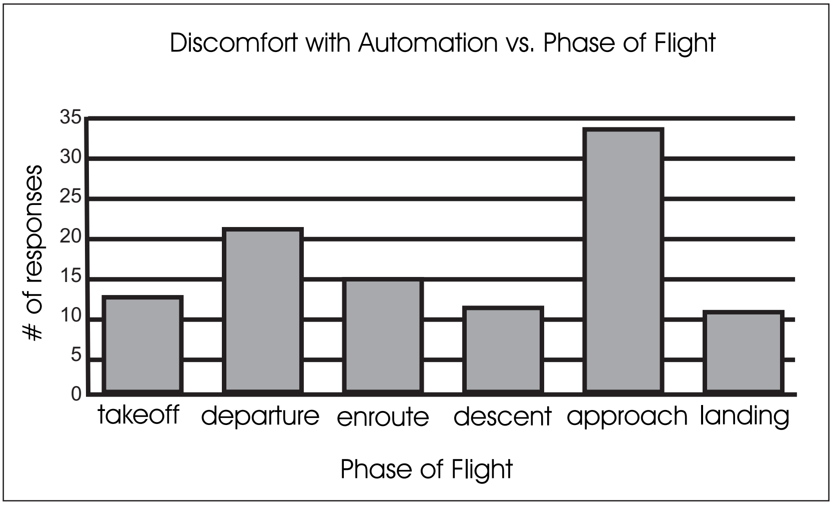

Figure 5. In what phases of flight do you feel most uncomfortable when using automated flight systems?

Finally, survey respondents were asked how often they flew approaches and departures using automated flight deck systems (versus manually-flown approaches using raw data). On a 1 to 5 scale with 1 as never and 5 as always, the most common response was either occasional (22) or frequent (42) use of flight automation systems during line operations (Figure 6). Given responses to the previous question, these responses probably reflected compliance with company policy, rather than a level of confidence with automated flight systems during particular phases of flight.

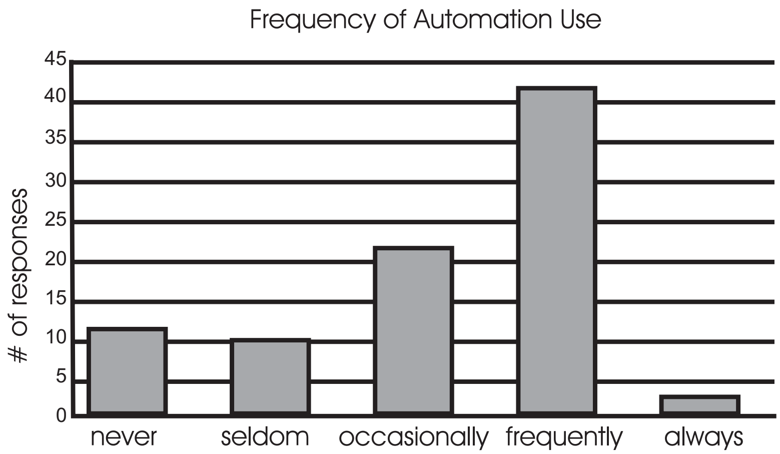

Figure 6. How often do you fly approaches and departures using automated flight systems (versus hand flown with raw data)?

Study participants with glass cockpit experience had accrued an average of 1,915 hours in glass cockpit aircraft. The majority of these pilots indicated frequent use of flight automation features during flight. They reported that use of automated flight systems was strongly encouraged or mandated by company policy. Study participants identified departure and instrument approach as phases of automated flight with which they were most uncomfortable. Since both phases of flight tend to be labor intensive and critical to flight safety, such findings are not unexpected and are consistent with findings about vertical navigation modes suggested by earlier studies (Dornheim, 1995; Sarter & Woods, 1992)

Responses to other survey questions revealed general, yet qualified satisfaction with glass cockpit training curricula. When queried about the difficulty of initial glass cockpit training, only a few pilots (6) rated their courses as "very easy" or "very difficult." Most responses fell in the "satisfactory" or slightly better range. Respondents eagerly anticipated their initial transition to a modern, automated cockpit. They viewed automation technology as especially helpful in the completion of flight duties and reported that glass cockpit aircraft were easier to fly due to a simplified instrument scan. The new display technology provided them with most of the information they needed on two screens and a level of situational awareness that had not been available in the past. Most pilots (70) were generally satisfied with the overall training they received during their initial glass cockpit training.

When asked to identify what they least liked about glass training, several (20) respondents pointed to methods of instruction. The two main complaints in this regard were the lack of interactivity with actual systems components and the use of older instructional media, such as videos, slides, and picture handouts, to introduce the subject. The absence of hands-on practice and, in a few cases, the presence of instructors who were only marginally familiar with glass technology, also led to frustrating training experiences. A few pilots reported that course formats were not responsive to their particular learning styles and rates of subject mastery. Other respondents reported that glass cockpit training courses were too fast, too short, and contained too much information, frequently leading to information overload. In a few cases, respondents felt that too much training was allocated to self-study with computer-based training and manuals. Others found it difficult to learn an entirely new aircraft operating philosophy and concept of cockpit management. A few pilots reported the flight management system (FMS) was particularly difficult to master. Much of the FMS training was left to instructors during full flight simulator or actual aircraft training. Study respondents also noted little emphasis was placed on methods of scanning a glass cockpit display, where vertical tape instruments predominate. Finally, some respondents reported that during simulator training, too much emphasis was placed on automation and not enough on basic hand flying.

Discussion

The majority of pilots surveyed during this study currently were flying glass cockpit airplanes in line operations and the prospect of returning to an older technology airplane with traditional round dial instrumentation, especially during an employment interview, was met with some trepidation. Having spent several years flying glass, many study participants were concerned with their abilities to effectively gather information from widely separated instruments rather than interpret a single primary flight display (PFD). Others were more concerned about the interpretation of individual "steam gauge" instruments, after using their integrated, computer-generated display counterparts, map displays, trend vectors, and other features common to newer automated cockpits. Several pilots were concerned about manual flying skills during instrument maneuvers such as turns, rate climbs and descents, holding, and hand-flown instrument approaches using raw data. They felt that their instrument scan proficiencies were degraded due to established reliance on automated flight modes. It is unclear whether this reported issue reflected concerns with an upcoming pre-employment evaluation in older technology systems or concerns for personal skills.

Survey respondents suggested that training on automated flight systems begin early in the aircraft training curriculum and that part task trainers be incorporated within the course of instruction. Many flight training courses rely on the "drink from the fire hose" approach, yet adequate training time with glass cockpit technology seems particularly deficient as reported by study participants. Mastering the automated flight deck terminology and interacting with part task trainers, especially the FMS, would better prepare pilots for expanded training sessions in full flight simulators and/or actual aircraft.

Study participants suggested that all aspects/modes of automated flight be introduced during training to promote proficiency and minimize the potential for operational surprises. In addition, pilots should be proficient in programming manual flight operations and resuming manual control during any phase of flight should the situation dictate. Unfortunately, exposure to such activity frequently is relegated to experimentation during actual line operations, after formal training has been concluded. Pilots who are new to glass cockpit operations need to be especially alert to complacency during automated flight operations, since over reliance on automated systems has been identified as an important factor in several accidents and incidents. Several pilots recommended that currency in basic flight procedures be maintained by periodically hand flying the aircraft with reference to raw data, especially during instrument approaches. Rather than reflect a lack of confidence in automated flight operations, this suggestion may represent a basic need for more active involvement in aircraft control through monitoring activity during automated flight.

Other suggestions for glass cockpit trainees include learning the efficient manipulation of displays to obtain needed information and to declutter the screen. Exposure to common programming errors can be helpful in this area. Strategies for developing a new scan to address vertical tape instruments (instead of round dial instruments), trend vectors, and the vast amount of information on one display unit should be developed by pilots transitioning to an automated cockpit. Significant training time should be spent on the interaction of all aircraft systems. Again, the speed and sequence with which glass cockpit training information is introduced seems to be directly linked to comprehension. Glass cockpit instrumentation functions should be presented early during aircraft initial/transition training and then reinforced with hands-on practice throughout the training course.

Recommendations for New Generation Aircraft Training

Based on insights provided in the literature review and comments from professional pilots who participated in this study, the authors offer the following recommendations for improved glass cockpit training:

1. Begin training in new technology aircraft with glass cockpit terminology and definitions. Defining nomenclature and basic concepts early on will help to make the transition to an automated flight deck easier. Introducing this instruction near the beginning of aircraft systems training will allow more time to master this new material, which has been viewed by many as the most difficult part of the training curriculum.

2. Spend sufficient time on FMS training prior to simulator and/or airplane training. Part-task or computer-based FMS trainers are particularly helpful. Inadequate training in this area can significantly impact success with other aspects of flight automation while transitioning to line operations.

3. Integrate part-task trainer and flight training device instruction with ground school instruction. The hands-on approach will help to reinforce desired instructional objectives.

4. Use interactive media, whenever possible, to discuss subject areas. Maximize free-play opportunities with CBT and part-task trainers prior to simulator and/or aircraft training.

5. Emphasize new scan techniques, including interpretation of vertical tape instruments and operations with degraded automation displays.

6. Discuss all available information on the display screens, and how to move quickly to new screens to obtain additional information. The ability to remove clutter on a screen when too much information is displayed can make flying the aircraft easier.

7. Begin exposure to flight automation with basic flight phases that are familiar to the trainee from past experience with round dial aircraft. As proficiency is gained, add layers of automation until the new pilot is comfortable and proficient in a totally automated environment. Then make sure he/she can reduce the layers of automation when experiencing task saturation or conducting maneuvers that require a reduced level of flight automation.

8. Stress the need to remain situationally aware and mentally ahead of the aircraft. Students must avoid complacency and over reliance on the automation.

Conclusion

Modern aircraft use glass cockpit technology to ensure more efficient flight operations and to minimize pilot workload. Advances in computer technology and miniaturization will promote further advances in this area. Studies of automated flight incidents/accidents and pilot surveys suggested that the human operator remains the weak link during the employment of advanced flight instrumentation (Funk & Lyall, 1999; Sarter & Woods; 1992). This study presented findings from a broad cross-section of professional pilots who offered insights for improved glass cockpit training methods. These inputs are presented against a backdrop of concerns faced by the aviation industry, including the need for effective training, the high-cost of flight training resources, and the pressure to turn out trained pilots in minimum time. Further studies are needed to understand cognitive aspects of the human pilot/automated systems interface. Instructional strategies for tailoring flight automation topics to various learning styles should be key outcomes of such investigations and should shape future glass cockpit training curricula. As the number of round dial cockpits in the air transportation industry continues to decline, the need for effective flight automation training methods becomes more imperative. The authors believe the glass cockpit considerations suggested by this study will provide useful insight for the development of ab initio and other training methods to prepare the next generation of air transportation professionals for service in automated cockpits.

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Automated Hover Trainer: Simulator-based Intelligent Flight Training System

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Abstract

The Training Research Simulator (TRS) was developed as a low-cost research simulator, in support of the U.S. Army's Initial Entry Rotary-Wing (IERW) program. Four previous experiments demonstrated positive transfer of training (TOT) to the UH-1 aircraft. The TRS was modified to become the Automated Hover Trainer (AHT), by integration of an artificial intelligence (AI) - based software control model. Its purpose was to investigate adaptive training of student pilots (SPs), by providing automated instruction of hovering skills (stationary hover, hover taxi, hover turns, takeoff to, and landing from a hover) without an instructor pilot (IP). A TOT experiment was performed, in which 46 U.S. Army officer trainees were randomly drawn from IERW classes. Sixteen learned to hover the AHT before training in the UH-1; thirty served as controls. IPs, blind to conditions, evaluated performance in the aircraft by counting the total iterations of each maneuver required to attain proficiency. It also was noted whether an iteration required the IP's assistance, and, if unassisted, whether it met formal training standards for that maneuver. AHT participants performed fewer iterations requiring assistance, but this difference was not significant. Compared with AHT participants, controls performed significantly more iterations in the aircraft below training standard, (p <. 01, one-tailed); these were significant for stationary hover (p < .01, one-tailed), hover taxi (p <. 002, one-tailed), and hover turns (p <. 04, one-tailed). The research demonstrated that AI-based adaptive training, when combined with proficiency-based instruction, could save time and resources in training the basic hover maneuvers.

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Background

One of the critical helicopter flight skills that must be learned by ab initio trainees in the U.S. Army's Initial Entry Rotary-Wing (IERW) training program is hovering. Hovering maneuvers such as stationary hover, hover taxi, hovering turns, takeoff to, and landing from a hover must be mastered before the trainee pilot can learn more advanced piloting skills. In the IERW curriculum, the student pilot (SP) must learn coordinated hovering skills before the 20th flight training hour in order to be cleared for solo flight, and to avoid setback or elimination from training.

Successful hovering flight requires the coordinated use of the helicopter flight controls in order to overcome the interactions built into the aircraft. For example, when power is added by raising the collective pitch lever in order to climb to a higher hover altitude, there also must be an increase in the pitch of the anti-torque (tail) rotor, which is accomplished by simultaneously applying left pedal input (in U.S.-manufactured helicopters equipped with tail rotors). In short, any change in one helicopter control position requires a concomitant change in other controls to maintain the aerodynamic balance required for stable hovering flight. These control interactions and the rapid but small control movements required to maintain constant position over the ground, especially with varying winds, constitute a large part of the challenge that trainees must meet in order to master the various regimes of hovering flight that comprise the IERW syllabus. In addition, rapid eye-hand coordination is required in order to perceive and respond to small changes in helicopter position and/or attitude. Instructor pilots (IPs) on the flightline estimate that the typical beginner pilot will require 5 to 10 hours of instruction to acquire basic hovering skills and considerably more time to master hovering flight in the fundamental maneuver tasks. During this time, the IP must be vigilant because of the consequences of errors in control inputs while operating near the ground. This makes basic hover training demanding and potentially hazardous, for both student and instructor.

The Automated Hover Trainer

The idea of a simulator-based automated hover trainer (AHT) occurred to the second author (JAD) during his first attempts at hovering flight in 1977. The standard training method used by the Army is to give the SP control of only the pedals, next only the cyclic pitch control, and finally, the collective pitch lever. The problem with this approach comes when the student later tries to integrate the separately learned control responses by taking all of the controls simultaneously.After reviewing the manual-task training literature, Wightman and Lintern (1985) concluded that integrated perceptual-motor tasks should not be fractionated for training. This review suggested that the integration time for separately learned tasks is longer than the time required to learn the tasks simultaneously.The reader can see at this point the paradox; that is, integrated psychomotor tasks should be trained holistically, but for safety reasons, the new trainee should not be given all three of the flight controls at once.

The investigators believed the best means of training these complex hovering tasks to be a low-cost simulator employing automated adaptive training, without the need for an IP. There has been no previous research on rotary-wing adaptive training systems not requiring an instructor. For primary fixed-wing training, two notable examples of automated flight training systems are worthy of mention. Koonce, Moore, and Benton (1995) developed and demonstrated the Basic Flight Instruction Tutoring System (BFITS), which was a PC-based system with both tutorial and criterion-referenced performance measurement systems. It is criterion-referenced in that it requires the student to meet predetermined standards on one maneuver before proceeding to the next one. It is tutorial in that it teaches students to perform a given maneuver, demonstrates the maneuver, measures performance when the student executes the maneuver, and then provides corrective feedback if the maneuver is performed outside of parameters. Students pretrained in the BFITS were able to solo significantly earlier in a Cessna 152 than non-pretrained controls. IPs noted that students required fewer attempts to land the airplane. The main training advantage of BFITS is that it alleviates many of the problems inherent in subjectively evaluating student performance.

The Semi-Automated Flight Evaluation System (Baldwin, Benton, Petriel, & Koonce, 1995) was derived from the BFITS, and can be considered a complementary, aircraft-based system. It is a PC-based, on-aircraft performance evaluation and tutoring system that is intended to be easily installable and removable, incorporating automated performance measurement in the aircraft. Since it consists of off-the-shelf components, it is much more cost-effective than digital flight recorders.

The challenge before the present researchers was to develop an artificial intelligence (AI)-based training simulator with built-in stability augmentation such that the beginning student could successfully operate all three of the helicopter's flight controls, in order to accomplish hovering in the aircraft on the first attempt. Stability augmentation should be variable, capable of providing substantial help to the inexperienced student and much less to the student who has nearly mastered the task of hovering. The amount of stability augmentation should be varied intelligently in response to the level of trainee performance. This should help the trainee by adaptively augmenting control stability only to the degree needed to retain aircraft control. This premise served as the foundation for the development of the AHT. This simulator-based trainer would continuously review trainee performance and adaptively augment control inputs such that the demand characteristics of the simulation would accommodate the student's ability to hover.

The above requirements drove the engineering development of the AHT. Aerospace and electrical engineers at the University of Alabama applied the Optimal Control Model (OCM; Kleinman, Baron, & Levison, 1970), to the design of an adaptive trainer providing inner loop stability augmentation. The rationale behind the OCM, as set forth by Kleinman, et al., assumes that a skilled machine operator manipulates the machine's controls in some identifiable, optimal manner. In the context of helicopter flight, the OCM defines correct performance of a maneuver task by a highly experienced pilot as the minimization of a quadratic performance index, which includes vehicle states, control inputs, operator delays, and external disturbances to the vehicle. OCM identifies the expert and beginner via comparison of their respective quadratic performance indices. This mathematical model periodically compares student performance with expert performance based on the criterion of a highly skilled pilot flying the same maneuver without augmentation. As the trainee's performance approaches the criterion, computer software switches to a lower level of augmentation until the student is flying the unaugmented helicopter aerodynamic model (Krishnakumar, Sawal, Bailey, & Dohme, 1991).

The OCM also supports the design of a stability augmentation system (autohelp) to compensate for errors and overcontrolling inputs by the beginner. Krishnakumar, et al. (1991) developed a family of stability augmentation equations that model 13 levels of autohelp, with level 0 being no autohelp, to level 12, where the simulator is so stable in a hover that extreme control inputs are required to change the state of the virtual aircraft. These levels correspond to varying amounts of inner loop compensation required for the trainee to maintain control of the helicopter simulation as training progresses, and as deviations from the skilled pilot model diminish. The software monitors the quadratic performance indices and "steps" the student from one autohelp level to the next, depending upon whether the root mean square errors are increasing or decreasing.

In simpler terms, as student performance improves, the amount of control "thrashing" diminishes, and smoother control inputs become more frequent. If the student manifests these inputs for a preset time period (e.g., 30 sec), the autohelp steps down to a lower level. Conversely, if inputs become rough and less coordinated, autohelp is stepped up to a higher level. In the AHT, students are introduced to autohelp level 6, and the software then determines their progress in training. To use a mundane example, autohelp is analogous to learning to ride a bicycle with training wheels. At autohelp level 12 the training wheels are firmly on the ground, while at autohelp 0 the training wheels are in full up position.

A controlled experiment was undertaken to evaluate the training effectiveness of the AHT.Army IERW SPs served as research participants, and the experiment was embedded in the IERW course. SPs pretrained in the AHT later performed the same maneuver tasks in a UH-1 aircraft on the flightline. Control SPs trained in the aircraft alone. Flightline IPs and flight examiners were blind to experimental conditions. IPs recorded the number of iterations to proficiency for each task, and whether or not the task was performed within the Flight Training Guide (FTG) standards (U.S. Army Aviation Center, 1994).

Hypotheses

AHT participants should manifest more iterations of a hover task at the FTG standard than controls, while requiring fewer unassisted iterations to attain proficiency. By the same rationale, controls would be expected to generate significantly more iterations *not to standard* than AHT participants. The rationale being proposed is analogous to a standard of marksmanship. The more proficient sharpshooter should require fewer rounds to qualify, when the criterion for success is three consecutive rounds in the bull's eye; the less proficient sharpshooter would have to expend more rounds in order to attain the same result.

Method

The UH-1 Training Research Simulator (TRS)

The TRS, the same simulator used in the four transfer of training (TOT) experiments reported in Stewart, Dohme and Nullmeyer (2002), served as the platform for the AHT. The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) developed the TRS from an existing UH-1 Synthetic Flight Training System (SFTS) instrument simulator. The SFTS is a motion-based, non-visual simulator, which represents the UH-1 helicopter. Three out-the-window displays were added, with 68.58 cm monitors and collimating optics, providing a forward view for both pilot and copilot and a right-side view for the pilot (U.S. helicopters are designed to place the pilot in command in the right seat). One image generator drove the forward visual displays; another controlled the right-side visual display. Besides a visual display system, the TRS had the high fidelity cockpit, hydraulic control loaders, a seat-shaker, and the five degree of freedom motion base of the SFTS. Two image generators (BBN 120 TX/T; Bolt, Baranek & Newman Technologies, Cambridge, MA) were employed for the present experiment. For the entire system, the maximum measured transport delay was 108 milliseconds.

The TRS has been improved in several ways since the above referenced TOT experiments. The NASA UNCLE aerodynamic model (Talbot & Corliss, 1977) was replaced with the NASA ARMCOP model (Mittal & Prasad, 1993). The ARMCOP model employed on the TRS was improved by enhancing its low-speed and in-ground-effect characteristics, through incorporation of data collected in flight on an instrumented UH-1H helicopter.

Conceptually, the AHT accomplishes Primary (visual) phase IERW hover training by using the TRS in place of the UH-1 training helicopter, and the OCM-derived software in place of an experienced IP. The SP is able to hover the UH-1 TRS because the inner control loop augmentation makes it "easy to fly." This augmentation replaces one function of the IP: helping the SP to maintain control of the vehicle.

Participants and Design

U.S. Army IERW officer trainees, (44 men and 2 women, mean age = 24.65 years) were randomly drawn from U.S. Army IERW training classes. Two were African American; the rest were Caucasian. Forty-five were Second Lieutenants and one was a First Lieutenant. Sixteen learned to hover the AHT before training in the UH-1 aircraft; 30 SPs from the same classes served as a comparison (control) group. Flight Aptitude Selection Test (FAST) scores for the two groups (M = 127.45, SD = 11.40, experimental; M = 126.44, SD = 9.13, control) were not significantly different (t (44) < 1.00). All trainees with prior flight experience were eliminated from the sample, and consequently were not selected as either experimental or control participants. The experiment was a simple two-group TOT design, in which TOT was assessed by comparing the hover training performance of the experimental group with that of their nonselected (control) classmates in the UH-1 training helicopter during Primary Phase IERW flight training

Procedure

Experimental participants performed the following maneuver tasks in the TRS/AHT: stationary hover, hover taxi, hovering turns, landing from a hover, and takeoff to a hover. The five hovering maneuvers were trained in the order presented above. In the hover training software program, the simulator initiated stationary hover training by performing an "autotakeoff' by automatically performing a normal takeoff to a .92 m hover. When the simulator reached a skid height above ground of .92-1.5 m, autotakeoff was terminated and control authority given to the student, who began learning the sensorimotor coordination required to perform a stationary hover. The autotakeoff feature was used to initiate training on the first four maneuvers.

The AI logic that created the autohelp function is described by Krishnakumar, et al. (1991). This function, created by the OCM with an internal feedback loop, augmented the SP's control inputs to damp out overcontrolling responses. All participants began at autohelp level 6. The goal for the trainee was to reduce the level of assistance provided by autohelp from 6 to 0, with 0 being the unaugmented UH-1 software aerodynamic model. Performance to criterion was defined as two consecutive minutes at autohelp level 0. It was common for participants in the experiment reaching level 0 to return to level 1 and sometimes even level 2, before finally mastering the control movements required to maintain the autohelp model at level 0.

When the trainee had met the 2 minute criterion on stationary hover, hover taxi, hovering turn, and landing from a hover, the AHT initialized on the ground and the trainee then made the first unassisted takeoff to a hover. When the student met criterion on all maneuver tasks, training was considered completed. A senior IP, graded performance in the AHT on a daily basis. This same IP did not provide instruction to the SPs, either verbally or manually; his role was simply to evaluate performance in the AHT.

Both groups later performed the same maneuver tasks in the UH-1 aircraft as part of the IERW Primary Phase training curriculum. The flightline IPs conducting IERW were blind as to whether SPs had been pretrained in the AHT. A Standardization IP administered the End of Primary Phase Checkride in the aircraft. SPs were evaluated in the aircraft using an evaluation slip mounted on the IP's kneeboard. For each iteration of a maneuver in the aircraft, the IP recorded whether the SP's attempt at the maneuver (1) was assisted by the IP; (2) was unassisted by the IP; and if unassisted (3) was performed to standard; (4) was not performed to standard. The purpose of this experimental evaluation slip was to develop more objective, refined performance measures than the traditional flight grades. The meaning of performance to standard will be explained in more detail in the next section.

Measures of Performance

Recording iterations of a maneuver task. With each daily training session in the aircraft, the Primary Phase IP recorded the number of times each hovering maneuver was demonstrated to the student, each time the student attempted to execute the particular maneuver, and each time the IP assisted the student in its completion. In addition, the IP noted whether or not the SP had completed the maneuver to U.S. Army Aviation FTG standards. Successful completion of each maneuver task was defined as three consecutive iterations within the FTG standard. On an a priori basis, three student performance measures were deemed most important for the present research: the number of unassisted iterations performed by the student to criterion, and the number of iterations (out of the total number of unassisted iterations) which met or did not meet FTG standards for each maneuver task.

Criterion vs. standard. To avoid confusion, the distinction between the terms *standard* and *criterion* should be made clear at this point. Performance to *standard* refers to the performance of a particular maneuver so that formal standards for successfully executing the maneuver are met. For example, the FTG standard for stationary hovering (Task #2004), requires the student to maintain an altitude of .92 m, with variation of + or - .30 m permitted. Heading must be maintained within + or – 10°, and drift of the aircraft above a fixed point on the ground must not exceed .62 m. A student who hovers the aircraft within these limits is said to have performed the task *to standard*. *Criterion* is met when the student performs the task to standard *three consecutive times*. The reader should likewise be aware that the criterion was different in the AHT and the aircraft. In the former, it was two consecutive minutes without autohelp, whereas in the latter, it was three consecutive iterations to FTG standard.

Performance measurement issues. There are some caveats regarding the use of these measures: total unassisted iterations to criterion, and the number of these that meet and fail to meet FTG standards. Once the 3-iteration criterion is met, the student is said to have completed the task. For this reason, large differences could not be expected for this measure, due to a floor effect (i.e., the student could not have fewer that three iterations to standard). Contrariwise, the number of iterations *not to standard* is not limited by a floor effect. A student could produce no iterations that did not meet standard, or a very large number.

Results

Performance in the AHT

All experimental participants successfully learned to hover in the AHT, within the eight training days allowed. Training time with autohelp for the 16 experimental participants ranged from 131 to 197 minutes (M = 165.96 min, SD = 18.59). Training time range without autohelp (i.e., level 0) was 27 to 93 minutes (M = 46.10 min, SD = 21.00). The overall average grade across all five maneuvers was 78.94 (SD = 4.12). The lowest grade was 72, the highest, 86.

Performance in the Aircraft

Flight grades and total training time. Because all hypotheses are unidirectional, and previous TRS research demonstrated overall positive TOT to the aircraft, one-tailed probabilities will be used in all of the comparisons that follow. In much the same way as in previous ARI TOT experiments (Stewart, et al., 2002), it was evident that neither put-up (t (44) < 1.00) nor checkride (t (44) = 1.05, p <. 15, one-tailed) scores distinguished the two groups (put-up scores are the flightline IP's estimates of how the student will perform on the checkride, based on daily flight grades). Even though pretraining in the AHT saved more than one hour training time in the aircraft, this difference was not statistically significant (t (44) = -1.08, p <. 15, one-tailed). Means and standard deviations for these measures are presented in Table 1.

Table 1
Means and Standard Deviations for Checkride and Put-up Grades, and for Total Flight Hours to Proficiency.

Condition	Checkride Grade	Put-up Grade	Total Flight Hours
	Means		
AHT	86.88	87.50	11.46
Control	85.93	86.77	12.75
	Standard Deviations		
AHT	2.50	2.76	3.98
Control	3.08	2.66	3.82

Assisted iterations in the aircraft. Because standard deviations approximated the means for most of the maneuver tasks, and variances were often heterogeneous, the iterations to criterion for the maneuver tasks were compared via a Mann-Whitney U test, (Hays, 1973), which is among the more robust of the nonparametrics. For these results, due to sample size, U can be expressed as an approximation to the normal z distribution. This test will be employed on all comparisons involving iterations of maneuver tasks.

As participants attempted to perform each task in the aircraft, the IP noted whether or not the SP required assistance for the maneuver to be completed safely. It would seem a reasonable expectation that participants pretrained in the AHT would require less assistance from the IP in the aircraft, than would controls. For *assisted* iterations, controls required assistance from the IP on more attempts (M = 32.87 SD = 22.02) than did experimental (AHT) participants (M = 25.69; SD = 20.98). A Mann-Whitney U test performed on the data showed that for total assisted iterations, differences only approached significance (z = -1.50, p <. .07, one-tailed). For individual maneuvers, differences approached statistical significance only for stationary hover (z = -1.58, p <. .06, one-tailed), and takeoff to a hover (z = -1.46, p <. .07, one-tailed). The directionality of differences, though nonsignificant, was consistent with expectations.

Means and standard deviations for this performance measure are shown in Table 2.

Table 2

Means and Standard Deviations for Assisted Iterations Performed in the Aircraft for Five Hovering Maneuver Tasks

Maneuvers	Stationary hover	Hover taxi	Hover turns	Landing from a hover	Takeoff to a hover	Total
Condition						
			Means			
AHT	4.07	4.50	6.31	5.88	4.94	25.69
Control	5.97	5.10	8.13	6.87	6.80	32.87
			Standard Deviations			
AHT	3.75	3.88	6.60	5.15	4.51	20.98
Control	4.52	4.15	5.67	5.47	5.01	22.02

Unassisted Iterations to standard. Unassisted iterations in the aircraft can either meet or not meet the FTG standard for a particular task. The criterion for successful performance of a maneuver was three consecutive iterations to standard. It would be reasonable to expect AHT participants to demonstrate more iterations within standard than control participants. Because of the floor effect on this measure, large differences between groups were not expected. This was borne out when the means for total iterations that met standard, across all maneuvers, were compared: (M = 23.50, SD = 5.38), AHT;(M = 21.00, SD = 5.15), control. This difference was significant (z = 1.71, $p < .05$, one-tailed). For the individual maneuver tasks, the difference was significant only for hover turns (z = 1.76, $p < .04$, one-tailed). Table 3 presents means and standard deviations for the number of iterations, which IPs judged as meeting standard in the aircraft, by treatment condition.

Table 3

Means and Standard Deviations for Unassisted Iterations Performed to Standard in the Aircraft for Five Hovering Maneuver Tasks

Maneuvers	Stationary hover	Hover taxi	Hover turns	Landing from a hover	Takeoff to a hover	Total
Condition						
			Means			
AHT	4.75	4.19	4.69	4.88	5.00	23.50
Control	4.33	4.00	4.07	4.27	4.30	21.00
			Standard Deviations			
AHT	1.57	1.42	1.25	1.89	1.63	5.38
Control	1.75	1.62	1.41	1.39	1.37	5.15

Unassisted iterations not to standard. Table 4 presents means and standard deviations for unassisted iterations not performed to FTG standard. It was expected that those pretrained in the AHT would produce significantly fewer iterations not to standard, compared to control participants. The results, presented in Table 5, confirm the hypothesis. While attempting to perform maneuver tasks, the control group had significantly more iterations not meeting FTG standards than did the experimental group, when summed across all 5 maneuvers ($z = -2.27$,

$p < .01$, one-tailed). Looking at individual tasks, the difference was significant for hover taxi ($z = -2.90$, $p < .002$, one-tailed), stationary hover ($z = -2.21$, $p < .02$, one-tailed), and hover turns ($z = -1.80$, $p < .04$, one-tailed). Figure 1 summarizes the three performance measures graphically.

Table 4
Means and Standard Deviations for Unassisted Iterations Not Performed to Standard in the Aircraft for Five Hovering Maneuver Tasks

Maneuvers	Stationary hover	Hover taxi	Hover turns	Landing from a hover	Takeoff to a hover	Total
Condition						
			Means			
AHT	5.44	5.38	6.69	4.63	5.63	27.69
Control	8.53	9.97	9.93	6.77	7.67	42.83
			Standard Deviations			
AHT	7.82	8.77	10.10	5.43	8.04	39.05
Control	6.90	9.22	9.21	5.78	7.35	34.73

Table 5
Mann-Whitney U test on Unassisted Iterations Not Performed to Standard in the Aircraft as a Function of Pretraining in the Automated Hover Trainer

Test Statistic	Stationary hover	Hover taxi	Hover turns	Landing from a hover	Takeoff to a hover	Total
U	144.50	114.50	162.50	182.00	174.50	141.50
z	-2.21	-2.90	-1.80	-1.34	-1.52	-2.27
p (one-tailed) <	.02	.002	.04	.09	.07	.01

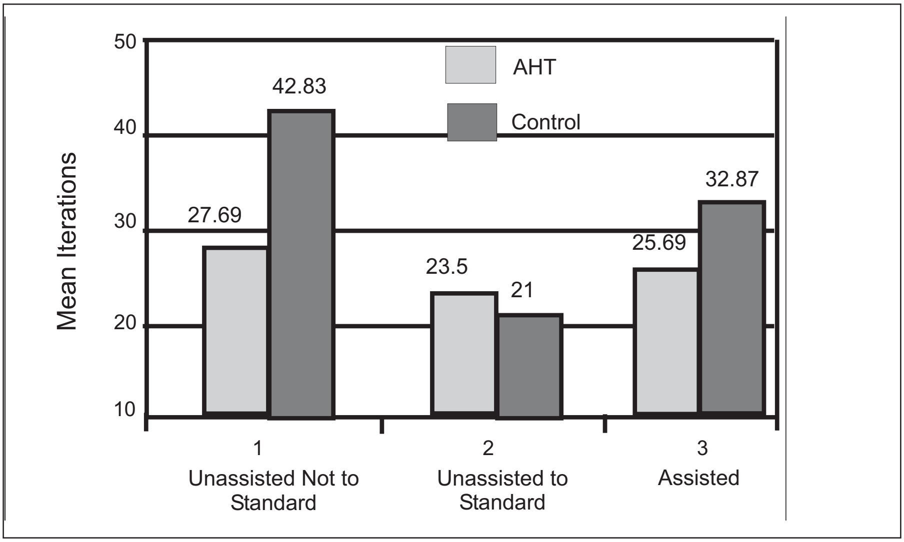

Figure 1. Mean iterations in the aircraft as a function of pretraining in the AHT.

Discussion

Implications of Findings

The AHT represents a prototype AI-based training technology.The results of this experiment were encouraging, in that they demonstrated that training in the AHT did save performance iterations in the aircraft. For the five maneuver tasks practiced in the AHT, there were no instances of negative transfer of training. All differences were in the direction of fewer iterations of all maneuver tasks in the aircraft for the AHT-trained participants than for their control (aircraft-only) counterparts. Experimental participants mastered the tasks more rapidly than controls, manifesting fewer unassisted iterations that did not meet FTG standards. It seems that the AHT had the most impact on hover taxiing, followed by stationary hovering and hovering turns. Takeoff to and landing from a hover only approached statistical significance. One reason for this finding could have been that these three tasks include a more "steady state" hovering component than the latter two, which involve transitioning into and out of a hover state.

One additional finding of this research effort was the refinement and validation of the dependent measures used to assess performance in aviation training. The deficiencies of the use of daily flight grades, flight training hours, and checkride scores as measures of student performance have been previously noted (Stewart, et al., 2002). Unfortunately, these researchers simply counted the number of iterations to proficiency and did not note whether these iterations were or were not assisted by the IP, or whether or not they met or did not meet FTG standards. The present study has demonstrated that this additional analytical effort was worthwhile, in that it provided a more refined picture of student performance, in that differences, though not all significant, were logically consistent and in the expected direction.

From AHT to IFT

The AHT is now called the Intelligent Flight Trainer (IFT) to reflect the expansion of the device's capabilities to include the training of maneuver tasks beyond hovering, and to include traffic pattern flight maneuvers, which also prove difficult to beginning trainees. The addition of traffic pattern flight, which includes a substantial cognitive component, has resulted in development beyond the OCM towards a more knowledge-engineered Intelligent Training Systems (ITS) approach. As before, the OCM autohelp function facilitates the acquisition of piloting skills that would obviate overcontrolling the aircraft, and consequent pilot induced oscillation, which are all too common among new trainees. The ITS function provides guidance, information, and feedback, through a voice synthesizer, to the student during traffic pattern flight training. The voice feedback will instruct the student how to correct errors in various flight parameters. For example, if, during simulated takeoff, the synthetic aircraft is not trimmed to within + or – 10° of the runway heading, below an altitude of 15.38 m, the IFT will first tell the student: "check heading." If the student continues to deviate, he or she will be instructed to turn left or right for a specified number of degrees. Finally, if the student is still off the assigned heading after the passage of a preset time interval, the IFT will instruct the student to apply left or right pedal. If the third message does not bring the student back into proper parameters, the IFT will automatically reset to the beginning of the training phase, and the lesson will have to be repeated. The interaction between student and the ITS function, then, consists of three phases: (1) performance control activity monitoring, by which it is determined that the student has exceeded a parameter; (2) diagnostics, where action(s) required to correct the error are identified; (3) advisement, by which the student is given progressively specific instructions on how to correct the error

The platform is no longer the SFTS, but a PC-based, non-motion simulator which represents the TH-67 training helicopter, the successor to the UH-1. The simulator, built from the salvaged cockpit of an OH-58D, has a "glass" instrument panel and collimated optics for the pilot's front and side-view window CRT displays. These visual displays are not replicated on the left (copilot's) side, since the IFT is designed for automated training, not requiring an IP.The goal is to develop an AI-based TH-67 trainer in which the entire Primary Phase IERW syllabus can be trained. Its most effective application should be as a pretrainer, in which SPs will train to FTG standards on the Primary Phase maneuvers, prior to transitioning to the aircraft. Engineering and research evaluation of the IFT will continue during its development, to determine its most effective integration into the IERW curriculum.

Application to IERW Training Program Development

All participants in this study successfully completed IERW training, but those pretrained in the AHT required fewer attempts to master training in the five target maneuvers in the UH-1 aircraft, and were more likely to show proficiency at these tasks from the outset. The present research should have external validity in that the participants were Army IERW SPs. This experiment, along with Stewart, et al., (2002) demonstrated that expanding the use of simulation beyond the instrument phase of IERW could derive further benefits. However, the current Army IERW primary training curriculum remains a lockstep, hourly-based program that is not optimized for the use of simulation.

Hence, the present findings may be a somewhat conservative estimate of what could be attained by a simulation-based program augmented by a low-cost, AI-based adaptive training system. For this reason, it would be informative to develop a training curriculum specifically tailored to the use of these two technologies. On the average, criterion-based hovering performance on five fundamental flight maneuvers was achieved in the AHT in slightly more than 3.5 hours, and in less than 12 hours in the aircraft. This may not strike the reader as indicating highly efficient use of adaptive, simulator-augmented training. However, one must be aware that this research was conducted in a training environment that was not optimized for the use of simulation, since simulation is currently not employed at all in IERW primary (visual) flight training. Training time in the AHT had to be limited, due to class scheduling and other administrative concerns. Though a cost-benefits analysis is beyond the scope of this study, one must also keep in mind that the AHT did not require an IP for the administration of training, and that its successor, the IFT, is a simple, PC-hosted trainer costing far less to operate than any training helicopter. Still, the ultimate efficiency of institutional simulation-based IERW training remains to be demonstrated. This awaits the development of a simulation-focused (i.e., proficiency-based) curriculum for IERW training.

For these reasons, it would have been difficult to conduct the same research in the context of the current hourly-based Army Aviation syllabus. If future training programs are developed which rely heavily upon the use of simulation, they will be successful only insofar as the institutional training culture also changes. This will require major change and readjustment of an organizational culture based on the notion of the flight training class, daily training hours, and daily flight grades. Programs will have to be developed that center around the use of simulation, and more objective criteria for performance adopted.

Stewart, Dohme, and Nullmeyer, (1999), in a review of the Army IERW training program, concluded that flight grades and checkride scores are unsatisfactory criteria for assessing SP or program performance. In the IERW course, the daily training grade is a letter (A, B, C, or U) while put-up and checkride scores are numerically based on a 100-pt scale, with a minimum passing score of 70. The modal daily flight grade is a B. If an A or C is given, the IP must justify the grade in writing. Thus, the grade B is parsimonious with regard to the IP's time; there is little incentive to give more or less. For these reasons, past research efforts have shown that there is too little variance in these institutional performance measures, to make them effective criterion measures or predictors of future performance. Bale, Rickus, and Ambler (1973) followed up Naval aviators after graduation from flight training. They found that grades in flight school did not predict later operational performance. They concluded that training grades did not assess all of the mission-oriented aviator skills critical to determining success in the field.

This makes the evaluation of new instructional systems and strategies moot, in that effective institutional benchmark criteria do not exist. Likewise, the training performance measurement technology has consistently lagged behind the rapid evolution of training device technology (Salas, Bowers, & Rhodenizer, 1998). A state-of-the-art simulator's effectiveness will remain a mystery, as long as it is employed in a lockstep training program, employing the same outdated institutional criteria to assess performance. In brief, new simulators are frequently integrated into old training programs. Simulation technology has been evolving at a rapid pace; it is now time for the training technology to adapt to meet these challenges.

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Practices of High-time Instructors in Part 61 Environments

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Abstract

As Technically Advanced Aircraft (TAA) become more prevalent, pilot tasks in turn become more automated. Examples are the Cirrus and Diamond aircraft that feature glass cockpits, advanced autopilots, and very inclusive databases. As pilot tasks become more automated, more attention has been given to Aeronautical Decision Making (ADM), since good judgment appears to be even more strongly related to use of advanced systems. Much attention is now being paid to "scenario training" which is said to be more realistic and to foster better ADM. However, there is a great deal of discussion of what a "scenario" should contain and what are the convictions about training it should reflect.

This survey investigated some background information connected with the development of scenario training models, which more strongly address ADM, particularly the Federal Aviation Administration (FAA) Industry Training Standards (FITS). That is, *are there* individuals whose methods more strongly address ADM now giving flight instruction? If so, what are their attitudes and methods connected with this task?

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This study surveyed extremely experienced flight instructors (from 3000 to 16,000 hours of dual given) to identify any information, training methods, or practices, which are over and above the FAA requirements or perhaps even in violation of FAA requirements. Extensive interviews elicited the attitudes which motivated their training methods and which illuminated their day-to-day interactions with flight students.

The findings indicated that high levels of experience in flight training (many in excess of 10,000 hours of dual given) usually result in a strong move away from maneuver-based training as mandated by the FAA and a strong move toward scenario-based training. In fact, it may be said that the subjects of this study are among the original scenario-based instructors. This is reflected in the performance and safety records of their former students and provides new information to assist the current national discussion of what forms flight training should take in the future.

Introduction

Scenario training is a recent catchword. It is associated with the FAA Industry Training Standards (FITS) program as well as transition training for professional pilots who are entering the world of Part 121. This led the researcher to wonder if there was anyone in the industry who had a history of scenario training.

The vast majority of flight instructors identified in this study are young people who regard instruction as an hour of indentured servitude. Most of these youngsters have between 300 and 1000 total hours, of which a large proportion has been spent in light trainers in dual instruction. Those who work full time for Part 141 schools have a more predictable experience, in that they have a certain measure of job security and a predictable, if small, income. On the other hand, they are also the most scrutinized and regimented. Since the chief instructor in such schools is required to *personally* ascertain that anything to which the instructors are signing off really occurred and the specifics of the approved curriculum, Part 141 instructors are not encouraged to innovate – quite the opposite, in fact. Most of them lack the experience to know what to change in any event. In this regard, they are more like apprentices than indentured servants, in that they do receive some degree of supervision and feedback on their performances from a chief pilot, who is presumably a master.

Part 61 flight training programs, on the other hand, are much more reflective of an honor system. Instructors come from many backgrounds, sometimes working for personal enjoyment as much as pay.The general survey connected with this interview study indicated that most are part-time employees or sub-contractors who show up at odd hours and make use of whatever training facilities the fixed-base operator (FBO) or school offers. There is often not much supervision. In the end, the instructor signs off on the student's ability to perform the maneuvers and pass the oral exam, and the student either passes or not. Nearly all of the "old pros" are found here, flying on sunny days at county airports or in the evenings with instrument students. Our survey showed that, though these individuals are empowered to train students for the commercial and certified flight instructor (CFI) license, in four states the great majority of their time is spent in private and instrument work. These Part 61 schools, with their entire cadre of instructors, from young to old, turn out the great majority of pilots in the U.S. who are not industry bound. That is to say, their natural customer is the person who wishes to own and operate a personal plane.

If there is any latitude for highly experienced instructors unofficially to modify the training system to better reflect the reality of solitary, cross-country flying in many weathers, it is in the Part 61 programs. Yet, they are certainly not encouraged to do so. The FAA, for obvious reasons, wants a uniform training process that can be evaluated for rigor and where candidates can be tested in concrete terms. However, it may be possible that experienced instructors do add, modify, or complement the FAA mandated training process for reasons of their own. To find out to what extent this is true, this study investigated the practices of very experienced flight instructors.

The General Research Question

The general research question was:

How much variance is there in instruction in Part 61 schools? Do experienced flight instructors, who have had many students and much time to reflect on the training process, modify, add to, or complement the training process mandated by the FAA? If so, how? To what degree? In addition, to what extent do they engage in instructional practices that are discouraged or forbidden by the FAA?

Subjects

Subjects were identified by cold calling FBOs and Part 61 flight schools in a four state area (Tennessee, West Virginia, Virginia, and North Carolina). These were identified through the states' aviation bureaus. These contiguous states were selected because they boast many, vigorously operated FBOs and Part 61 flight schools, more so than a number of other areas of the U.S. Every airport not in airspace classified as C or B in each state was contacted.

FBO and school managers were asked if they employed flight instructors who had in excess of 3000 hours of dual instruction given. These individuals were contacted and asked to participate in a telephone interview study. Permissions that reflected informed consent were obtained prior to interviews.

Methodology

Subjects responded to a general set of interview questions. The intent was to influence subjects to share their reflections about flight instruction and to reveal any non-standard practices they might employ. Eliciting questions were employed in an attempt to keep subjects talking and verbalizing the life lessons they have learned in many hours of dual instruction given (Spradley, 1979). Interviews were subjected to an item analysis to identify common themes and summarize those themes. To the extent the data warranted, conclusions in reference to the culture of flight instruction as it relates to expert performance were drawn (Cortazzi, 1993). This is a naturalistic study, using qualitative data analysis. No claim is made for traditional external validity, nor are the subjects' experiences represented as exemplifying a greater whole. The small number of subjects indicated that they are a minority sub-set of instruction in general, and their views presented as a means to gain insight into one view of how instruction should proceed.

The General Question Asked Was: What Do You As A CFI Do That Is Over And Above The Minimum Required By The FAA?

The interviewer then continued to ask probing questions to illuminate the general question.

Subjects

A total of 266 airports were contacted. Each contact person was asked if flight training was conducted on the field. When answers were affirmative, the researcher introduced himself, briefly explained his purpose, and asked if any instructors who fit the parameters worked at the field. Twenty-six suitable individuals were identified. Fourteen participated; two declined for unspecified reasons; and two accused the researcher of engaging in an FAA inspired sting operation to entrap them. The remaining eight were involved in either corporate or Part 135 flying and did not consider themselves current instructors. These were the only individuals who met the dual-instruction-given criterion out of several hundred instructors surveyed from all the FBOs and Part 61 flight schools in the four states. This confirmed the notion stated earlier that most flight instructors tend to be young and relatively low in total time.

The basic criterion for selection was having given more than 3000 hours of dual instruction. This number was selected because it tends to eliminate most instructors who are airline or corporate bound. Instructing, as previously stated, acts as an unofficial apprenticeship for many neophytes who hope to fly turbine airplanes for a living. Most of these instructors have about 250 hours total time when they begin instructing and go on to higher paying jobs before accumulating less than 2000 hours of dual instruction given. Those remaining in the job tend to be instructors who might spend thousands of hours instructing. When asked, most of those in this study indicated that they instruct part-time for the pleasure of it, and a few others instruct as part of their duties as airport or FBO managers, Part 135 pilots, or mechanics.

The average age was 42 and the hourly experiences are listed in Table 1. It might be added that all but one of them have flown multiple types of single, twin, and small turbine aircraft. All of them were multi-engine instrument instructors, the most complex sort of instructor rating. None of these instructors has ever had a candidate for a private license fail the first checkride. All of them were, therefore, either Gold Seal or eligible to be Gold Seal instructors, in that they exceeded the requirement that 80% of candidates pass the first ride. Only three of them actually held the Gold Seal, however.The others were indifferent to it as an honor and had never applied for the distinction.

Table 1
Instructors' Hourly Experiences

Instructor	Total Time	Dual Given
1	18,000	9,000
2	3,200	3,000
3	3,700	3,000
4	6,000	4,000
5	20,000	5,000
6	17,000	16,000
7	25,000	5,000
8	12,000	8,000
9	3,200	3,000
10	3,200	3,000
11	4,000	3,200
12	25,000	3,000
13	3,700	3,000
14	10,000	8,000

As may be seen from the above table, the subjects ranged from 3,200 hours total time to 25,000. Instruction time ranged from 3000 to 16,000. Another factor held in common was that none of them admitted to being airline or corporate turbine bound for employment. While this is not to say that it could never happen, none of them saw "the industry" as a career path. All of them saw flight instruction as a desirable activity in and of itself, not as a stepping stone to another, more attractive outcome.

Findings

There was no attempt to conduct a quantitative analysis and numbers were employed for comparison only. However, a qualitative examination proved instructive. A simple item analysis of these interviews revealed fifteen areas that recurred in interviews.

Characterizations. A few characterizations that subsume all fourteen interviewees were made.

1. None of these individuals gave much thought to the checkride. All expressed concern repeatedly about safety. Only one of these men had ever lost a student or a former student to an accident. That exception was a student who directly disobeyed the instructor and violated a number of Federal Aviation Regulations (FARs) in the process. The emphasis was on being a proficient pilot, not meeting minimums, or passing checkrides. Acceptable to these instructors was universally defined as safety and good decision-making. All but one required full stop landings on grass strips, usually following a simulated engine failure. As one commented, "How can you expect a student to fly to save his life if he can't land short and slow in a real cornfield? I land'em on grass up hill and down. And

over the trees." All the instructors used recurring failure scenarios as a part of training. They failed avionics, instruments, systems, circuit breakers, and themselves. One instructor said, "In all these years, I've seen about every emergency there is. I teach'em all."

2. All were contemptuous of pilots who could not control an airplane to near the edge of the flight envelope. Every instructor taught full stalls and slowflight well beyond the FAA requirements. All but one allowed students to do at least one-half turn into a spin via full stalls in steeply banked flight and recover. All required students to land within the first 500 feet of the airstrip and all but two required students to be fully competent on short or rough fields. During the interviews, the instructors repeatedly reported failing active pilots on Flight Reviews and their disdain for pilots who were fearful of what the plane could do. As one said, "If you can't drive the airplane to the edge and control it, how can you make it do what you want? If you can't, you are a snap-spin accident waiting to happen 'cause you don't know what you can do and what you can't." Other examples included slowing the plane down to less than 55 mph and doing full control deflections and doing repeated deep stalls followed by full rudder deflection into a spin with recovery after one-half turn. All but one did full stalls from steep bank angles into half turn spins, both power on and off. These instructors did these maneuvers with their students repeatedly until each student mastered them.

3. All were unwilling to limit training scenarios and exercises any more than absolutely necessary. They drove planes to full stall, into spins, to full stop landings on grass strips when practicing emergencies, and flew their students into actual IFR (instrument flight rules). They flew in crosswinds and haze. As one said, "If my student can't handle the full demonstrated crosswind component, what do I say to him when he wants to come out here and rent my airplane? It's too windy?" Another said, "We get haze here that gives us less than three miles and no horizon on days when there isn't a cloud in the sky. I can't have students who can't handle actual IFR." One said, "How the ... are you supposed to learn something from an engine out sim that terminates 500 feet above the ground, like the FAA says? I make'em land!"

4. These men included their students into their flying lives. They made repeated reference to taking students on Part 135 trips, waiting for students to be available before fixing some problem on the plane, and giving free time on the ground to talk about decision-making, growth as a pilot, and personal problems. One said, "I give students a lot of my free time. I do informal seminars with them; there has to be time to talk about this stuff. They all have problems that have to be delved into, and they answer each other's questions and cheer each other up. I make them try and understand the airplane, what it will do. I let them help me fix the planes; sometimes I put a repair off until a student can be here. We talk a lot about how to fly outside the regular envelope, what to do when things get hairy. You know, a lot of instructors have never even flown more than two or three types of airplane. What can they find to talk about?"

5. All the instructors required considerably more than the minimum in cross-country training. This skill subsumes a number of sub-skills and requires considerable integration. It is not only possible, but also common to receive a private license with less than 10 hours solo cross-country experience, but *not* if you are the student of one of the subject instructors. Moreover, all the instructors required considerably more than the required three hours of flying in IMC (instrument meteorological conditions). Eleven out of fourteen instructors required flying in actual IFR conditions on route. A number of them commented on how easy it is to defeat a "hood" and on what a shock it can be the first time a pilot encounters a real cloud. Several instructors required slow flight, steep turns, stalls, and extreme unusual attitudes, including full stalls from steep banks while wearing a vision-limiting device. Some of this exceeds even the standards for IFR rating. It was represented as survival training repeatedly in interviews.

Categories that Characterize the Masters Group. Eight categories emerged from the data analysis that characterized the highest time group and were poorly represented in the group that had less than 5000 hours dual instruction given.

1. Emphasis on stable approaches. Higher timers placed considerable value on the ability to fly the pattern and conduct stable approaches in any conditions. They required the ability to cope with turbulence, crosswinds, runway length, obstructions, or up or down slope. The lower timers, by contrast, tended not to require extended practice in unusual conditions, doing most of the training in conditions that were more docile and without added stress to the student. It was sensed from the comments of the lower time instructors that they had a greater reluctance to offend or discourage students by going to the limits, which the more experienced instructors did not share. The lower timers were somewhat more concerned about student retention, while the higher timers were more concerned with student survival in situations, which they considered more inevitable than the journeymen.

2. The high-timers were vehement in reference to dead reckoning and pilotage. They had no faith in avionics and assured their students how much they would need chart and stopwatch skills in the future. One said, "I had two Students in the Aztec and the alternator and the whole board died coming back from Charleston. I had the stopwatch running, and I knew the winds and I let down slap over the airport. I didn't have so much trouble convincing the students after word got around." Another said, "Everybody has a GPS and I do too but what happens when the thing breaks? And it will. You need to find your way home with a chart and your brains." Yet another said, "I turn off the GPS to start with. Then I fail the VOR and the ADF one at a time. I make them use pilotage and I make them read water towers if that is what it takes. I don't want them to ever run out of things to try." A distrust of avionics in these comments was not sensed, but more a distrust of things going as planned in general.

3. The high-timers believed in slowflight skills that far exceed anything a candidate is likely to encounter on a checkride. Students were commonly expected to slow down to the very edge of controllability and then execute any

combination of climbs, descents, and turns, particularly steep turns. This is seen as the underlying skill necessary for stable approaches, emergency landings, short field landings, partial power situations, and a number of other scenarios. One said, "A lot of students get hurt on rejected landings and go arounds. "

4. The high-timers emphasized emergency training and emergency mental preparedness more than the lower time instructors. They assumed that flying would include emergencies of various types, electrical, weather, fire, partial power, and others that are not addressed by the Practical Test Standards (PTS). As a result, they trained for these emergencies more than for the traditional engine out at altitude or in the pattern, though they trained for those extensively as well. This was seen by the high-timers as equally a mental process as much as a set of procedures. One said, "Emergency procedures are a good example. I teach this very differently from how the FAA wants. We do 1.5 hours in the classroom for every twenty minutes in the plane. We have three sessions like that minimum, maybe more depending on the student.... The greatest gift I give a student is emergency procedures."

5. The high-timers included spin training. Eight simply trained spins the traditional way for entry and recovery and then used that as the basis for recovery from unintentional spins from approach turns, steep turns, partial power departures, and the like. Another two skated on the edge of the FAA requirements by allowing spin entry and recovery at half a turn predicated on the notion that this constitutes "spin awareness." Most instructors made clear their disillusionment with "spin awareness" as it is promulgated by the FAA. One FBO operator and high-time CFI said, "I ask you... how can a person do one turn left and one turn right and get to be a CFI. You can't teach spin awareness about something you can't do yourself. I make applicants here show me three turns with a precision recovery before I will hire them." Another said, "We spin them all...I spin everybody and make them recover until they are comfortable about getting it back. Then we do spin awareness. There is no point in doing spin awareness until they can spin and aren't terrified."

6. As an outcome of some of the above factors, (stable approaches, good slowflight skills, grass field skills, and good emergency procedures) all the high-timers required students to become competent at short runways. They were contemptuous of pilots who were afraid of or prohibited from landing on a short, paved, public use airport as is common in Part 141 programs. They saw the ability to land slow and short as a basic skill of flying. One said, "The local 141 school won't go into little airports. Their students aren't even allowed to land here.... We see people all the time who bounce and porpoise because they won't slow down. People are afraid of the flare.... You have to arrive at the right speed or you can't get down on this airport."

7. The high-timers emphasized weather flying. They required many more weather briefings to be obtained by the students than are strictly required, and they flew the students into all kinds of weather, IFR, haze, wind, turbulence, and

so on as often as possible. One said, "We set them a scenario of a snake bite victim who will die if they don't go in for rescue. We make them go into marginal weather and make the decisions necessary. Sometimes, the right decision is ultimately mission failure. We teach that the first life you save is your own, mission notwithstanding." And again…."We don't want students who have less than a lot of hours to feel comfortable about the weather. We make them fly in bad weather with an instructor, the more marginal the better. We want them to respect the weather and know when to be actually afraid."

8. The high-timers addressed decision-making and airmanship as the two most critical skills in flying. All of them addressed decision-making and situational awareness directly and often in a variety of ways, from emergency planning, to weather, to wherever it led. An instructor said, "We make decision making part of everything. On the first supervised cross-country, we pretend I have a kidney stone and I make them divert to the closest and actually land there. They have to find it on a chart and navigate there and figure out how to land and talk on the radio and the whole thing. I don't say a word. I'm sick, ha ha." Another said, "We teach them that they will be *alone*! I save and hand out articles about people who made the wrong decision and flew into something they couldn't handle. I want our students to realize that this [flying] isn't really dangerous but that it kills those who don't think. We build judgment from the git go."

Categories that Characterize Instructors with Less than 5000 Hours Dual Given. The two categories that represent this instructor sub-set are curious.

1. These instructors generally have a much higher approval of the FAA. An instructor with 3000 hours dual given said, "I get along with the FAA. The guy who inspects us does a good job and seems to know his stuff. I think people get intimidated." More experienced instructors did not share this belief. In fact, there was a strong negative correlation between flight time and trust of the FAA. Most of the higher time pilots expressed lack of faith with the activities of the FAA with which they were familiar.

2. Instructors with less than 5000 hours dual given felt strongly that students need first hand, supervised experience with classified airspace, particularly Classes C and B. While this requirement of the PTS was addressed by all the instructors, only the lower timers devoted extra instruction to this task. They perceived greater dangers in operating in crowed airspace than did the high-timers and expressed a concern that their students would violate the regulations or get hurt if this issue was not given extra attention.

Conclusions

Part 141 and large corporate-driven Part 61 programs tend to be staffed by comparative youngsters and to be somewhat PTS- and checkride-oriented. In general, these schools are comparatively large, concerned with student retention, and tend to hire their own graduates as instructors. There can be a strong flavor of "teaching to the test." However, if these fourteen experienced instructors were any indication, by the time a CFI reaches 3000 hours of dual given, he or she may become considerably more self-directed than less experienced counterparts.

There is some disagreement about how many hours nationally the average private student has accumulated when he or she takes the checkride, but it is probably about 50. (NOTE: On inquiry the neither the Aircraft Owners and Pilots Association (AOPA) nor the FAA could state a number based on data. The general impression stated by personnel in both organizations was about 50). The instructors in this inquiry averaged 61. A number of them commented that they could not in good conscience sign off a student with less. The figure of 61 was determined by each instructor examining and averaging the number of hours of their past several students. Then the fourteen responses were averaged.

It appeared that experience with both flying in general, and instruction in particular, leads CFIs to begin an on-going period of expansion of the minimum necessary to sign off a student to test for the credential. It also appeared that these instructors were in substantial disagreement with the FAA as to what the minimum set of sub-skills and skills ought to be. Their solutions have been quietly to include a variety of additional skills and sub-skills in what they personally required. Some of these obviously are desirable as examples of going above and beyond. Others were discouraged by the FAA or even prohibited. These included the considerably more intense emergency training, the grass strip training, the more realistic cross-country training, the spin experience, the much more extensive stall and slowflight experience, the marginal weather experience, the IFR experience, the fairly extreme unusual attitude recoveries, and the much more realistic training in reference to landing in crosswinds, on short fields, and in turbulence.

In general, all the differences between the subjects of this study and their less experienced colleagues appeared able to be subsumed by what might be called "realistic training," which lately has come to be called "scenario training." For these very experienced and confident instructors, if a part of training is to be useful, it must be highly applicable to the reality of single pilot performance. Moreover, these instructors made the integration of individual sub-skills into overall skills a daily part of learning to fly. It would be easy to infer that they are the original "scenario" instructors and that they quietly have perceived and had the impetus to implement what is only now becoming popular in the industry at large.

The initial set of general questions connected with this study asked what changes (if any) were made and to what extent. The last question addressed how the instructor "got away with it." In answer, it appeared that the more dual instruction time these CFIs had, they more they tended to avoid the FAA. This was accomplished simply by becoming as invisible as possible. Most of the masters did not attend the FAA sponsored safety seminars and the like, and they did nothing else to attract attention to themselves. None of them reported any contact with the FAA at all except via CFI renewals, Part 135 inspections, and other unavoidable occasions. However, they reported garnering credibility with the FAA by their students having a 100% passage rate on first checkrides. In the end, a CFI with five or ten thousand hours of dual given quietly spinning the students in the vicinity of an obscure county airport is unlikely to attract the FAA's attention or anyone else's, unless someone complains. Considering the level of personal attention that the students of these instructors apparently receive, the likelihood of someone complaining is diminished.

In 2000, there were 672 fatalities among GA pilots (AOPA Air Safety Foundation, 2001). Given the normal turnover in typical flight training, these fatalities probably were the students and former students of more than 1500 instructors. This number of fatalities is about the norm for the last six or seven years. Therefore, in the last six years, about 9,000 instructors have lost a student or former student. The instructors in this study of fourteen individuals represent a total of 76,200 hours of dual given. Out of these, one student or former student has been lost in a twenty-five year period to accident and this individual directly disobeyed the instructions of his instructor to stay on the ground. This hardly represents a numerical analysis, but it does give a flavor for the quality of training that the students of these instructors receive.

Overall Conclusions

Any complicated system is a result of people's intentions and history. While the purpose of this paper was hardly to review the history of flight instruction, it is necessary to cite a few influences. The intention of flight instruction, of course, is to provide a pathway for interested people to become competent, safe pilots. The outcome to this time in the U.S. has been very favorable. The airline industry is being provided with a steady stream of acceptable neophytes, primarily via the Part 141 system, and Part 61 training for everybody else has been commonly available. Taken over a period of decades, it appears that considerable improvements have been made in safety. For instance, between 1974 and 1999, GA fatalities per 100,000 hours declined by more than 50% (AOPA Air Safety Foundation, 2001). The present system, whatever its merits and warts, produces a set of outcomes to which we have become accustomed and regard as reality. Whether the rate of fatalities and the dropout rate for beginning students are actually acceptable is a subject for another paper.

However, if one considers only single or light twin engine, personally owned and flown aircraft, the figures are less encouraging. In the glory days of single engine production (the early 1960s), Cessna alone produced over 3000 airplanes a year, and the most complex aircraft they produced was the piston twin 310. In 2001, Cessna's total single engine production was 244. In the same year, Beech produced 12 singles. Piper produced 34. In other words, the number of single engine aircraft leaving the system each year – 1050 crashes alone – due to accident, wear-out, and other reasons exceeds the number entering by several multiples (AOPA Air Safety Foundation, 2001). The slack is taken up by turbine airplanes, few of which are personally owned. These turbines are flown by professional pilots, for the most part, and maintained to airline standards; yet, these aircraft are classified as "general aviation." It is hardly surprising; therefore, that overall GA safety is improving, when professionally flown and maintained turbine aircraft increasingly characterize what is called "GA." The confirmation for this view comes from the Nall Report (AOPA Air Safety Foundation, 2001). It indicates that while single engine, piston, personally operated flights accounted for less than 12% (source, NBAA) of the flights, they accounted for 67% of the GA accidents. In other words, while GA safety has marked steadily improving safety figures, it cannot be said definitively that personal flying is any less dangerous than it has ever been. In short, flying single and light twin engine, personally owned and operated aircraft still carries significant risks, despite improved technology, airspace, and avionics.

Many are pinning new hopes on improved technology, particularly "glass cockpits," to change this. However, the history of technological change does not reflect this view.The invention of IFR instruments in the 1920s and 30s, for example, did not lead to improved safety, rather the opposite as the flights attempted became more complex. In fact, better technology for light aircraft has usually resulted in more complex and risky missions. What seems to be indicated is the need for a new way to train pilots, one that better prepares them for the complexities of modern airspace and cross-country flight than the "maneuvers" based system, which we inherited, from the Army Air Corps of the late 1930s.

One new means to conduct training is the so-called "scenario-based" curriculum now being tested at a number of universities, including Embry Riddle Aeronautical University, the University of North Dakota, and Middle Tennessee State University. In addition, the FAA is committing resources to scenario-based training as a part of the FITS program, which is reflected to some degree in newly released IFR Practical Test Standards. It will be interesting to see to what extent a more modern and learner-centered syllabus, curriculum, scope, and sequence will result in improvements to single pilot performance and safety.It will be even more interesting to see to what extent the "new, improved" national training system will resemble the system that has been in use for many years by these high-time instructors at obscure, county airports.

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Psychological Strain Mediates the Impact of Safety Climate on Maintenance Errors

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Abstract

Maintenance errors are known to be a key cause of aviation mishaps and the search for their causes is now given high priority in the aviation industry. In parallel with the search for causes, research efforts are focusing also on the ways in which various background factors link together to influence safety outcomes. The present study set out to validate a structural model wherein psychological strain is depicted as a major contributor to maintenance errors through the direct influence of strain on maintenance errors and also via its role as a mediator of the effects of safety climate on errors. The Maintenance Environment Survey (MES) was administered to 150 personnel responsible for maintenance of a large military helicopter fleet (Fogarty, 2004). Structural equation modelling then was used to test the fit of the mediation model. The findings supported claims that the effect of safety climate on errors is at least partially mediated by individual level factors, such as psychological strain. In our efforts to secure better safety outcomes, we therefore should maintain a dual focus on organisational and individual level variables. Regular administration of safety climate and psychological health surveys can help to achieve this aim.

Introduction

The growing literature on safety climate and the proliferation of instruments designed to measure safety climate (Wiegmann, von Thaden, Mitchell, Sharma, & Zhang, 2003) pointed to the importance of organisational variables as background causes of error. The various error taxonomies used throughout the

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aviation industry (Shappell & Wiegmann, 1997) emphasised the role of organisational as well as individual variables. From a more general perspective, following Reason's (1990) seminal publication on the bases of human error, descriptive models of accident causation suggested that individuals err because of latent organisational pathogens that create conditions wherein human weaknesses are exposed unnecessarily. Within the context of human error, it is now generally acknowledged that it is the interaction of organisational and individual variables that lead to error.

Having reached this point, researchers must turn their attention to teasing out the nature of this interaction. Structural equation modelling (SEM), a technique that combines factor analysis with regression analysis, is well-suited to this purpose because of its ability to accommodate both organisational climate and individual differences approaches. The present study employed SEM to cross-validate a structural model that depicts organisational factors as impacting on psychological health, which in turn impacts on maintenance errors (Fogarty, 2004). The rationale for the model is spelled out in the earlier publication. What follows, is a brief summary of the relevant literature and a description of the parts of the model that are to be tested in the present study.

Most safety climate studies have relied on regression techniques and bivariate correlations to demonstrate the existence of a relationship between safety climate and safety performance without attempting to explain the bases of the observed correlations. However, a small group of studies outside the aviation domain have used path analysis or SEM to address this issue. Two of these studies are of particular interest in the context of the present validation study. In the first of these, Tomás, Melia, and Oliver (1999) employed path analysis to examine the effect of safety climate on accidents. Contrary to their expectations, safety climate did not have a direct effect on workers' safety behaviour. Instead, organisational variables influenced group processes (supervisors' and co-workers' safety response), "which in turn influenced workers' safety attitudes and behaviours, usually reported as the 'main' direct cause of accidents" (p.57).

In a second study, Oliver, Cheyne, Tomás, and Cox (2002) collected data from a wide range of industrial sectors in the Valencia region of Spain, using structured interviews and employed SEM to test models depicting the influence of organisational and individual variables on accidents. They found that individual level variables, including safe behaviour and general health, mediated the indirect effects of the organisational variables. Stress, in particular, was an important mediator of both organisational and environmental variables.

Working within an aviation maintenance context, Fogarty (2004) found support for a structural model that showed organisational factors influencing individual factors such as psychological health and morale, which in turn had an impact on self-reported workplace errors and job turnover intentions. Specifically, organisational factors accounted for 67% of the variance in a construct called Morale and 44% of the variance in a construct called (psychological) Health. The organisational variables did not have a direct effect on Errors or Job Intentions, but they did have a significant indirect effect through Morale and Health. Morale, Fatigue, and Health, between them, accounted for 45% of self-reported maintenance errors and 27% of turnover intentions. The Fogarty (2004) study therefore supported the findings of these other researchers and demonstrated the relevance of the findings to the aviation industry. However, because the data were cross-sectional in nature and drawn from a single sample, it is important that the structural model developed by Fogarty be cross-validated. If it can be established that the primary influence of organisational variables is on the psychological health of the individual worker, rather than on errors per se, and if it can be established that individual factors have a direct link with errors, then we will have a better idea of the likely efficacy of interventions directed at different parts of the error chain. The primary purpose of the present study was to attempt this cross validation.

To provide the full context for the present study, the Fogarty (2004) model is reproduced in Figure 1.

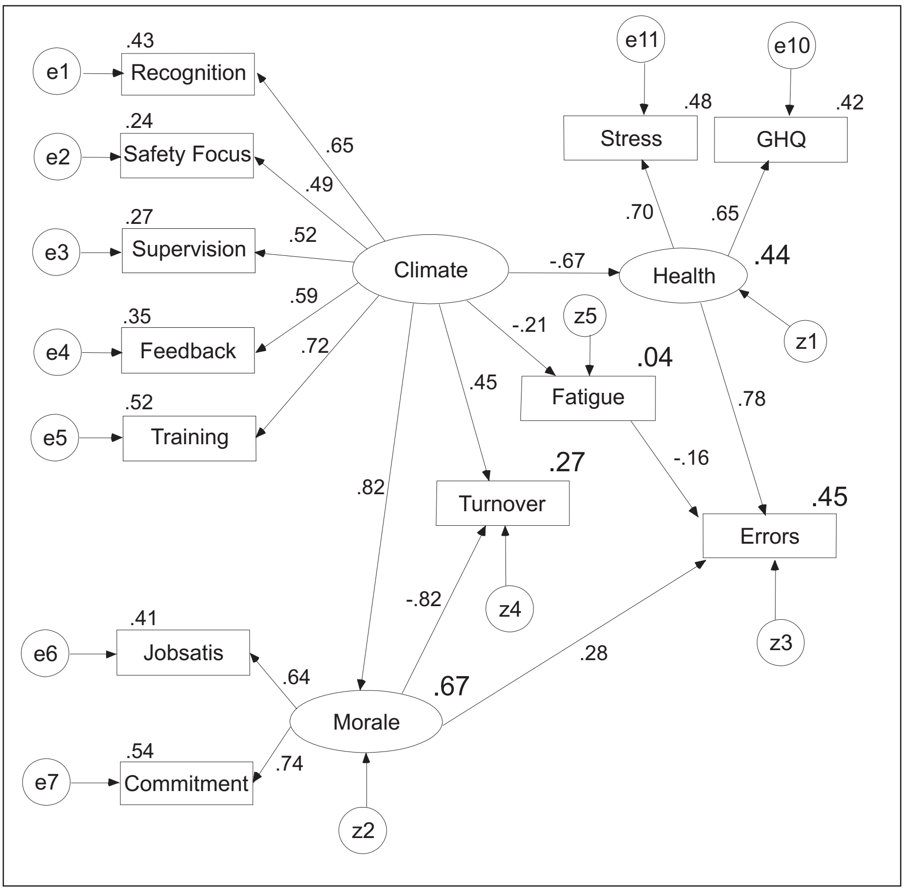

Figure 1. Fogarty's (2004) model depicting interactions among Climate, Morale, Health, Fatigue, Turnover, and Errors

For the purposes of the present study, the key parts of this model are those linking Climate with Health and Errors. Morale was included in the earlier study as a predictor of turnover intentions and it also made a contribution to the prediction of maintenance errors. However, both morale and turnover intentions were omitted in the present cross-validation study which was concerned primarily with the construct of psychological strain and its direct impact on errors and its role as a mediator of the effects of safety climate.

In this model (see Figure 2 page 59) Recognition, Safety Focus, Supervision, Feedback, and Training were treated as aggregate variables (Gribbons & Hocevar, 1998) serving as reflective indicators of an underlying construct labelled Safety Climate (the same construct labelled as Climate in the earlier study). Stress and the General Health Questionnaire (GHQ) also were treated as aggregate variables serving as reflective indicators of an underlying construct called Psychological Strain. Errors were treated as a single indicator latent trait that forms the main outcome in this study. In accordance with standard SEM practice (Jöreskog & Sörbom, 1989), the factor loading of the single indicator was set to 1.0 and the residual variance is set to (1-reliability)*variance. Finally, Psychological Strain is conceptualized as a variable that entirely mediates the influence of Safety Climate on Errors.

A competing model with a direct link between Safety Climate and Errors was also tested on the grounds that a significant direct pathway would rule out the possibility of full mediation.

Method

Participants

A total of 150 maintenance engineers (146 males) working at a major helicopter repair base for the Australian Army responded to the survey, representing a response rate of over 92%. The survey was targeted primarily at trainees (36.7%), tradespersons (33.3%) and supervisors (30%). The average age of the respondents was 30.5 years and most respondents (82.4%) had been working as a maintenance engineer or a trainee engineer for at least one year.

Materials

A slightly modified version of the Maintenance Environment Survey (Fogarty, 2004) was used to measure safety climate. Modifications consisted of an additional item for the Supervision scale, a reduction of three items for the Training Standards scale, and an increase of nine items in the Error scale. The scales are described below under the headings of the constructs for which they were intended to act as markers. The Cronbach alpha internal consistency reliability estimates obtained from the present study are reported for each scale.

A. Safety Climate (MES scales).

1. Recognition for doing good work (5 items). This scale assessed the extent to which people feel that they are rewarded and recognised for doing

good work. Sample item: In this job, people are rewarded according to performance. Alpha = .78.

2. Safety focus of the organisation (5 items). This scale assessed the perception that the organisation has a strong concern for safety issues. Sample item: This unit regards safety as a major factor in achieving its goals. Alpha = .72.

3. Supervision standards (7 items). The items in this scale focused on the expertise of the supervisor and the extent to which the supervisor assisted the worker. Sample item: My immediate supervisor really understands the maintenance task. Alpha = .86.

4. Feedback on work performance (4 items). These items assessed workers' perceptions of the amount and quality of feedback they received. Sample item: The quality of our work is rated or evaluated frequently.Alpha = .73.

5. Training standards and appropriateness (5 items). The items in this scale covered a number of different aspects of training, including adequacy of training for the job, encouragement to undertake further training, and opportunities for on-the-job training. Sample item: My training and experience have prepared me well for the duties of my current job. Alpha = .62.

B. Psychological Strain (MES plus GHQ).

6. Exposure to workplace stressors (9 items). The questions comprising this scale tapped the actual feelings and consequences of stress, rather than background factors that might be causing the strain. Sample item: I get anxious when I work to strict deadlines. Alpha = .84.

7. Health. The abbreviated, 12-item form of the GHQ (Goldberg & Williams, 1988) was used. The GHQ explores four aspects of psychological health: somatic symptoms; anxiety and insomnia; social dysfunction; and severe depression. High scores indicate poor psychological health. Alpha = .88.

C. Outcome Variable (MES).

8. Maintenance errors (13 items). The revised MES included 13 questions that asked the respondents to indicate whether they made maintenance errors on the job. These included errors that they detected themselves and those picked up by their supervisors. Sample item: I make errors in my job from time to time. Alpha = .82.

All items, except for those involving the GHQ and the Positive and Negative Affect (PANAS) scales, employed a five-point (1-5) Likert scale format where 1 indicated strong agreement and 5 strong disagreements. High scores on all Safety Climate variables were desirable whilst low scores were regarded as desirable on Stress, GHQ, and Errors. [A copy of the version of MES used in this study can be found at http://www.usq.edu.au/users/fogarty/]

Procedure

The procedure was identical to that followed by Fogarty (2004). The survey was sponsored by Army Aviation Headquarters and survey forms were included in the pay envelopes of all maintenance personnel along with a covering letter explaining the purposes of the survey. To ensure anonymity, self-addressed envelopes were included so that the forms could be returned directly to the investigator. At the completion of the study, feedback sessions on the main findings of the study were conducted by the investigator and a research assistant.

Results

All scales, except for Training, had satisfactory reliability estimates with alpha estimates above .70 (Nunnally & Bernstein, 1994). The low reliability of the Training scale (.62) was not of concern given that it acted as just one of five markers for the Safety Climate construct. It also could be argued that the components of a training program are not necessarily correlated and should therefore be treated as an index rather than a scale (see Diamantopoulos & W inklhofer, 2001). SPSS (version 11.0.1), data analysis software, was used to calculate means, standard deviations, and scale intercorrelations. The results are shown in Table 1.

Table 1
Summary Statistics and Correlations for MES Scales (N = 150)

Scale	M	SD	Correlations						
			1	2	3	4	5	6	7
1. Recognition	2.90	.52							
2. Safety Focus	3.58	.60	.25						
3. Supervision	3.59	.61	.32	.23					
4. Feedback	2.99	.48	.46	.29	.43				
5. Training	3.07	.64	.32	.29	.36	.52			
6. Stress	3.05	.59	-.32	-.36	-.20	-.31	-.32		
7. GHQ	1.94	.46	-.40	-.30	-.21	-.37	-.35	.60	
8. Errors	2.57	.57	-.05	-.27	-.06	-.09	-.11	.34	.25

Note. Correlations above ± .18 are significant at the .01 level

The bottom row of Table 1 shows the correlations of the Errors scale with all other scales. It can be seen that the only significant correlations involving Errors were with Safety Focus, a Safety Climate marker, and the two Psychological Strain variables, Stress and GHQ. It also can be seen that the Safety Climate variables were all correlated with both of the Psychological Strain markers. These findings supported those reported by Fogarty (2004) and are in keeping with the proposition that safety climate acts primarily on the psychological health of the individual workers and that psychological strain is a primary determinant of maintenance errors. This proposition was tested in the next section by using path analysis.

Maximum likelihood procedures from Version 5.0 of the AMOS structural equation modelling (SEM) package (Arbuckle, 2003) were employed to test the hypothesized model of the relations among the MES variables. Because of the unfavourable ratio of free parameters to cases, a partially aggregated model (Gribbons & Hocevar, 1998) was used wherein subscales represented the various first-order constructs in the conceptual model. Three fit indices are reported. The first is the traditional c^2 goodness of fit test where p values above .05 can be taken to indicate good fit. One incremental fit index was used; the comparative fit index (CFI) (Bentler, 1990), which is considered to be reasonably robust against violations of assumptions and where a value above .95 was considered to indicate satisfactory fit. The third index used was the root mean square error of approximation (RMSEA) (Steiger, 1990), which indicates the mean discrepancy between the observed covariances and those implied by the model per degree of freedom, and therefore has the advantage of being sensitive to model complexity. A value of .05 or lower indicates a good fit and values up to .08 indicate an acceptable fit (Kline, 1998).

A test of the path model shown in Figure 2 yielded acceptable fit indices with c^2 (19, N = 150) = 23.29, p = .23; CFI = .98; RMSEA = .04. The model predicted 39% of the variance in Psychological Strain and 15% of the variance in Errors. All factor loadings and regression pathways were significant. A second model with a pathway from Safety Climate to Errors was also fitted. However, there was no improvement in model fit and the direct pathway was not significant. Accordingly, the more parsimonious model is the preferred solution.

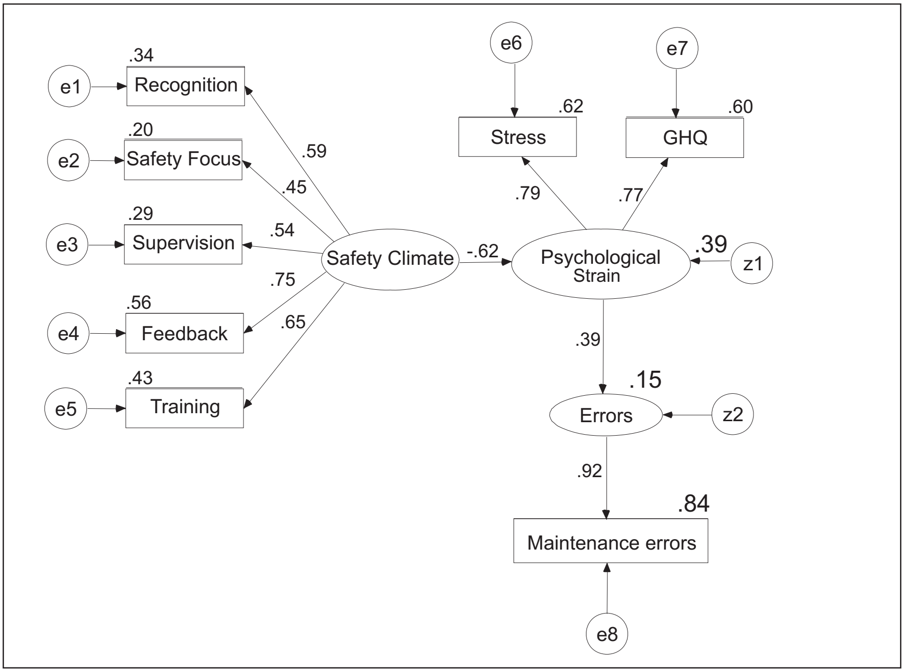

Figure 2. Model depicting interactions among Safety Climate, Psychological Strain, and Errors

Discussion

The main aim of the present study was to test Fogarty's (2004) proposition that the link between safety climate and errors is mediated by psychological health and to confirm the important role of psychological strain in particular as being among the immediate causes of maintenance errors. The study was successful in these aims. The bivariate correlations revealed a significant association between safety climate and psychological strain and a further significant association between psychological strain and maintenance errors. The path model established that the linkage between safety climate and errors is a mediated one.

These results replicated the Fogarty (2004) findings and supported claims by researchers working in other high-risk industries (Oliver et al., 2002; Tomás et al., 1999) those organisational and individual level variables cannot be regarded as having additive effects on safety performance. As other researchers have asserted, many errors result from interacting causes involving physical, cognitive, social, and organisational factors. To understand this interaction requires a model of how the components of the system work together to influence outcomes. The model tested in the current research program is conceptually driven and already validated on a military population (Fogarty, 2004). Its cross-validation in the present study suggested that we have a way of measuring and quantifying some of the main sources of error.

The implications of these findings were spelled out in Fogarty (2004) but again will be summarised here. The demonstration of indirect links between climate and errors (via psychological strain) suggests that the mere presence of unfavourable perceptions of organisational factors is not sufficient in itself to lead to errors. Unfavourable organisational conditions place pressure on the individual and when the individual begins to succumb to these pressures, errors begin to occur. From a management perspective, it is therefore important to monitor both safety climate and individual health variables on a regular basis to ensure that there are no problems of this kind developing. Studies such as the present one, therefore, lend strong support to initiatives designed to measure climate and individual health (e.g., Wiegmann et al., 2003; Civil Aviation Authority, 2003). Such measures will be even more useful if benchmark comparisons within and across organizations become possible (Mearns, Whitaker, & Flin, 2001).

Limitations and Future Research Directions

In closing, it is important to recognize the theoretical and methodological shortcomings of the approach followed in the original Fogarty (2004) study and, hence, in the present validation study. From a theoretical point of view, it could be argued that the set of markers used for Safety Climate in the present study was not truly representative of the safety climate construct and that a different set of variables may define a factor that is directly related to errors. The earlier paper justified the selection of marker variables but it is certainly true that this proposition needs to be tested. The fact that Safety Focus was correlated with

Errors in the present study (*r* = -.27, *p* < .01) is an indication that some aspects of climate may have a direct relationship with errors. In ongoing research, we are extending the error scale in an attempt to capture the various dimensions of this construct and to search for evidence of direct links between organisational variables and specific types of error.

A further limitation of the current research program was that it was confined to the military environment. Maintenance engineers working in this setting face some challenges (e.g., demands of military duties) that are not faced by those working in commercial settings. The converse also holds true. It is also possible that military settings imposed a uniformity of working conditions not found in the commercial environment. If safety climate is reasonably uniform throughout an organization such as Army Aviation, the consequent restriction in range will have the effect of suppressing correlations with other variables. The model therefore needs to be tested in different organisational settings. Against this criticism, it must be noted that there was sufficient variability in the safety climate construct in both of these studies to enable it to account for a significant proportion of the variance in psychological health.

Conclusion

There is still much work to be done in identifying the contributors to both psychological health and errors. The restricted model tested in the present study explained 15% of the variance in errors. The Fogarty (2004) study included morale and fatigue as additional predictors and succeeded in capturing 45% of the variance in errors. The aim of the present study was to clarify the pathways by which organisational and psychological variables contribute to errors, rather than to maximize the prediction, but we should not lose sight of the fact that both aims are important. When the predictor space has been well defined using these self-report measures of error, the challenge will then be to see if these findings can be applied to real-life measures of error gathered in actual work settings. A growing number of studies examining the relationship between psychological variables such as stress and actual accident data (e.g., Fogarty & Shardlow, 2004; Hoffmann & Stetzer, 1996; Zohar, 2000) suggested that this will be the case and that we already have a good platform for designing interventions that will assist in error reduction.

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HFACS Analysis of ROC Air Force Aviation Accidents: Reliability Analysis and Cross-cultural Comparison

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Abstract

Human Factors Analysis and Classification System (HFACS) has been used extensively to analyze accidents involved in military and civil aviation in the USA over the past several years (e.g. Shappell & Wiegmann 2001; 2003 & 2004; & Wiegmann & Shappell 1997; 2001a; 2001b; 2001c & 2003). However, with increasing world-wide use of the framework there is now a need to examine the reliability and applicability of the HFACS in different countries and cultures. Hofstede (1984) identified four different dimensions of culture, which may affect the social interactions of aircrew and impact aviation safety. This research examined the applicability of the HFACS framework for the analysis of accidents in a military, collectivist, high power-distance culture, the Republic of China (R.O.C.) Air Force. As a secondary objective, it also examined the inter-rater reliability of the 18 categories of HFACS framework. A total of 523 accidents occurring in the R.O.C. Air Force between 1978 and 2002 were analyzed. The inter-rater reliability, using

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Cohen's Kappa, was between 0.440 and 0.826, which was indicative of moderate agreement to substantial agreement (Landis & Koch, 1977). Differences were observed between USA and R.O.C. at the HFACS levels of organizational influence *and* unsafe supervision. *The findings of this research highlighted critical areas of human factors in R.O.C. military aviation in need of further safety initiatives, such as setting up stress management and confidential counseling programs for military pilots, improving the attitude of military pilots toward Crew Resource Management (CRM), improving the professional supervisory training for supervisors, and effective management of organizational resources for aviation operations.*

Introduction

To improve flight safety, the Republic of China (R.O.C.) Air Force Headquarters investigates the pattern of aviation mishaps annually.The findings have shown that the rate of military aviation accidents attributable solely to mechanical failure have decreased markedly in recent years, but the contribution of human error has declined at a much slower rate and remains the primary cause of all accidents. The role of human error in aircraft accidents is a topic of much scientific debate. There are a number of perspectives for describing and analyzing human errors, each based on different assumptions about their nature and the underlying causal factors of the human contribution in the sequence of events leading up to an accident. For example, Dekker (2001) proposed that human errors are systematically connected to features of operators' tools and tasks, and error has its roots in the surrounding system: the question of human or system failure alone demonstrates an oversimplified belief in the roots of failure. The important issue in a human factors investigation is to understand why pilots' actions made sense to them at the time the accident happened (Dekker, 2002). Earlier work by Feggetter (1991) similarly suggested that the role of psychologists who investigate accidents is to collect and make a detailed examination of the large amounts of information associated with human errors and to gain a complete understanding of the surrounding circumstances. By examining and correlating information across a number of accidents, predictors may be identified which may then be applied to individual crews or situations in order to developing the effective prevention strategies. Many human factors accident analysis frameworks, taxonomies, and analysis strategies have been devised over the years (e.g. Diehl, 1989; Feggetter, 1991; Harle; 1995; Hollnagel, 1998; Hunter & Baker, 2000; NTSB, 1983). Beaubien & Baker (2002) reviewed several of these frameworks and taxonomies. The Human Factors Analysis and Classification System (HFACS) developed by Wiegmann & Shappell (2003) is becoming one of the most commonly used and is the one used herein as a basis for the current work.

In recent years, in accident investigation scientific focus has shifted away from psychomotor skill deficiencies and emphasis is now placed more upon inadequacies in decision-making, attitude, supervisory factors and organizational culture as the primary causal factors (Diehl, 1991; Jensen, 1997, & Klein, 2000).

From a more social psychological perspective, military aviation operations can be characterised as social interactions among pilots, tactical air traffic controllers, dispatchers, ground crew, maintenance staff, and the mission's leader (number one). As a result, Human Factors specialists have to deal with social factors, including crew communication, teamwork, and organizational culture as well as psychological factors that affect the operator's performance, such as workload, stress, vigilance, attention, g-forces, and oxygen deprivation (Jensen, 1997).

As suggested previously, perhaps the most widely reported human factors accident analysis framework is that developed by Wiegmann and Shappell (2001c). HFACS is a generic human error framework originally developed for US military aviation as a tool for the investigation and analysis of the human factors aspects of accidents. HFACS is based on Reason's (1990) system-wide model of human error in which active failures are associated with the performance of front-line operators in complex systems and latent failures are characterized as inadequacies or misspecifications which might lie dormant within a system for a long time and are only triggered when combined with other factors to breach the system's defenses. These latent failures are spawned in the upper management levels of the organization and may be related to manufacturing, regulation, and/or other aspects of management. As Reason (1997) noted, complex systems are designed, operated, maintained, and managed by human beings, so it is not surprising that human decisions and actions are implicated in all organizational accidents.

Reason's model revolutionized the manner in which the role of human error in aviation accidents was viewed but it did not provide a detailed method for the analysis of aviation accidents and mishaps. However, Wiegmann and Shappell developed HFACS to fulfill such a need. The development of HFACS is described in a series of books and papers (e.g. Shappell & Wiegmann 2001; 2003 & 2004; & Wiegmann & Shappell 1997; 2001a; 2001b; 2001c & 2003). Wiegmann & Shappell (2001b) suggested that the HFACS framework bridges the gap between theory and practice by providing safety professionals with a theoretically based tool for identifying and classifying human errors in aviation mishaps as the tool focuses on both latent and active failures and their inter-relationships, and it facilitates the identification of the underlying causes of human error. However, as aviation accidents are the result of a number of causes, the challenge for accident investigators is how best to identify and mitigate the causal sequence of events leading up to an accident.

HFACS examines human error in flight operations at four levels. Each higher level affects the next downward level in HFACS framework (see figure 1).

- Level-1 *Unsafe acts of operators*: This level is where the majority of causes of accidents are focused. Such causes can be classified into the two basic categories of errors and violation.
- Level-2 Preconditions *for unsafe acts*: This level addresses the latent failures within the causal sequence of events as well as more obvious active failures. It also describes the context of substandard conditions of operators and the substandard practices they adopt.

- Level-3 *Unsafe supervision*: This level traces the causal chain of events producing unsafe acts up to the front-line supervisors.
- Level-4 *Organizational influences*: This level encompasses the most elusive of these latent failures, fallible decisions of upper levels of management, which directly affect supervisory practices, as well as the conditions and actions of front-line operators.

Wiegmann and Shappell (2001a) found HFACS categories such as organizational process were involved in 8.4% of accidents in US civil aviation between 1990 and 1996: Resource Management was involved in 2.5% of accidents; inadequate supervision was involved in 5% of accidents. However, skill-based errors were involved in 60.5% of accidents; decision errors were involved in 28.6% of accidents: Crew Resource Management was involved in 29.4% of accidents; and violations were involved in 26.9% of accidents.

The current research examines 523 accidents occurring in the ROC Air Force between 1978 and 2002 by applying Human Factors Analysis and Classification System (HFACS, Wiegmann & Shappell, 2003). To date, the HFACS framework has mainly been used in North America for the analysis of aircraft accidents. However, with increasing world-wide use of the framework there is now a need to examine the reliability and applicability of the HFACS framework in different countries and cultures. Beaubien and Baker (2002) criticised the validation evidence presented for supporting the utility of the HFACS system as it has all been collected and analysed by the authors of the system themselves. It was also suggested that further inter-rater reliability evidence would be desirable. Wiegmann and Shappell (2001a) reported that the framework as a whole had an inter-rater reliability figure (using Cohen's Kappa) of 0.71, indicating substantial agreement; however, no figures were reported for the individual HFACS categories.

National culture has been implicated as a factor in many aircraft accidents and it has also been suggested that many safety concepts (such as Crew Resource Management - CRM) are biased toward a North American/Western European culture. Merritt (1993) called the failure to take into account the effects of national culture "cultural imperialism." Hofstede (1984) pointed out that national cultures vary on dimensions such as *individualism*, *power distance*, *uncertainty avoidance*, and *masculinity*, four areas which can affect interactions in the cockpit and which are known to have an impact on safety. On Hofstede's first dimension, individualist cultures can be characterized as having loosely knit social frameworks, which emphasize the individual taking care primarily of themselves and their immediate family and friends. Collectivist cultures have tight social networks and people in them expect organizations to protect their members in exchange for total loyalty. On the power-distance dimension, high power distance cultures place a great deal of emphasis on titles, rank, and overt status. Low power-distance cultures are quite the opposite, where superiors still have authority yet people lower in the organization do not necessarily defer to this authority. Hofstede's dimension of uncertainty avoidance describes the degree to which members of a culture feel threatened by ambiguous or uncertain situations. In high uncertainty avoidance cultures organizations tend to have a great number of formal mechanisms, deviant behavior is not tolerated and people strive to arrive at black and white answers to questions. Low uncertainty avoidance cultures operate in quite the opposite manner. On the final dimension of masculinity versus femininity, masculine cultures are characterized by dominance and assertiveness, and to an extent, an apparent lack of care for others. Feminine cultures place much higher emphasis on relationships and care for others (Descriptions of Hofstede's dimensions are adapted from Robbins, 1991).

Using the Hofstede categorization, it has been observed that NATO nations such as the UK, USA, Canada, Norway, Denmark and the Netherlands, which are individualist cultures and show low uncertainty avoidance, have the lowest accident rates (Soeters & Boer, 2000). Countries including Greece, Portugal, and Turkey with a collectivist culture and exhibiting a strong avoidance of uncertainty have the highest accident rates. Helmreich (1994) described an accident where a Boeing 707 ran out of fuel during a second approach following an initial missed approach (NTSB, 1991). It was suggested that as Colombia was a high *power-distance* culture there was reluctance on the part of the First Officer to question the Captain's actions and decisions, even though the aircraft was running low on fuel. Helmreich also suggested that as part of a collectivist culture, there was also unwillingness within the crew to instigate a potentially acrimonious debate, which may damage intra-group harmony.

In addition to cultural factors being related to accident rates, it also has been noted that safety initiatives developed in individualist cultures (e.g. the UK and USA) may be rejected in collectivist, high power-distance cultures (e.g. R.O.C.), as it would be seen as completely unacceptable to criticize group members or question superiors about their actions (see Johnston, 1993; Helmreich & Merritt, 1998; or Maurino, 1999 for further discussion on the affects of cultural factors). As a result, the pattern of accident contributory factors observed when applying HFACS to accidents occurring to North American operators is likely to be quite different to those observed in R.O.C., especially in those dimensions which are most likely to reflect the contributions of national culture, for example managerial and organizational aspects.

To date, HFACS has been shown to be useful within the context of US military aviation, as both a data analysis framework and an accident investigation tool (Shappell & Wiegmann, 2003). This research examined the applicability of the HFACS framework for the analysis of accidents in a military, collectivist, high power-distance culture, the R.O.C. Air Force. It is anticipated that those dimensions most likely to reflect cultural differences, for example managerial and organizational aspects, will exhibit different frequencies in their contributions to accidents. As a secondary objective, it also examined the inter-rater reliability of the 18 individual categories of HFACS framework.

Method

Data

The data were comprised of the narrative descriptions of accidents occurring in the R.O.C. Air Force between 1978 and 2002. In total, the complete data set comprised 523 accidents in this 25 year period.

In addition to the narrative description in the report, the following information was also collected: the type of mission in which the accident happened (e.g. air interception, cross country, surface attack); the flight phase (e.g. take-off, flight in the operational area, approach, and landing); the rank of the pilot(s) involved; and the type and category of aircraft.

Classification framework

This study used the HFACS framework as described in Wiegmann and Shappell (2003). The first level of HFACS categorizes events under the general heading of *unsafe acts of operators* that can lead to an accident; these include and are comprised of four sub-categories of *decision errors*, *skill-based errors*, *perceptual errors*, and *violations* (see figure 1). The second level of HFACS concerns *preconditions for unsafe acts* which has a further seven sub-categories of *adverse mental states*, *adverse physiological states*, *physical/mental limitations*, *crew resource management*, *personal readiness*, *physical environment*, and *technological environment*. The third level of HFACS is *unsafe supervision* including *inadequate supervision*, *planned inappropriate operation*, *failure to correct known problem*, and *supervisory violation*. The fourth and highest level of HFACS is *organizational influences* and comprises the sub-categories of *resource management*, *organizational climate*, and *organizational process*.

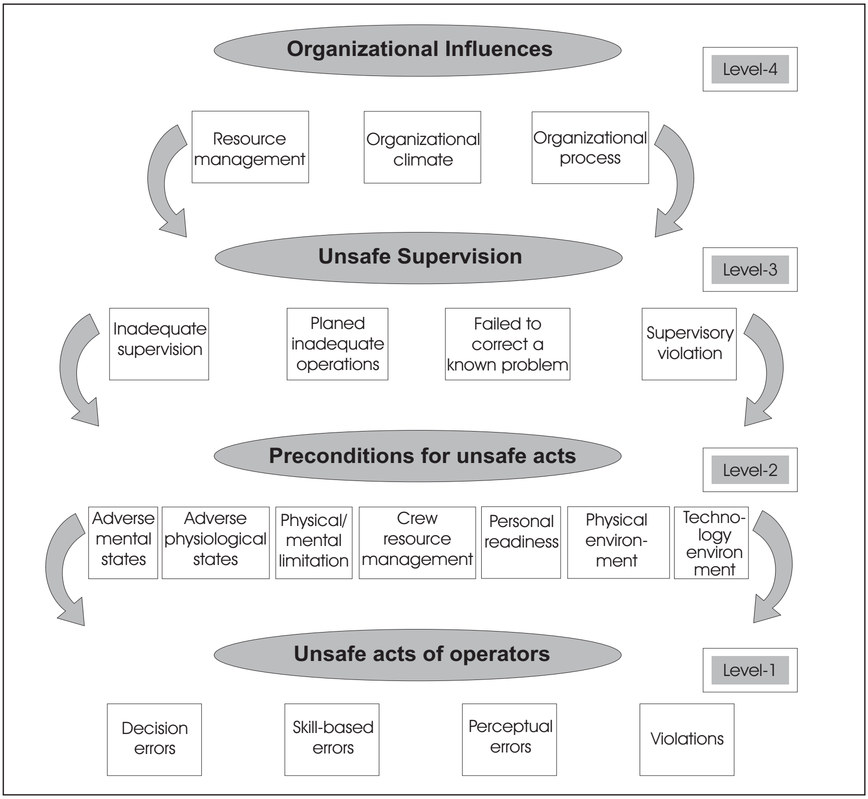

Figure 1. The HFACS framework, each upper level would affect downward level, proposed by Wiegmann and Shappell (2003).

Coding process

Each accident report was coded by two investigators, an instructor pilot, and an aviation psychologist. These two investigators were trained together on the H FACS framework for 10 hours to ensure that they achieved a detailed and accurate understanding to the categories of the HFACS. They then analyzed each accident report independently.To avoid over-representation from any single accident, each HFACS category was counted a maximum of only once per accident. The count acted simply as an indicator of presence or absence of each of the 18 categories in a given accident.

Results

Sample characteristics

A total of 523 R.O.C. Air Force accidents were analyzed. In these accidents, 1,762 instances of human error were recorded within the HFACS framework. The sample included 206 (39.4%) class-1 accidents (cost to repair over 65% of original price of aircraft), 78 (14.9%) class-2 accidents (cost to repair between 35 and 65% of original price or crew had serious injury), and 239 (45.7%) class-3 accidents (cost to repair between 3-35% of original price or crewmember has a minor injury). Fighter aircraft were involved in 353 (67.5%) accidents, trainers involved in 113 (21.6%) accidents, and cargo aircraft were involved in 57 (10.9%) accidents. Cadet pilots were involved in 30 (5.7%) accidents, first lieutenants in 10 (1.9%) accidents, lieutenants in 92 (17.6%) accidents, captains in 144 (27.5%) accidents, majors were involved in 148 (28.3%) accidents and lieutenant colonels (or above) were involved in 70 (13.4%) accidents.

Initial results found that acts at the level of *unsafe acts of operators* was involved in 725 (41.1%) instances; the *preconditions for unsafe acts* level was as a causal factor in 552 (31.3%) instances; the *unsafe supervision* level was involved in 221 (12.5%) instances, and the *organizational influences* level in the H FACS model was involved as a factor in 264 (15 %) instances. It must be noted in the following analyses that the percentages quoted refer to the percentage of times that an HFACS factor was implicated in the sequence of events leading up to an accident. However, in most instances many more than just a single factor was implicated in an accident sequence, hence the percentages quoted sum to more than 100% across the results section as a whole.

Causal factors associated with 'unsafe acts of operators'

In level-1, *skill-based errors* exhibited the highest frequency of occurrence in the HFACS framework. These included actions such as inappropriate stick and rudder coordination, excessive use of flight controls, glide path not maintained, and adopting an improper airspeed or altitude. *Decision errors* had the second highest rate of observations. Instances in this category included selecting inappropriate strategies to perform a mission, improper in-flight planning, making an inappropriate decision to abort a take-off or landing, or using improper remedial actions in an emergency.The category of 'violations' included intentionally ignoring standard operating procedures (SOPs), neglecting SOPs, applying improper

SOPs, and diverting from SOPs. The category of *Perceptual errors* exhibited the lowest frequency of occurrence. This category included experiencing spatial disorientation, visual illusions, making incorrect distance estimations and descent rate during approach, and vertigo during tactical maneuvers (figure 2).

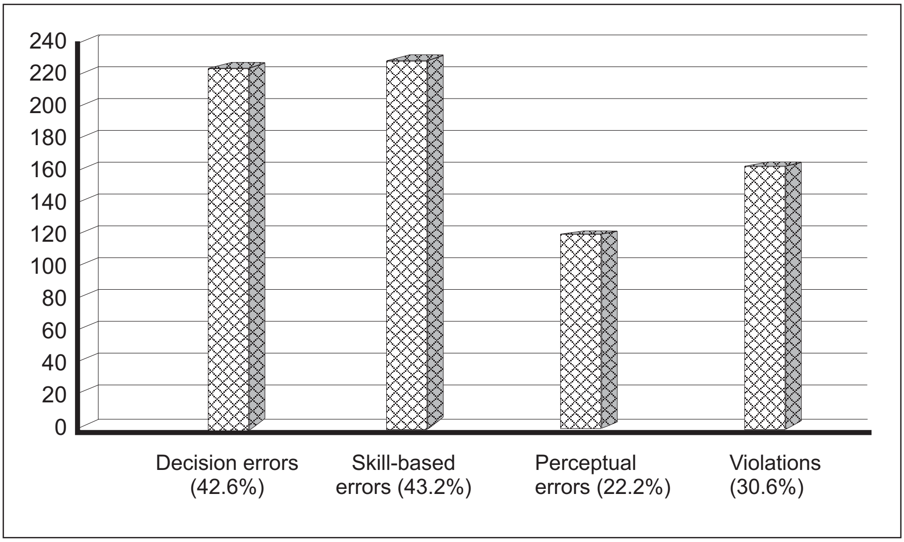

Figure 2. Frequency and percentage of factors implicated in accidents at level-1 'unsafe acts of operators'.

Causal factors associated with 'preconditions for unsafe acts'

At level-2 of the HFACS framework, instances of causal factors in the 'adverse mental states' category (the most frequent category of occurrence) included issues such as over-confidence, stress, loss of situational awareness, distraction, channelized attention, and task saturation. *Crew resource management* (CRM) issues, the next most frequent category, included a lack of teamwork, poor communication, failures of leadership, and inadequate briefing. In the *physical environment* category, contributory factors included poor responses to factors in the environment such as, bad weather, foreign object damage, and terrain. The *physical/mental limitations* category included instances of visual limitations, information overload, and a lack of experience to deal with a complex situation. The *technological environment* category covered issues such as equipment design, cockpit display interfaces, automation, and checklist layout. *Personal readiness* which encompassed issues associated with inadequate training, self-medication, poor diet, and overexertion while off duty, was involved in relatively few accidents, as was instances of *adverse physiological states* (see figure 3 on the following page).

Causal factors associated with 'unsafe supervision'

The most frequently occurring category in level-3 was *inadequate supervision*. Contributory factors included a failure to provide proper training, a failure to provide adequate rest periods, a lack of accountability, failure to track qualifications and performance, using untrained supervisors, and loss of situation awareness at

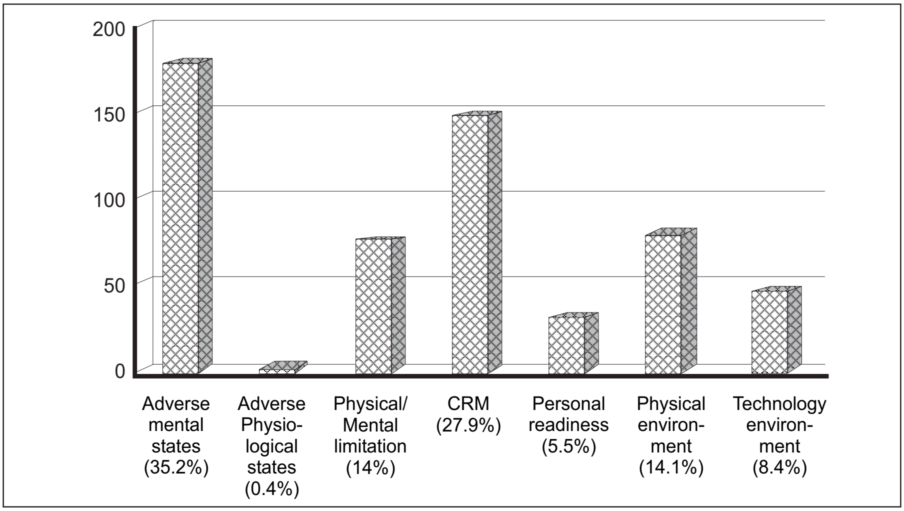

Figure 3. Frequency and percentage of factors implicated in accidents at level-2 'precondition for unsafe acts'.

the supervisory level. *Planned inadequate operations*, including issues surrounding poor crew pairings, a failure to establish if risk outweighed benefit, excessive task/workload, and failure to provide adequate time for briefing, was the next most frequently occurring category at this HFACS level. In the category of *failure to correct a known problem*, instances included failures to correct inappropriate behavior, failing to remove a known safety hazard, failing to report unsafe tendencies, and failing to initiate corrective actions. *Supervisory violations* which included authorizing an unqualified crew for flight, supervisors violating procedures, inadequate documentation, and a willful disregard of authority by the supervisor, was implicated in relatively few accidents (see figure 4).

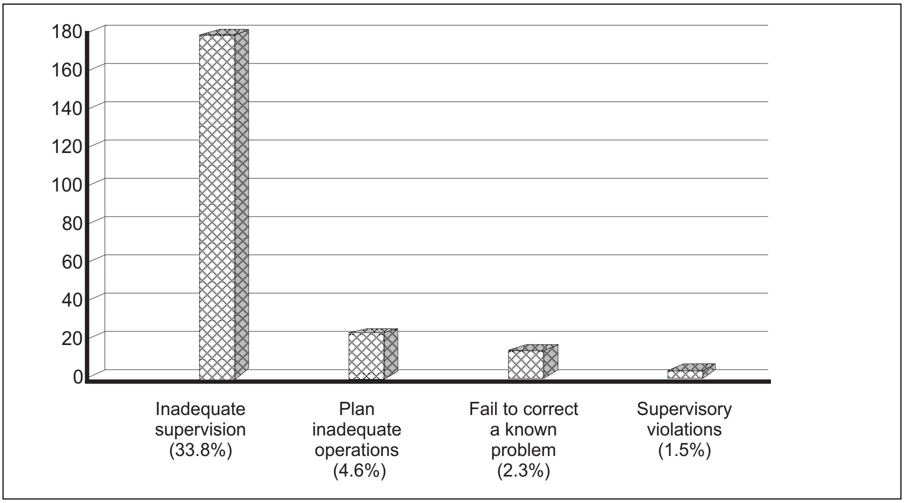

Figure 4. Frequency and percentage of factors implicated in accidents at level-3 'unsafe supervision'.

Causal factors associated with 'organizational influences'

At level-4, *resource management*, which included the selection, staffing and training of human resources at an organizational level, excessive cost cutting, providing unsuitable equipment, and a failure to remedy design flaws, was most frequently involved in accidents. *Organizational processes* including excessive time pressures, poor mission scheduling, poor incentivization, failing to set clearly defined objectives, poor risk management programs, inadequate management checks for safety, and failing to establish safety programs, was the next most frequent category at this level in the HFACS framework. Issues surrounding the *organizational climate* including inadequacies in the chain of command, poor delegation of authority, inappropriate organizational customs and beliefs, and poor accident investigation, were only involved in very few accidents (see figure 5).

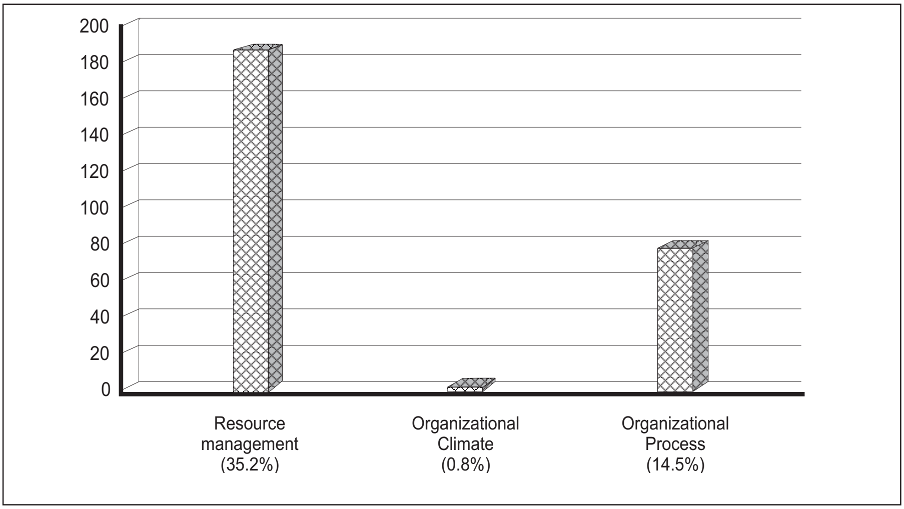

Figure 5. Frequency and percentage of factors implicated in accidents at level-4 'organizational influence'.

Inter-rater reliability of HFACS classification

The inter-rater reliabilities assessed using Cohen's Kappa ranged between 0.440 and 0.826, a range of values spanning between moderate agreement and substantial agreement. Fourteen HFACS categories exceeded a Kappa of 0.60, which indicated substantial agreement. Four categories had Kappa values between 0.40 and 0.59 indicating moderate levels of agreement (Landis & Koch, 1977). Inter-rater reliabilities calculated as a simple percentage rate of agreement obtained reliability figures between 72.3% and 96.4%, also indicating acceptable reliability between the raters (table 1).

Table 1

The frequency and percentage of accident and inter-rater reliability of HFACS categories (ranked in terms of increasing inter-rater percentage agreement)

Categories of HFACS	HFACS level	Frequency of occurance	Inter-rater Reliability	
			Cohen's Kappa	Percentage Agreement
Personal readiness	2	29	0.695	72.3%
Decision errors	1	223	0.675	81.5%
Skilled-based errors	1	226	0.712	83.4%
Violations	1	160	0.695	84.9%
Perceptual errors	1	116	0.667	85.1%
Adverse mental states	2	184	0.748	86.0%
Resource management	4	184	0.768	86.4%
Organizational process	4	76	0.593	87.4%
Inadequate supervision	3	177	0.826	89.7%
Crew resource management	2	146	0.801	89.7%
Technology environment	2	44	0.608	89.9%
Physical/mental limitation	2	73	0.691	90.4%
Physical environment	2	74	0.797	92.2%
Planned inadequate operations	3	24	0.706	94.6%
Failed correct known problem	3	12	0.548	95.8%
Supervisory violation	3	8	0.694	96.2%
Organizational climate	4	4	0.440	96.4%
Adverse physiological states	2	2	0.441	96.4%

Discussion

Analysis of accident data by applying HFACS framework

At the level of *unsafe acts of operators*, *skill-based errors* had the highest rate of occurrence (43.2%) in the HFACS framework, including actions such as inappropriate stick and rudder coordination, excessive use of flight controls, glide path not maintained, and adopting an improper airspeed or altitude. *Decision errors* had the second highest rate (42.6%) including instances of selecting inappropriate strategies to perform a mission, improper in-flight planning, making an inappropriate decision to abort a take-off or landing, or using improper remedial actions in an emergency.The frequency of both categories of *skill-based errors* (226) and *decision errors* (223) were very similar, comprising the majority of instances in HFACS framework. The initial training programs for cadet pilots focus almost solely on factors at the skill-based level. There are no *decision-making* training programs in existence in the R.O.C. Air Force so far.Therefore, there is an urgent need to address the importance of aeronautical decision-making for military pilots.

At the level of *preconditions for unsafe acts*, *adverse mental states* had the highest rate of implication in accidents (35.2%) implicating factors such as mental fatigue, stress, over-confidence, distraction, poor vigilance, or poor communication. *Crew resources management* had the second highest rate of accidents (27.9%). Many military pilots in the ROC Air Force feel that CRM is only good for civil aviation pilots. The findings of this investigation revealed that military aviation does need CRM but perhaps a modified version. Even pilots of single-seat fighters require good communication with their wingman to backup each other and avoid a mid-air collision. They need to follow their leader (number one) to form a tactical formation to undertake a mission and they need to exchange information with Tactical Air Traffic Control (TATC) clearly. *Physical environment* causal factors had the third highest rate of accidents (14.1%). The majority of these accidents involved an inappropriate response to bird strikes. The research suggests that bird strike projects need to be improved.

Inadequate supervision had the highest rate of accidents (33.8%) at the level of *unsafe supervision*. It was observed that supervisors' failure to provide proper training for crew, a supervisory loss of situation awareness and untrained supervisors were the major contributors to accidents. It suggested that there is a need for improving the training of supervisors. Moreover, if *routine violations* at the level of *unsafe acts of operators* were condoned at the supervisory level, it reinforces the inappropriate behaviors and attitudes of the flight crew. Therefore, supervisors must be encouraged to perform their tasks appropriately and precisely.

Resource management had the highest occurrence frequency at the *organizational influences* level. It is important to find the weak link in the *resource management* chain and then to find appropriate remedial strategies; however, it is also difficult to locate *latent failures* at an organizational level. This study found that major contributors to accidents included poor pilot selection practices and flight training, poor aircraft design, and failures to correct known flaws.

Cross-Cultural Comparison of HFACS

The HFACS framework that was originally developed for use in US military aviation. Many categories, such as *supervisory violation* had a relatively low percentage of occurrence in both the reported U.S. data and in the data in the current study, - only 1.7% in U.S. and 1.5% in R.O.C. Some categories, such as *skilled-based errors*, had a much higher percentage of occurrence in the U.S. (60.5% - Wiegmann & Shappell, 2001a) than in R.O.C. (43.2%). Generally, though, the percentages of most HFACS categories were relatively similar between the USA and R.O.C. In both countries, at the level of *unsafe acts of the operator*, *skill-based errors* were the primary human cause of accidents, followed by *decision errors*, violations, and perceptual errors (see table 2). However, there were some categories were there was a big difference between USA and R.O.C. For example, only 2.5% of occurrences in USA fell into the category of *resource management* at the level of *organizational influence* but errors in this category were implicated in 35.2% of instances in accidents in R.O.C. Air Force. Similarly, *inadequate supervision* at the *unsafe supervision* level was implicated in only 5% of accidents in USA but 33.5% in R.O.C. sample (see table 2).

Table 2.

Categories of HFACS		Accidents' Frequency and Percentage ROC		Accidents' Frequency and Percentage USA	
		Frequency	Percentage	Frequency	Percentage
Level-4, Organizational Influences	Organizational process	76	14.5%	10	8.4%
	Organizational climate	4	0.8%	0	0%
	Resource management	184	35.2%	3	2.5%
Level-3, Unsafe Supervision	Supervisory violation	8	1.5%	2	1.7%
	Failed correct a known problem	12	2.3%	2	1.7%
	Planned inadequate operations	24	4.6%	1	0.8%
	Inadequate supervision	177	33.8%	6	5.0%
Level-2, Preconditions for Unsafe Acts	Technology environment	44	8.4%	na	na
	Physical environment	74	14.1%	na	na
	Personal readiness	29	5.5%	0	0%
	Crew resource management	146	27.9%	35	29.4%
	Physical/mental limitation	73	14.0%	13	10.9%
	Adverse physiological states	2	0.4%	2	1.7%
	Adverse mental states	184	35.2%	16	13.4%
Level-1, Unsafe Acts of Operators	Violations	160	30.6%	32	26.9%
	Perceptual errors	116	22.2%	17	14.3%
	Skilled-based errors	226	43.2%	72	60.5%
	Decision errors	223	42.6%	34	28.6%

Note 1. The percentage in the table will not equal 100%, because more than one causal factor is associated with each accident.

Note 2. na indicates no information available for the categories of 'technology environment' and 'physical environment' in the paper for the published date.

Note 3. The information of USA accident's frequency and percentage is taken from Wiegmann, D.A. and Shappell, S.A. (2001a) 'Human Error Analysis of Commercial Aviation Accidents: Application of the Human Factors Analysis and Classification System', *Aviation, Space, and Environmental Medicine, 72,* (11) 1006-1016.

According to Wiegmann and Shappell's (2001a), factors at the level of *unsafe acts of operators* were involved in 63.4% of accidents in the USA sample (in this research it was 41.1% in R.O.C.), factors at the level of *preconditions for unsafe acts* were involved in 26.8% of accidents in USA (31.3% in this research), at the level of *unsafe supervision* 4.5% of causal factors were associated with accidents in USA (12.5% in R.O.C.), and at the level of *organizational influences* 5.3% of causal factors were associated with accidents in USA (15% in R.O.C.). It is difficult to suggest with any certainty if the true explanation for the differences in the data were attributable to the USA data being taken from civil aviation or if it was a national, cultural difference between USA and R.O.C. As Hofstede (1991) pointed out, the culture of USA is characterized as small power distance and individualist. Subordinates acknowledge the authority of their superiors but do not bow to it, and emphasis is firmly placed on individual initiative (and reward). This supported the findings of Wiegmann and Shappell's (2001a), that individual operators have greater bearing on accidents in the USA. On the other hand, in the R.O.C., a high power distance collectivist culture, it has been found in this research that supervisory and organizational influences have a greater influence in accidents. Furthermore, Johnston (1993) found that social inequality is readily accepted in high power-distance countries where leaders are expected to be decisive and subordinates are expected to know their position.

Reliability of HFACS

From the Cohen's Kappa results, the HFACS framework was found to have an acceptable level of agreement between the raters coding the data. However, the indexes of reliability using Cohen's Kappa and percentage of agreement between raters was occasionally discrepant in some categories. For example, *organizational climate* had the lowest of Kappa coefficient (0.440) but had the highest percentage agreement (96.4%). *Adverse physiological states* had second lowest coefficient of Kappa (0.441) but had high percentage agreement (also 96.4%), and *failed to correct a known problem* had low coefficient of Kappa (0.548) but had high percentage agreement (95.8%). The explanation for this is two fold. These HFACS categories had very low frequencies of only four, two, and 12, respectively.These low frequencies are unreliable and easily can distort the Cohen's Kappa value in such instances, actually deflating its value where there is actually a very high level of agreement. Cohen's Kappa also becomes unreliable when the vast majority of observations fall into just one of the categories and there also is high percentage of agreement between raters in this category. In this instance, there is a high percentage agreement between the raters while simultaneously the value of Cohen's Kappa is low, as the latter is based upon expected probabilities based upon the marginal observed totals (Huddleston, 2003).

Certain categories of accident causal factors in the HFACS were found to have lower reliabilities than other categories. Harris (1995) noted that certain categories of causal factor in the post-hoc coding of incident data were less likely to be reliably categorized by two independent raters than were others. The categories least likely to show high levels of reliability were those that required a great deal of inference (on the part of the assessors) when coding the data, and also dealt with more abstract concepts, such as inferring a lack of situational awareness. It is notable that from the data in Table 1, with the exception of *personal readiness* all categories at level 1 in the HFACS system show the poorest levels of inter-rater reliability.The pre-cursors of these actions (level 2) and causal factors at the level of *unsafe supervision* (level 3), however, showed much higher levels of inter-judge reliability.

W iegmann and Shappell (2001a) found that HFACS framework as a whole had an inter-rater reliability figure calculated using Cohen's Kappa of 0.71, which indicated substantial agreement. This research found that coefficient Kappa generally indicated high reliability across the majority of individual categories in the framework when applied to R.O.C. Air Force accidents, but that the categories in level 1 were consistently the factors showing lowest inter-rater reliability.

Conclusions

This research has demonstrated that the HFACS framework can be used to identify the human factors associated with accidents in the R.O.C. Air Force. It also has suggested that there are cross-cultural differences at the levels of *organizational influence* and *unsafe supervision* in the prevalence of the underlying human factors that contribute to accidents. The HFACS framework has proved to be a useful tool for accident investigation and it has acceptable inter-rater reliability at the level of individual categories. To improve aviation safety, the precise identification of human errors in accidents and the pinpointing of human factors problems in order to develop effective prevention strategies are imperative. The application of the HFACS framework appears to be reliable and culturally-sensitive and it is suggested that it is a tool of great utility in this respect.

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WEBSAT: Development of Process Measures for Aircraft Safety

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Abstract

Inspection and maintenance errors that occur in aircraft maintenance systems have a formidable impact on the safety and reliability of air transportation. Evaluation of the aircraft maintenance system requires an analysis of the maintenance processes in use. Significant efforts have been made to investigate and track inspection and maintenance errors. Although valuable in terms of their contributions to the identification of the performance-shaping factors that lead to maintenance errors, these efforts have tended to be reactive in nature. The systematic evaluation of data collected on the aviation maintenance process can provide management with feedback on the performance of the airline and consequently provide proactive support of the decision-making process prior to the dispatch of the aircraft. Recognizing that surveillance, auditing, and airworthiness directives form a significant portion of the quality assurance function of an airline, it is critical that data be collected on these processes. Process measures for these work functions were identified by the research team based on human-factor principles, utility of data being captured, and working around mental models of the quality personnel. This research presents the identification strategy adopted by the research team to finalize the process measures for the three work functions mentioned above. Following this identification phase, the team carried out two surveys to validate the process measures. The first survey was taken by FedEx to finalize and prioritize process measures, the results of which are presented in this paper. In the second survey, the team will validate with other industry partners to prioritize process measures, the results of which are awaited.

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Introduction

Air transportation is becoming continually complex. To ensure safe and reliable air transportation, the Federal Aviation Administration (FAA) issues and enforces regulations and minimum standards covering manufacturing, operations, and aircraft maintenance to minimize aircraft accidents. Maintenance error has been found to be a crucial factor in aircraft accidents (Boeing & US ATA, 1995). The significance of the maintenance function was captured by Weick, Sutcliffe, and Obstfeld (1999) when they observed that: "Maintenance people come into contact with the largest number of failures, at earlier stages of development, and have an ongoing sense of the vulnerabilities in the technology, sloppiness in the operations, gaps in the procedures, and sequences by which one error triggers another" (p. 93). Given the ever-increasing complexity of an aircraft, a significant proportion of these errors come at the hands of the maintenance personnel themselves due to greater demands on these individuals. Thus, it is very important to take a closer look at the humans involved in aviation maintenance, understand the causal factors for these errors and the possible solutions to counter this situation. Human factors research in maintenance deemed the human as the central part of the aviation system (Gramopadhye & Drury, 2000). This human factors research considered the psycho-physiological aspects of the human and explained the need for developing different human factors interventions, which ensure that the task, job, and environment are defined judiciously to match human capabilities and limitations. This enduring emphasis on humans and their role in the aviation system, results in the development of error-tolerant systems.

There has been research involving the analysis of a maintenance incident database and the associated incident investigation reports. Although the database and incident reports highlighted the relevance of factors such as inadequate training, poor supervision, and individual factors such as stress and fatigue as causes of maintenance-related incidents, this approach is still very reactive in nature. This approach involved a series of focus groups and interviews with maintenance personnel and their supervisors to ascertain their perceptions of factors that impact on maintenance work. The aviation maintenance industry also invested a significant effort in developing methodologies for investigating maintenance errors. The literature on human error has its foundations in early studies of errors made by pilots (Fitts & Jones, 1947), work following the Three Mile Island incident, recent work in human reliability, and the development of error taxonomies (Swain & Guttman, 1983; Norman, 1981; Rouse & Rouse, 1983; Rasmussen, 1982; Reason, 1990). This research centered on analyzing maintenance accidents and incidents. Figures emerging from the United Kingdom Civil Aviation Authority (CAA) showed a steady rise in the number of maintenance error mandatory occurrence reports over the period 1990 to 2000 (Courteney, 2001). A recent Boeing study of worldwide commercial jet aircraft accidents over that same period showed a significant increase in the rate of accidents where maintenance and inspection were primary factors (cited in ICAO, 2003). The FAA, in its strategic plan for human factors in aviation maintenance through to 2003, cited statistics from the Air Transport Association of America (ATA) showing that the number of passenger miles flown by the largest US airlines increased 187% from 1983 through to 1995. Over that same period, the number of aircraft operated by those airlines increased 70% but the number of aviation maintenance technicians increased only 27%. The FAA concluded that the only way the maintenance program could cope with the increased workload was by increased efficiency at the worker level (cited in McKenna, 2002).

Various airlines also have developed their own internal procedures to track maintenance errors. One such methodology employs the failure modes and effects analysis approach (Hobbs & Williamson, 2001) and classifies the potential errors by expanding each step of a task analysis into sub-steps and then listing all the failure modes for each sub-step. The US Navy Safety Center developed the Human Factors Analysis and Classification System – Maintenance Extension Taxonomy and the follow-up web-based maintenance error information management system to analyze naval aviation mishaps (Shappell & Wiegmann, 1997; Schmidt, Schmorrow, & Hardee, 1998; Shappell & Wiegmann, 2001). Later, this system was used to analyze commercial aviation accidents (Wiegmann & Shappell, 2001). The development of descriptive models of human error and accident causation (Reason, 1990; Senders & Moray, 1991) and the recent adaptation of Reason's model to aviation maintenance (Reason & Hobbs, 2003) are major steps in the right direction. Research on error classification schemes (e.g., Patankar, 2002; Shappell & Wiegmann, 1997) and, more recently, safety culture (Taylor & Thomas, 2003; Patankar, 2003) are some other valuable literature in this area of research. The increasingly sophisticated error classification schemes now in use in the aviation industry recognize the multiple causes of error by providing categories that capture the role of organizational, social, and individual variables. These categories embrace the roles of maintainers, operators, supervisors, as well as various levels of management (e.g., Shappell & Wiegman, 1997). The problem with classification schemes, however, is that there is no causal model embedded in the schemes to show how the linkages within the system operate. Classification schemes, provided they are backed by comprehensive investigation procedures, are very useful for identifying weak points in a system. However, in addition to these schemes, empirical models are needed to illustrate how the parts of the system work to influence outcomes. Another recent example would be the Maintenance Error Decision Aid (MEDA) (Rankin, Hibit, Allen, & Sargent, 2000). This tool, developed by Boeing, with British Airways, Continental Airlines, United Airlines, the International Association of Machinists, and the U.S. Federal Aviation Administration, helps analysts identify the contributing factors that lead to an aviation accident. MEDA was easy to use once it had been implemented – the main problem was MEDA process implementation. MEDA needed a management champion for its implementation at each airline. Consequently, airlines that typically punished maintenance technicians for errors found it harder to implement MEDA than airlines that had not carried out discipline for error. Since the MEDA process is dependent on the erring technician's willingness to be interviewed about the error, anything that would decrease this willingness, such as a fear of being punished for the error, would have a detrimental effect on MEDA implementation.

Attempts have been made to define a core set of constructs for safety climate (Flin, Mearns, O'Connor, & Bryden, 2000). Although not entirely successful in establishing core dimensions, this research is useful in suggesting constructs that should be considered for inclusion in research on maintenance errors. Taylor and Thomas (2003) used a self-report questionnaire called the Maintenance Resource Management/Technical Operations Questionnaire (MRM/TOQ) to measure what they regarded as two fundamental parameters in aviation maintenance: professionalism and trust. The dimension of professionalism is defined in their questionnaire in terms of reactions to work stressors and personal assertiveness. Trust is defined in terms of relations with co-workers and supervisors. Patankar (2003) constructed a questionnaire called the Organizational Safety Culture Questionnaire, which included questions from the MRM/TOQ along with items from questionnaires developed outside the maintenance environment. Following the application of exploratory factor analytic routines to a dataset generated from respondents that included 124 maintenance engineers, Patankar identified four factors as having particular relevance to the safety goals of aviation organizations: emphasis on compliance with standard operating procedures, collective commitment to safety, individual sense of responsibility toward safety, and a high level of employee-management trust.

In addition to the descriptive accident causation models, classification schemes, and self report questionnaires, there is a need for empirically validated models/tools that capture data on maintenance work and provide a means of assessing this data. However, such models and schemes often tend to be ad hoc, varying across the industry, with little standardization. In order to contend with this issue, the devised empirical models and tools are required to employ standardized data collection procedures, provide a basis for predicting unsafe conditions, and design interventions that will lead to reduction in maintenance errors.

Analyzing the effectiveness of maintenance and inspection procedures is of primary importance to accomplish the objective of standardized data collection and to proactively identify the potential factors contributing to improper maintenance. This can be achieved by closely monitoring and evaluating aircraft maintenance and inspection activities. As a part of this evaluation, surveillance of maintenance and inspection activities is conducted in a rigorous fashion by the quality assurance and or control department of airlines. The surveillance, auditing, and airworthiness directives groups constantly monitor and evaluate the flight procedures to determine their level of compliance. The objectives of these groups are achieved through effective functioning of the representatives who perform surveillance and auditing activities. Their findings help in the evaluation and assessment of the internal and external organizations associated with the airline, which influences the safety and airworthiness of aircraft. The surveillance and auditing activities are of foremost importance in ensuring adherence to the quality requirements and also maintaining a consistent level of supervision over maintenance operations.

Surveillance

Surveillance is the day-to-day oversight and evaluation of the work contracted to an airframe substantial maintenance vendor to determine the level of compliance with airline's Maintenance Program and Maintenance Manual. The primary objective of surveillance is to provide the airline, through the accomplishment of a variety of specific surveillance activities on a planned and random sampling basis, an accurate, real-time, and comprehensive evaluation of how well each substantial maintenance vendor is complying with the airline's and FAA requirements. For example, FedEx has a Quality Assurance (QA) representative, stationed at the vendor location who schedules surveillance of an incoming aircraft. The specific task to be performed on an aircraft at a vendor location is available on a work card. The representative performs surveillance on different work cards according to the surveillance schedule. The results are documented and used to analyze the risk factors associated with the concerned vendor and aircraft. The FedEx surveillance department is already using categories to collect the data obtained from a surveillance visit at the maintenance facility.The team used these categories as a starting point in their process to identify the process measures. Some of the categories currently being used by FedEx are in-process surveillance, final walk around, verification surveillance etc. These categories were created based on the various surveillance tasks and the C.A.S.E. (Coordinating Agency for Supplier Evaluation) guidelines that have to be adhered to by the substantial maintenance vendor and the airline.

Audit

Audit is a more formal activity that addresses specific issues. Auditing may be performed at two levels – Internal and Technical audits. Internal audits are those that are performed within and/or across the airline departments. Oversight of functions relating to aircraft line maintenance, ramp operations and aircraft fueling, whether owned by the airline or contracted, is accomplished by a formal system of technical audits performed by qualified technical auditors. The audit manager assigns an auditor and schedules the audit. The auditor selects the audit standards, performs pre-audit analysis, and finally completes the audit. The auditor then reports the findings to the manager.This results in a corrective actions report. These audits are recurrent. Currently, FedEx's team of internal auditors uses categories to group the data that is collected during an internal audit. The categories are built into the checklist used by the auditors. Although not much analysis is done on the data collected, this method presents a good approach to viewing the information collected during an internal audit. A similar approach is used by the FedEx technical audit team for some of their audits.

Airworthiness Directives Control

The Airworthiness Directives Control Group (ADCG) is responsible for the implementation of new, revised, or corrected Airworthiness Directives (AD) appearing in the Federal Register. If the "applicability statement" of an AD refers to an aircraft model and series or engine model and series operated by the airline, or if the AD addresses an appliance or component that could be installed on an aircraft operated by the airline company, the ADCG considers the AD to be initially applicable. A Work Instruction Card (WIC) generated by the ADCG is used by the maintenance personnel to check for compliance with the AD. There are checklists to review the compliance of a WIC. These checklists can be used as a process measurement tool to review each WIC and identify any discrepancies. The findings obtained from these reviews can be used to identify risk factors. Follow up of these discrepancies results in corrective actions.

Given the four above mentioned work functions, the goal of surveillance and auditing activities can be achieved through implementation of a system that documents the processes and outcomes of maintenance activities and makes this documentation more accessible. Thus, there is a need to develop a system that ensures superior performance of these activities. This system should perform the following functions:

1. Seek input from diversified sources
2. Proactively identify contributing factors
3. Promote a standardized format for data collection, data reduction and data analysis within and across the aircraft maintenance industry
4. Generate trend analysis for problem areas (causal factors within and across organizations)

In response to this need, the research team is developing a proactive surveillance and auditing tool to devise strategies that enable identifying future problem areas. The identification of these problem areas will allow the industry to prioritize factors that apply across the industry to systematically reduce or eliminate potential errors. The work is done in collaboration with FedEx in Memphis, TN. The system will be a web-based application (WebSAT – Web-based Surveillance and Auditing Tool) which will initially be developed with FedEx as the aviation partner and later will be made available as an application that can be used by other airlines.

To achieve standardization in data collection, data needs to be collected on certain variables that measure maintenance processes and eliminate existing inconsistencies. These variables are defined by the research team as process measures. The process measures incorporate the response and observation-based data collected during surveillance, audits, and the airworthiness directives control processes. The specific objectives of this research are to:

1. Identify an exhaustive list of process measures that potentially impact aviation safety and transcend various aircraft maintenance organizations.
2. Develop data collection/reduction and analysis protocols to analyze errors for the identified set of impact variables.
3. Develop and implement a surveillance/monitoring tool, using the results of the aforementioned activity, which assures that a consistent level of oversight is maintained.

Once data is captured in terms of these process measures, data analysis can be conducted to identify the potential problematic areas affecting the safety of an aircraft. In this stage of data analysis, the performance of processes and those conducting these processes will also be evaluated.

The current paper focuses on the first phase of the project, which concentrates on the identification of process measures. The various steps taken to identify these process measures are explained in detail in the methodology section. The results section provides details on the various process measures that have been developed and currently being validated by other airlines through a survey. The discussion section presents the various decisions and problems encountered in the development of the process measures.

Methodology

A task analytic and user-centered software lifecycle development methodology was applied to this research. The team started of by gaining a comprehensive view of the different surveillance and auditing processes, their functions, and the different tasks involved in accomplishing these processes. Research was conducted to identify the process measurement variables and performance metrics that potentially impact aviation safety.These performance metrics were termed as process measures. It was ensured that the variables identified were appropriate and were representative of those used by other maintenance entities. This was done by working with other airline maintenance facilities (e.g., substantial maintenance vendors and third party repair stations). The product design and development phase was guided by a user-centered design methodology that enabled the development of tools that perform at a high level in the hands of the end user.The structured approach of contextual design was used to gather and represent information acquired (Beyer & Holtzblatt, 1998).

W ebSAT Phases

The WebSAT research was conducted in three phases:

Phase 1: Identification of Process Measures and Data Sources

- Product planning phase
- Gathering stakeholder data
- Interpreting raw data in terms of customer needs and process measures
- Identify the process measures
- Ensure that the identified process measures are representative of those used by most maintenance entities
- Identify the limitations in using the specific process measures identified

The first phase of the research finalized the list of process measures.

Phase 2: Develop Prototype of Auditing and Surveillance Tool

- Needs analysis phase
- Product specifications phase
- Concept generation and selection phase
- Detailed design of selected concept to create an initial working prototype
- Testing and refinement
- Delivery of a refined prototype to FedEx for trial use

Phase 3: Develop Data Analysis and Validation Module

- Develop advanced data analysis tools that include multivariate analysis and risk assessment.
- Validate using field data.

The details on the current phase (Phase 1) are presented below:

Product planning phase. This phase included the assessment of technological developments and project objectives. The output of the planning phase was a project mission statement that specified a vision for the product, the target market, project goals, key assumptions, constraints, and stakeholders. The mission statement for WebSAT is given in Figure 1.

Mission Statement: Web-based Surveillance and Auditing Tool Prototype

Product Description	• An application, incorporating a recommended categorization and data collection scheme for maintenance auditing and surveillance application; a data reduction module that allows the analysts to conduct central tendency analysis and data analysis module that facilitates trend analysis.
Key Business Goals	• Achieve standardized data collection/reduction and analysis of maintenance errors across the geographically dispersed entities of the airline industry • Develop a proactive system that captures maintenance errors • Generate trend analysis
Primary Market	• FedEx
Secondary Market	• Other airlines in the Airline Industry
Assumptions & Constraints	• SQL server, ASP.NET
Stakeholders	• ·FedEx QA Department • ·Airworthiness Directives Control Group • ·FedEx Technology Group • Other airlines

Figure 1. WebSAT Mission Statement

A product mission statement briefly presents the key customer and user benefits of the product, but avoids implying a specific concept. It summarizes the direction to be followed by the product development team (Ulrich & Eppinger, 2004).To ensure that the appropriate range of development issues was addressed, all WebSAT stakeholders, i.e., the groups of people affected by WebSAT, were identified and listed in the mission statement. This stakeholder list begins with the end user and customer but also includes those people tasked with installing, managing, and maintaining WebSAT.The list of stakeholders helps to ensure that the needs of all who will be influenced by WebSAT are identified and considered in its development.

Gathering of stakeholder data. This phase identified the stakeholders' needs to support the performance of maintenance activities. The methods used to collect this data included interviews, focus groups, observations of the use of the existing system, and the analysis of documentation describing current procedures and regulations for maintenance auditing.

Interpretation of the raw data in terms of customer needs and process measures. The verbatim statements of the stakeholders and the information gleaned from observations of the existing process and documentation was used to understand the process as a whole. This allowed the WebSAT team to brainstorm on the process measures that would evaluate the various work functions of surveillance, auditing, and airworthiness directives group. The identified process measures were validated through a survey.The details on this phase are presented in the "Data Collection" section in this paper.

The information from the data gathering sessions will be translated into a set of user need statements and a task description. The need statements express stakeholder needs in terms of what an improved human-machine system has to do, but not in terms of how it will be done. The needs will be organized into a hierarchical list of primary and secondary needs using affinity diagramming. The primary needs are the most general categories, while the secondary needs express specific needs in more detail. The task description will be used to develop a set of representative task scenarios and to perform a detailed task analysis. A task scenario describes activities, or tasks, in a form that allows exploration and discussion of contexts, needs, and requirements with users. It avoids making assumptions about the details of a particular interface design. The task analysis assists in the identification of the specific cognitive and manual processes critical in the performance of the auditing task, as well as existing human-machine system mismatches leading to inefficiency and error (Gramopadhye & Thaker, 1998; Hackos & Redish, 1998).

Data collection

There are methodologies to collect and interpret information on process measures. The choice of a particular methodology is based on factors such as the type of data to be gathered, the manner in which the data is applied, and the time available for data collection. The methodology employed has a direct effect on the quality and value of the information collected. The team adopted interviews, as they are a suitable strategy to meet the airline managers. It also allowed the WebSAT team to take a first-hand look at the stakeholders' work environment and collect useful documents. It provided the stakeholders with an opportunity to put a face to the names involved in the research project. Observation sessions are important to understand how aircraft maintenance is done and to see how the maintenance personnel carry out their day-to-day work. Since the airline industry is a highly regulated industry, it was easier for the team to learn more about the industry by reading relevant procedural manuals. The team used questionnaires in a web survey subsequent to the interviews, focus groups, and observation sessions. This allowed the team to evaluate (remotely) the appropriateness of the identified process measures with FedEx and other airlines.

Procedure for initial data gathering

The team sought Institutional Review Board approval (IRB Protocol #40159) before beginning the trips to conduct interviews. The research team established the agenda for each visit, and got in touch with the concerned personnel via e-mail and telephone at least two weeks before the meetings. The team then e-mailed the personnel concerned with each visit with an agenda for the meeting, valid questions that the research team would plan to ask on the day of meeting, and an estimated time for each meeting. A time was finalized two days before the departure of the research team. The managers, quality assurance representatives, and the personnel associated with the daily repair and maintenance of the aircraft allowed the research team to have access to documents if the team found a certain document necessary for in-depth study, at their own research laboratory.The FedEx personnel were more than helpful in this regard.

Subjects for initial data gathering

The interview sessions, observation sessions, and the documents were the initial methodologies used to gather data for the first phase of the project. This data was used to finalize an initial WebSAT framework as shown in Figure 2.

The WebSAT framework strategy for the research revolved around three tiers. As seen in Figure 2, the first tier involved the collection of data with respect to work functions of surveillance, auditing (internal & technical), and airworthiness directives. Once the data involving the maintenance of an aircraft was gathered from these sources, they scrutinized with respect to the process measures. In the next stage, tier 2, the analysis of the relevant data was categorized. In the final tier, tier 3, another analysis categorized the variables into risk (impact variables), and non-risk variables.

The initial data also conveyed to the team the expectations of the personnel who were finally going to use the product. This data gave the team an insight into the utility of the process measures. For this initial phase, the subjects who were interviewed and observed in their work domain setting were quality assurance representatives from the surveillance, internal audit, technical audit, and the airworthiness departments at FedEx. The team conducted at least five sessions at the vendor facility at Mobile, AL, and the FedEx headquarters at Memphis, TN. The team also conducted phone interviews with FedEx personnel.

Procedure for the survey

Following the initial data gathering, surveys were conducted in two phases to validate the data gathered. In the first phase, there were four different surveys: one each for surveillance, internal audits, technical audits, and the airworthiness directives. The team sent out a detailed e-mail to all the participants regarding the survey, which had instructions on how to take a survey.All the four surveys provided a link to a definitions document, which explained what the process measures are and how they have been defined by the team. The e-mail also provided the participants with the contact information of the research team. The first survey was completed by all the participants at FedEx in 14 days. The feedback was utilized to refine the process measures definitions, and the scope of data being gathered by each process measure. The next seven days were utilized to refine the identified process measures based on the input obtained from this survey. In case the team needed some clarification in their decision making process, they made a conference call with the work function manager for clarification. The refined process measures were used to send out the next survey to other partnering airlines. The second phase of the survey with the partnering airlines is being conducted at present, and the research team is awaiting the results.

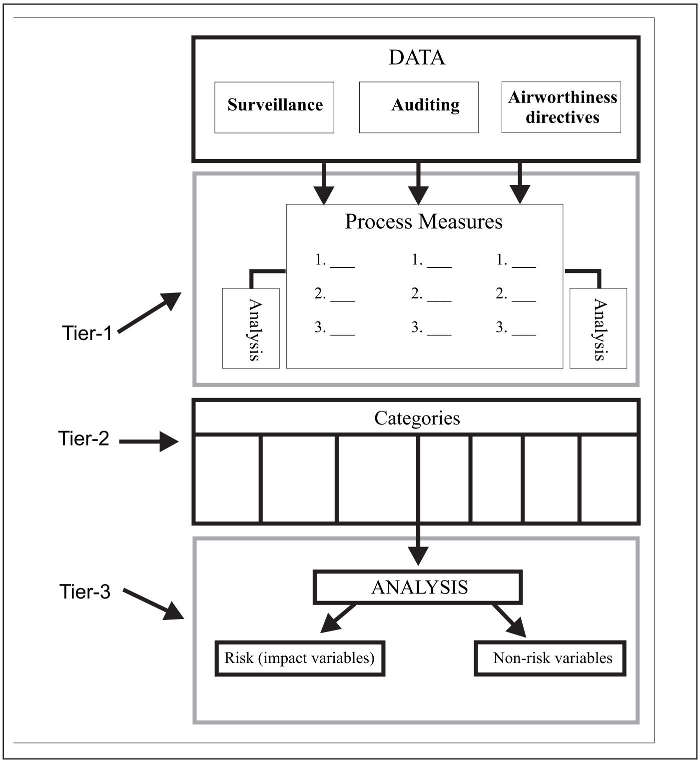

Figure 2. WebSAT framework.

Customer selection matrix for the survey

There were three kinds of users. The first kind was subjects in the managerial positions, who would be involved in intricate data analysis. They used findings, information, and data from their respective work domains and departments to keep a vigil on the proceedings in the organization and their own departments. The second kind of users was subjects who work under these managers. Their involvement was on a daily basis, and involved subjects from the surveillance departments. The third kind of user was auditors and personnel from airworthiness directives departments, who do not use the product on a daily basis, but as and when the need arises for some sort of data evaluation. The customer selection matrix is presented in Figure 3.

Market/Users	Managers	QA Representatives	Auditors / AD personnel
Surveillance	2	4	--
Internal Audit	1	--	5
Technical Audit	1	--	5
Airworthiness Directives	1	--	5

Figure 3. Customer Selection Matrix for the WebSAT survey.

Subjects for the survey

There were six subjects including the manager for each work function and hence a total of 24 subjects from the Quality Assurance department of FedEx who were randomly selected for the first iteration to finalize the appropriateness of the process measures. Definitions were refined based on their inputs to the survey. Twenty subjects from other partnering airlines were asked to take a survey to further validate the research team's findings on the process measures.

Survey design

The survey was designed to last a maximum of 60 minutes for each of the three work functions: surveillance, auditing, and airworthiness directives. The questions were of two kinds. There were Yes or No response questions, and open-ended questions. Irrespective of the nature of the questions, each question had a field for the comments of the personnel taking the survey. The reason for this was that the team wanted detailed feedback from the subjects taking the survey because of the regulated nature of the aviation industry. The team felt that if there were aspects which the subjects were not in agreement with the research team, the team wanted a detailed explanation from the subjects. See Figures 4a and 4b for survey screenshots.

All the participants of the survey were given the same set of questions. The participants taking the survey were not identified. With no identifiers, the WebSAT team would not know if the responses were from a manager or some other personnel lower on the hierarchy. Each survey had a link to an individual definitions document for each work function, which provided the detailed definitions and scope of each process measure. The initial part of the survey asked the participants on how they performed their day-to-day work routine. It also asked if the participants categorized their current work processes. Further into the survey, the questions became more specific to the process measures and their utility to the participants. The participants also were asked to rate the importance of each process measures. The survey also included questions on the redundancy, functionality, and purpose of the process measures as presented in the definitions document. The survey included 21, 14, 7, and 5 questions for the surveillance, technical audits, internal audits, and airworthiness directives survey, respectively.

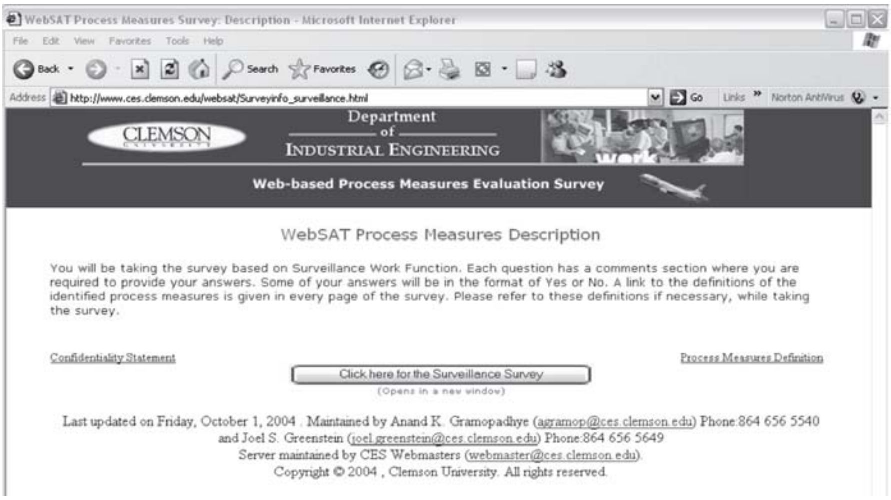

Figure 4a. Survey Screenshot – First screen the participant sees before taking the survey.

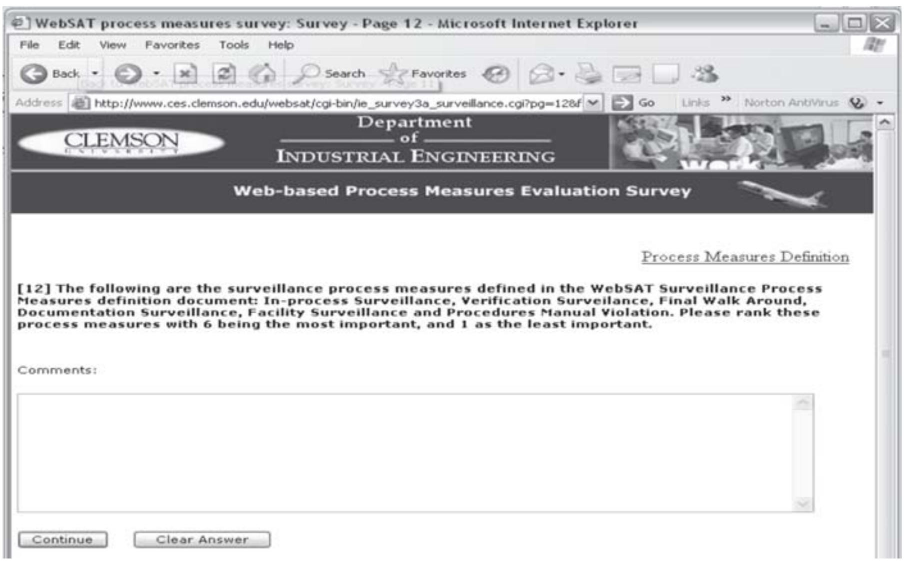

Figure 4b. Survey Screenshot – Questions' screen.

The programming effort required HTML, PERL scripting, and the usage of the cgi-bin on the Clemson engineering systems network. The data in terms of responses were stored in text files (.txt) with the date stamp in the cgi-bin.

Results

The identified process measures for different processes are given below:

Process measures for Surveillance

1. In process Surveillance: It is the act of observing a maintenance task that is currently in work. The on-site surveillance representatives will select certain work cards, AD driven work cards, EOs, EAs, and non-routines and observe the task being accomplished by the vendor mechanic or inspector to ensure competency, correctness, and adequacy of the customer's paper work to complete the task.
2. Verification Surveillance: It is the re-inspection/re-accomplishing of completed work cards, AD driven work cards, EOs, EAs, and non-routines that are signed off by the vendor personnel as "Complete." No additional reopening of access panels that have been closed or disassembly of the aircraft or assistance from vendor personnel will be required unless poor workmanship or other conditions are evident during the surveillance.
3. Final Walk Around: It is a surveillance of the aircraft at the end of the scheduled maintenance event that checks the general condition of the aircraft usually after the vendor has completed the work scope assigned. For example: obvious safety, legal fitness, airworthiness items, general condition, cleanliness, and completeness of the aircraft's cockpit, lavatory, landing gear wheel wells, and that all access panels are properly installed and there is no indication of fuel, oil, or hydraulic leaks.
4. Documentation Surveillance: This surveillance is performed on the vendor's documented system to validate the quality control, technical data control, inspection, and work-processing programs, as presented in C.A.S.E. standard 1-A (Revision 45- 1/7/2004). The vendor should be able to provide the required documents and certificates upon request.
    a. Certifications: This surveillance ensures that the certification program includes certificates, operations specifications, licenses, repair technician certificates, anti-drug and alcohol misuse program certificates, registrations, and capabilities listing required by the Code of Federal Regulations for any individual, equipment, or facility. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 2.
    b. Quality Control: This surveillance ensures that the quality control program includes procedures and operations, which must be described in a quality control manual or other appropriate document. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 3.
    c. Inspection: This surveillance ensures that the inspection program includes procedures to maintain an up-to-date roster of supervisory and inspection personnel who are appropriately certified and are familiar with the inspection methods, techniques, and equipment that they use. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 4.

d. Technical Data Program: This surveillance ensures that the technical data program requires all the maintenance operations to be accomplished in accordance with customer's manuals. It also ascertains that the vendor has a documented system to maintain current technical data and a master copy of each manual. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 6.

e. Work Processing: This surveillance ensures that there exists a documented system for all the programs and procedures that the vendor adopts for training, identification of parts, and use of appropriate tools, and keeping the equipment in good condition to perform a maintenance task. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 13.

f. Tool/Test Equipment: This surveillance ensures that the tools and the test equipment used by the vendor for maintenance are frequently calibrated to the required standards. It also ensures that the tools and the test equipment program includes identification of tools and test equipment, identification of individuals responsible for the calibration, accomplishment of periodic calibrations, and applicable tolerance or specification. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 8.

5. Facility Surveillance: This surveillance is performed on the vendor's facility to validate the shelf life control, housing and facilities, storage, and safety/ security/fire protection programs, as presented in C.A.S.E. standard 1-A (Revision 45- 1/7/2004). The vendor should implement programs to maintain the facility and prevent damage, material deterioration, and hazards.

   a. Shelf Life Control: This surveillance ensures that the vendor describes in their manual a shelf life program, procedure, and a detailed listing of parts and materials, which are subjected to shelf life. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 7.

   b. Storage: This surveillance ensures that the vendor identifies, maintains, and protects parts and raw materials during a maintenance event. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 12.

   c. Housing and Facilities: This surveillance ensures that the vendor houses adequate equipment and material, properly stores supplies, protects parts and sub-assemblies, and ensures that the facility has adequate space for work. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 10.

   d. Safety/Security/Fire Protection: This surveillance ensures that the vendor provides adequate safety, security, and fire protection at the maintenance facility. For detailed instructions and a description, refer to C.A.S.E. standard 1-A section 11.

6. Procedures Manual Surveillance: This surveillance ensures that the vendor is complying with the requirements set forth in the customer maintenance manual, and the compliance requirements presented in the vendor Inspection Procedures Manual (IPM) or Repair Station Manual (RSM).

a. Customer Maintenance Manual Compliance: This surveillance requires the vendor to comply with programs, documented procedures, and standards described in the customer maintenance manual.
b. Vendor Inspection Procedures Manual Compliance: This surveillance ensures that the vendor complies with programs, documented procedures, and standards described in the vendor IPM or RSM.

The other data capturing modules in surveillance, which facilitate capturing of the data but are not process measures of the surveillance work function, are given below:

1. Additional Findings Module: This module documents additional information pertaining to surveillance work domain. However, the categories in this module listed below do not hold the vendor responsible for the findings obtained. This module helps the surveillance representatives to document any information both technical and non-technical, beyond the work scope of the scheduled maintenance event. Note: Although these categories are not process measures, the findings obtained from this module are documented and reported through WebSAT.
   a. Information: It includes the surveillance activities and data that the on-site surveillance representative needs to document for informational purposes.
   b. Aircraft Walk Around: This surveillance category is to be used only for those technical findings that cannot be traced to a scheduled maintenance task and are beyond the current work scope of the scheduled maintenance event.
2. Fuel Surveillance Module: The fuel vendor surveillance module evaluates the fuel vendor's operational system, fueling equipment, records, and the quality of the fuel.

Process Measures for Internal Audits

1. Administration: This process measure ensures the departments' ability to manage up-to-date documented systems and ensure the adequacy of various programs followed in-house.
2. Training: This process measure ensures that the employees of the departments within the organization are trained properly, and have the required certification to perform operations.
3. Records: This process measure ensures that the required records are made available for review by the departments within an organization.
4. Safety: This process measure ensures the overall safety aspect of the departments within an organization.
5. Manuals: This process measure verifies the technical data, manuals, and forms provided by the departments within an organization.
6. Procedures: This process measure ensures that the maintenance and flight operations departments adhere to federal aviation

regulatory guidelines and company departmental policies while executing various operations within each program.

Process Measures for Technical Audits

1. Compliance/ Documentation: This process measure verifies documentation systems, authorization of personnel and administration requirements of vendors and sub-contractors. The process measure includes items such as quality programs, manuals and forms control, list of authorized persons, certification, certificate forms, etc. Listed below are some of the items that may occur in a technical audit checklist and will be evaluated by this process measure.
   a. Quality programs
   b. Certification
   c. Certificate forms
   d. Internal audit and surveillance
   e. Manuals and forms control
   f. Paper work control
   g. Administration requirements
2. Inspection: This process measure verifies the certification of the inspector, the existence of acceptable sampling procedures of parts, compliance of parts to specifications, and the validity of the inspection stamps at the vendor location. Listed below are some of the items that may occur in a technical audit checklist and will be evaluated by this process measure.
   a. Fuel inspection (Fuel truck inspection, Fuel farm inspection, Hydrant inspection)
   b. Inspection programs
3. Facility Control: This process measure verifies the vendor facility for shelf life control, housing and facilities, storage, and damage protection programs. Listed below are some of the items that may occur in a technical audit checklist and will be evaluated by this process measure.
   a. Housing and facilities
   b. Material control and storage
   c. Segregation of parts
   d. Packaging
   e. List of shelf items
   f. Practices to prevent damage and cannibalization
   g. Shelf life control and material storage
4. Training and Personnel: This process measure verifies that the vendor employees are properly trained, and have the required certification to perform operations. It also verifies the supervisory personnel, inspection personnel, return-to-service personnel, and personnel responsible for various programs in the facility like shelf life, technical data, calibration etc. Listed below are some of the items that may occur in a technical audit checklist and will be evaluated by this process measure.

a. Employee training
b. Verification of personnel
c. List of authorized personnel

5. Procedures: This process measure verifies that the vendor adheres to regulatory guidelines while executing various operations within each program such as shipping procedures, NDT evaluations, and Aircraft deicing programs at the vendor facility. Listed below are some of the items that may occur in a technical audit checklist and will be evaluated by this process measure.
   a. Shipping procedures
   b. Tool and test equipment (calibration & measurement) and procurement
   c. Scrapped parts
   d. Work processing
   e. Processing
   f. Process control
   g. NDT evaluation
   h. Precision tool control
   i. Aircraft anti-tipping and tether maintenance
   j. Aircraft deicing program
   k. Weight and balance
   l. Weighing scales
   m. Ramp operation Note : The findings of ramp activities related to administration requirements, employee training, and dangerous goods are not included in this process measure - 'Procedures.'
6. Data Control: This process measure verifies the availability of up-to-date technical data for parts at the vendor's facility. It also verifies the identification of parts to their testing records and validates the fuel audit records. Listed below are some of the items that may occur in a technical audit checklist and will be evaluated by this process measure.
   a. Technical data control
   b. Record keeping
   c. Fuel records (Fuel facility records, Fuel vehicle records, Pipeline fuel receipt records, Transport truck fuel receipt records)
7. Safety: This process measure observes the safety of the vendor facility. Listed below are some of the items that may occur in a technical audit checklist and will be evaluated by this process measure.
   a. Safety
   b. Fire protection
   c. Fire protection and flammable material protection
   d. Aircraft maintenance procedures
   e. Dangerous goods

Process Measures for Airworthiness Directives

1. Information Verification: This process measure validates the information presented on AD-related EO/WIC, manuals, and other

documents involved with the compliance of airworthiness directives. It also verifies information related to the AD status reports.

2 Loading and Tracking Verification: This process measure verifies the adequacy of the activities involved in the loading and tracking of airworthiness directives, including inspection intervals.

This survey was an attempt to understand if the identified process measures entirely capture all the relevant data from each department and clearly communicate their purpose. Hence, the data was mostly subjective generated from 'Comments' section. This paper does not report any quantitative analysis of data. However, there were questions in binary form that give the number of responses, which indicate complete satisfaction with the identified measures.

The results from the first survey, which were utilized in refining the identified process measures, have shown that these process measures evaluate the respective work functions precisely. In surveillance, four of the six responses (66.7%) indicated that these process measures were precise to evaluate surveillance process. However, two responses indicated that the metrics in the additional findings module – "information" and "aircraft walk around" needed to be incorporated as process measures rather than other modules. For internal audits, two responses of the six (33.3%) have indicated that the process measures do not capture data from the Air Transport Oversight System (ATOS) and hence do not capture the data relevant to the internal audits department in its entirety.The results obtained from technical audits have indicated that these process measures capture all the relevant data from the technical audit department and also communicate the purpose of each measure appropriately. However, one response indicated in the comments section that the process measure compliance/documentation should also verify the regulatory compliance and documentation standards of sub-contractors of the airline. All of the responses for airworthiness directives have indicated that the given process measures capture all the data relevant to ADs.

Discussion

There were 17 process measures initially in the surveillance work function. The interaction of the research team with the quality assurance personnel from this work function provided the team with the insight that 17 is a very large number for humans to remember. In spite of training, it could be a difficult task to accomplish on the shop floor. Moreover, the surveillance representatives are more focused on issues directly related to the aircraft than capturing data for later analysis. For example, if a discrepancy or defect is identified by a representative that has not been fixed by the vendor personnel, the representative's primary attention is focused on trying to fix the defect rather than collecting data on this issue. Although the surveillance representatives perform data collection on a daily basis, it is a secondary task to them, where the primary task is to attend to the safety of the aircraft that is ready to leave the maintenance facility. On the other hand, the perception of the managers is different from that of the quality assurance representatives. They want the representatives to record data from different work cards on which they perform surveillance. They are concerned that an adequate sample of data acquired from the surveillance activities performed by the representatives needs to be recorded to facilitate data analysis. Hence, the managers felt that 17 was an optimum number of process measures to capture data on all the aspects of surveillance. With this scenario, the team had to strike a balance between the perception of the managers and the representatives to come up with a reasonable number of process measures.

Considering human limitations on processing information, the team adopted a total of six process measures for surveillance, which fall in the range of seven plus or minus two (Miller, 1956). Further, there are two other modules that capture data from surveillance work function. However, these are not process measures that are required to be memorized by the QA representative. There are often anomalies in deciding into what process measure a particular work card would fall. Though the definitions of the existing process measures were not ambiguous to the managers, they often were confusing to the representatives. In view of these things, the research team tried to eliminate the ambiguity by reducing the number of process measures and incorporating sub-categories in some of these process measures. This allowed the representative to choose from the given options, rather than memorize them. For example, the research team identified a new process measure called "Facility Surveillance" and incorporated the currently used measures like 'Housing & Facilities', 'Shelf Life Control,' and others that have been borrowed from C.A.S.E. standards as sub-categories in this primary measure. Additionally, a lot of ambiguities in choosing a process measure for a given discrepancy arising from procedures manuals violation used by the vendors and the company and that of C.A.S.E. standards were identified. Further, the quality assurance personnel of the company have to be aware of the details in the procedures manuals of vendors at different locations and the company's manual. In order to assist the personnel in this regard, the research team combined these two measures in to one measure called "procedures manual violation" so that the data can be captured consistently into one process measure. There are advantages of having both these process measures because it provides the managers with an insight into the vendors' regulated procedures and the discrepancies that exist between vendors' and company's procedures. Hence, 'Vendors Inspection Procedures Manual' and 'Company General Maintenance Manual' are provided as sub-categories in the Vendor Inspection Procedures Manual. The survey results showed that the participants perceived no ambiguities in the identified process measures.

"Additional Findings" module further has two sections in it namely 'Information' and 'Aircraft Walk Around.' Information includes the surveillance activities and data, which the on-site surveillance representative needs to document for informational purposes and does not, necessarily, hold the vendor against these occurrences. For example, this data could provide details on a discrepancy identified in the company's own manuals, which would eventually help the company to refine it for future use. The other section, 'Aircraft Walk Around' captures data on any technical anomalies found on an aircraft, which are beyond the scope of the scheduled maintenance event. Every attempt has to be made by the surveillance representatives to make sure that the finding is not part of the scheduled maintenance event and hence cannot be measured by the process measure-verification surveillance. This metric also does not hold the vendor responsible for the finding because his scope.

As mentioned earlier in the results section, two responses indicated that 'Information' and 'Aircraft Walk Around' needed to be considered as process measures rather than a different module. They have also indicated that these measures help the representatives to document any important information related to the maintenance event and bring it to the notice of the managers. However, after carefully understanding the rationale behind this alternative, the research team reached a consensus to retain them in an additional findings module for two reasons: 1) the vendor is not held responsible for these findings; 2) the data can still be collected and analyzed to report the findings. Hence, these do not measure the process but are events that need to be recorded for later reference.

The fuel surveillance module has been identified by the team as a different module and not necessarily a process measure. Facilities in which fuel surveillance takes place will record the data in this module. Also, from the knowledge gained by the research team it is understood that fuel surveillance is done only in a few locations. Additionally, this fuel data is collected during the routine annual audit.

For internal audits, the team carefully discerned the existing measures and reached a consensus that these adequately capture the relevant data to measure the process in the internal audits department. Two responses of six in the survey have indicated that the process measures do not capture data from ATOS. The team did not take into consideration those measures, which look into ATOS because of the project scoping issues. The team identified that ATOS was not mandatory to a company, however, was a very good business practice. This supported the team's decision on not implementing ATOS in WebSAT. Hence, the team went ahead to the next survey with other airlines incorporating the existing number of six process measures.

The technical audits group did not have any process measures in place but had several checklists for various types of vendors. The questions in this checklist were process specific and were grouped into categories based on the requirements they address. The research team tried to understand the nature of these checklists and grouped various categories into process measures. The basis for these process measures are C.A.S.E. standards. The team addressed all the checklists that are related to the technical audits group. There are fuel, maintenance, and ramp audit checklists on one hand and there are other checklists for various types of suppliers. The identified process measures evaluate the standards and procedures of suppliers, fuel vendors, and ramp operations at a system level and ensure the compliance with FARs, and established company policies and procedures. All six respondents in the survey commented that these process measures effectively evaluate the technical audits process and also clearly communicate the purpose. They also indicated that there are no ambiguities in these process measures.

The responses from the airworthiness directives department indicated that the process measures capture all the relevant data in the AD department regarding the AD control process. The responses also indicated that there are many tasks assigned to AD group that are only remotely associated with AD control process and hence the process measures cover only the AD control process but not the other activities assigned to the group. This information indicated that the identified process measures adequately evaluate the AD control process.

The team sought an importance rating on the identified process measures for each of the work functions. Although, some of the respondents indicated the importance rating, from a safety perspective it was identified that all these process measures are equally important and hence cannot be ranked. All the process measures are required, equally, to evaluate the respective processes effectively and efficiently. For example, in AD group, if the process measure 'information verification' shows that the information is good but the loading and tracking is not done correctly in the computer, the process will fail as the work will not be done per the time constraint. On the other hand, if the information is bad and gives improper work instructions to the maintenance technician but it is loaded and tracking correctly in the computer, the process will fail as the work will be done within the deadline but it will be done incorrectly.

Conclusions

The survey provided a qualitative approach of validating the identified process measures. The definitions of these process measures were refined based on the inputs provided by the participants in FedEx. The results obtained from the second survey should further validate these process measures, which would eventually achieve standardized data collection through WebSAT across the aviation industry.After the completion of the first phase, the team will go ahead with Phase 2, which is the tool development.

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The Effects of Nighttime and Deteriorating Visual Conditions on Pilot Performance, Workload, and Situation Awareness in General Aviation for both VFR and IFR Approaches

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Abstract

A laboratory experiment was performed to better understand the effects of visual conditions on pilot performance, workload, and situation awareness during a simulated approach to a regional airport for both VFR and IFR flights. Eight VFR-only pilots and eight IFR-rated pilots performed landing approaches during daytime, nighttime, favorable weather, and deteriorating weather conditions using a medium-fidelity flight simulator. Few differences were found between VFR-only and IFR-rated pilots, or within each of the two pilot groups, in terms of objective flight performance. However, key differences in workload and situation awareness were exhibited between VFR-only and IFR-rated pilots, and within the two pilot groups, when conducting an approach under varying environmental conditions (nighttime, deteriorating weather). Understanding these performance differences in pilots during VFR and IFR helps inform the design of technologies to meet the demand of future aviation challenges.

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Introduction

Numerous flight simulator studies in the laboratory have been performed to study pilot performance in support of future General Aviation (GA) environments that involve the concept of free flight and the emergence of new technologies. Free flight is defined as "a safe and efficient flight operating capability under instrument flight rules (IFR) in which the operators have the freedom to select their paths and speed in real time" (e.g., Braune, Jahns, & Bittner, 1996, pp.102-105; Scallen, Smith, & Hancock, 1996, pp.68-76). In this operating system, the pilot/aircraft system is responsible for the air traffic control function and the aircraft itself will be able to 'self-separate' from other traffic in the vicinity. In the future GA environment, the role of the pilot will change from a manual controller to a supervisory controller. This gradual change requires thorough human factors research in order to ensure the safe transition to free flight (Braune et al., 1996) and to integrate new aviation technologies that will support these future aviation environments. This present study examined the current GA environment (specifically, final approach) and helped provide baseline data for future research that may examine new aviation technologies, for example. In this experiment, of interest was how the introduction of poor weather conditions and nighttime operations affected pilot performance, workload, and situation awareness for both pilots who fly by visual flight rules (VFR) and IFR. The difference between VFR-only and IFR-rated pilot performance was an important factor to consider in relation to the design of future aviation technology and systems. That is, IFR-rated pilots can be regarded as having a higher degree of training than VFR-only pilots, and technology used during instrument meteorological conditions (IMC) when flight is controlled only by reference to instruments, not outside visual information, can be regarded as further along the technological continuum than technology used during visual meteorological conditions (VMC).

Previous literature suggested that there is less risk during the approach and landing phase of IFR flights as compared to VFR flights (Bennett & Schwirzke, 1990; Bennett & Schwirzke, 1992). In fact, the data suggested that there is a two-times greater accident risk for VFR flights during these operations. The authors' finding was based on the analysis of accident data as reported by the National Transportation Safety Board (from 1979-1988) and the Statistical Handbook of Aviation (U.S. Department of Transportation). Bennett and Schwirzke (1992) also found that single pilot IFR accident rate during nighttime is almost 8 times the accident rate of day IFR approaches and 2.5 times the accident rate of day VFR approaches.

Wilson and Hankins (1994) measured pilot workload in an actual flight experiment using a Piper Arrow general aviation aircraft. The authors compared several segments of both IFR and VFR flights (e.g., VFR takeoff, VFR climb out, VFR cruise, VFR landing, IFR cruise, IFR hold, IFR landing). Using brain wave measures (EEG) and subjective ratings (NASA-TLX), the authors found a higher level of pilot workload with the subjective ratings during IFR approaches than VFR approaches. In a similar field test using a Piper Arrow aircraft, Wilson (2002) generally found higher levels of workload for pilots during IFR flight segments (especially IFR instrument landing system tracking) than during VFR flight segments using both psychophysiological measures (EEG, heart rate, eye blinks) and subjective ratings.

The current study examined objective pilot performance, workload, and situation awareness for both VFR and IFR flights during final approach with several hypotheses. First, significant differences in performance, workload, and situation awareness were not expected to be observed for IFR-rated pilots across weather conditions as IFR-rated pilots often rely on their instrumentation during an approach and not the external view for the visual portion of the approach. However, IFR-rated pilots were expected to experience poorer performance, greater workload, and reduced situation awareness for night operations. This hypothesis was based on previous accident statistics that suggest single pilot IFR accident rate during nighttime is almost eight times the accident rate of day IFR approaches (Bennett & Schwirzke, 1992). VFR-only pilots were expected to show poorer performance, greater workload, and reduced situation awareness in deteriorating weather conditions *and* in nighttime operations as these are major causes of GA VFR accidents (e.g., Goh & Wiegmann, 2001; Leland, 2001; O'Hare & Smitheram, 1995). Previous research suggested that poor pilot situation assessment is a major contributor of VFR flights into adverse weather conditions (Wiegmann, Goh, & O'Hare, 2002).

Finally, VFR-only pilots were expected to have poorer flight performance, greater workload, and reduced situation awareness compared to the IFR-rated pilots since IFR pilots undergo greater training and can rely on their instruments during nighttime and poor weather conditions. Much of a pilot's ambient vision (peripheral visual information) is lost at night (e.g., Mertens & Lewis, 1982; Leland, 2001), suggesting that VFR is more dangerous than IFR during nighttime operations. The loss of perception of the horizon and motion cues during night VFR suggests lower situation awareness (Leland, 2001). In contrast, instrument training disciplines a pilot in attention management and disciplines a pilot to ignore false sensory perceptions and "believe" in the instruments (Leland, 2001). VFR-only pilots would also seem to be at a disadvantage when interpreting changing weather conditions compared to IFR-rated pilots. The gradual transition from minimum visual meteorological conditions (VMC) to instrument meteorological conditions (IMC) could make discrimination of weather conditions difficult for VFR-only pilots (Goh & Wiegmann, 2001).

This study was part of a larger research endeavor that examined human-machine performance in a GA environment using a combination of laboratory experimentation and field study (Saleem, 2003). This paper reports on the laboratory results from this larger research effort.

Method

Participants

A total of 16 pilots, eight VFR-only pilots with no instrument training (outside of the nominal instrument training received during the instruction for a basic private pilot's license) and eight IFR-rated and current (as defined by Federal Aviation Regulations) pilots, were recruited for the laboratory study. Participants were at least 18 years of age and participation was equally available to both males and females. In addition, all participants possessed a pilot's license and pilots performing instrument approaches were IFR certified and current. Each participant's prior flight experience was recorded (VFR, cross-country, IFR, simulated, and total hours). No other exclusions were used in selecting participants.

Apparatus

The flight simulator used for this study was the 'iGATE', which is manufactured by FlyELITE and is FAA certified for IFR instruction. The iGATE is comprised of an instrument panel with a flat-screen monitor on which all items except the radio stack and control elements are depicted. The iGATE can be configured to simulate several different GA aircraft; for this experiment, it was configured to portray the instrument panel of a Cessna 172. Out-of-window view was limited to the upper-third portion of the 19-inch flat-screen simulator monitor (1024 x 768 resolution with 16-bit color). Relative motion of moving through the elements such as clouds and fog are given by slight color changes in the out-of-window view.The runway appears gradually out of low visibility conditions. Since the flight simulator did not have a peripheral out-of-window view, VFR approaches were a direct approach to the runway without entering a traffic pattern.

The system is equipped with an 'experimenter's station' in the form of a PC located outside the testing room which is connected to and controls aspects of the simulation. Live video of the simulator room was captured using a camera and was presented on a video monitor located next to the experimenter's station. The walls of the simulator room were lined with acoustical foam. Realistic aircraft sounds, produced by the simulator, predominately engine noise, were channeled through an amplifier and were presented through two speakers at a sound pressure level of 85dBA to approximate the actual engine noise of a Cessna 172. Participants wore an active noise reduction aviation headset during the experiment to minimize noise exposure and add realism to the simulation.

Procedure

Experimental design and independent variables. The flight simulator experiment followed a 2x2x2 mixed-factors design. The three independent variables were pilot type, daytime/nighttime, and weather. Pilot type, VFR-only and IFR-rated, was a between-subjects factor. Daytime/nighttime and weather conditions were within-subjects factors.

The two levels of weather were static, clear weather and dynamic, deteriorating weather.The static, clear weather level represented ideal weather conditions using unlimited ceiling and visibility. During daytime, this weather level served as the control. The dynamic weather level started with visual meteorological conditions (VMC) and deteriorated quickly to instrument meteorological conditions (IMC). Specifically, cloud ceiling above ground level and visibility began at 5000 feet / 5 miles respectively and deteriorated to 4000 feet / 2 miles during the simulation over the course of the approach.

The simulated task for the IFR-rated pilots was an instrument approach procedure with a Cessna 172 (depicted by the iGATE flight simulator) to the Roanoke Regional Airport (Runway 33). VFR-only pilots performed a visual landing approach to the same airport and runway.

Participant familiarization. Before the experimental session, for purposes of familiarization/training, participants flew simulated daylight approaches to the Roanoke Regional Airport (Runway 33) with unlimited ceiling and visibility using a three-degree approach angle. The training criterion was achieved after the pilot demonstrated two consecutive successful landings. However, the pilot was allowed to continue the familiarization session for up to one hour. A training criterion of two consecutive landings was established such that pilots could demonstrate at least an ability to successfully control the flight simulator in ideal flying conditions. All participants met the training criterion. The average number of trials required for completion of the familiarization training was 2.5 (SD = 0.53) for the IFR-rated group and 3.25 (SD = 1.16) for the VFR-only group. After participants completed the familiarization procedure, they were given a ten-minute break before the experimental trials began.

Experimental session. Beginning at a predetermined distance from the airport (i.e., ten nautical miles), both pilot types performed landing approaches using a three-degree approach angle with each of the four treatment combinations of weather and day/night. The starting altitude for each scenario was 2722 feet above ground level. Thus, pilots were never above the ceiling. Rather, deteriorating visibility (from five to two miles) was the limiting factor. The instrument landing system (ILS) was not disabled for the VFR-only pilots. In order to reduce the effects of practice on the experimental outcome, the treatment conditions were randomly assigned for each participant. Each treatment combination consisted of two consecutive runs (i.e., two landing approaches). Thus, each participant performed a total of eight landing approaches. Pilots were instructed to land only if they felt it was safe to do so. Otherwise, they were instructed to performed a 'go-around' or divert to another airport. Each landing run was completed and the simulation frozen upon a successful landing or if it became apparent that the participant intended to abort the landing.

Data collection / dependent measures. Objective flight-performance data from each participant's flight scenario (such as deviation from flight path) was automatically collected by the simulation software and written to a local file on the experimenter's computer. Several flight-performance variables are automatically collected by the simulator software. From these variables, the following measures were analyzed: total time, flight path angle, heading, pitch angle, roll angle, altitude, ground speed, indicated airspeed, vertical speed, ILS glideslope course deviation indicator (CDI), ILS localizer CDI, throttle input, flap deflection.

Subjective workload was assessed using the Modified Cooper-Harper (MCH) scale. The MCH was chosen as it was found to be sensitive to changes in workload across all types of pilot activities (Casali & Wierwille, 1983, 1984;

Wierwille & Conner, 1983; Wierwille, Rahimi, & Casali, 1985). The Situation Awareness Rating Technique (SART) was used as a measure of situation awareness for this study. Other measures of situation awareness include the Situation Awareness Global Assessment Technique (SAGAT) (e.g., Endsley, 1995; Endsley, Selcon, Hardiman, & Croft, 1998) and the use of real-time probes, or verbal queries posed to the operator concurrent with ongoing operations (e.g., Jones & Endsley, 2004). We chose to use SART for this simulation study so that we could also use the same SART scale in a related field study for consistency (Saleem, 2003); SAGAT can only be used for simulations as it requires the experimenter to freeze a simulation at randomly selected times. SART is a measure that provides an assessment of situation awareness based on operator opinion. The rating scale uses ten independent dimensions that were elicited from knowledge of aircrew and therefore, the scale has high ecological validity (Taylor, 1990). The ten dimensions are organized into three major groupings or *domains*: demand, supply, and understanding. User ratings from these domains are combined to provide an overall situation awareness score for the system (understanding total + supply total – demand total). The MCH and SART scales were administered after each treatment combination.

Statistical Methods

Multivariate analysis of variance (MANOVA) was performed by using a correlation matrix to partition the 13 flight-performance variables into three smaller groups of variables based on areas of relatively high correlation. Then, analysis of variance (ANOVA) was performed from the data for each flight-performance measure to uncover significant main effects and interactions. Non-parametric comparisons were used for the for MCH and SART ratings. Specifically, since the design was a mixed-factors design, the Wilcoxon Signed Ranks test was used for the within-subjects rating scale comparisons and the Kolmogorov-Smirnov test and the Mann-Whitney test were used for the between-subjects rating scale comparisons. An Alpha level of 0.05 was used for all of the statistical tests.

Results

Flight-Performance Variables

MANOVA was performed for the 2x2x2 mixed-factors design on three groups of variables where each group was based on logical clusters of variables with relatively high correlation. MANOVA indicated a main effect of Day/Night and an interaction of Pilot Type and Day/Night for one of the groups containing the following variables: Altitude AGL, ILS glideslope CDI, ILS localizer CDI, and flight path angle.

ANOVA for each of the 13 flight-performance variables was conducted for the 2x2x2 mixed-factors design. For ILS localizer CDI, ANOVA revealed a main effect of Pilot Type ($p = 0.014$). Mean ILS localizer CDI value for the IFR group was 0.002 dots ($SD = 0.030$), where each dot represents approximately four-tenths degrees horizontal deviation from the 3° glide slope centerline. Mean ILS localizer CDI value for the VFR group was 0.027 dots ($SD = 0.149$). There was a significant interaction of Pilot Type and Day/Night for altitude ($p = 0.029$). That is, while the mean altitude during the approach for IFR pilots remained relatively the same across the day (M = 1641 ft, SD = 35) and night (M = 1629 ft, SD = 38) conditions, the mean altitude for VFR pilots during the approach increased during nighttime (M = 1631 ft, SD = 96) compared to daytime (M = 1568 ft, SD = 163) (Figure 1). ANOVA for flight path angle revealed a main effect of Day/Night (p = 0.025). The mean approach angle during daytime was -2.29 degrees (SD = 0.06) compared to nighttime which was -2.27 degrees (SD = 0.06). No other significant effects were revealed for the 13 flight-performance measures.

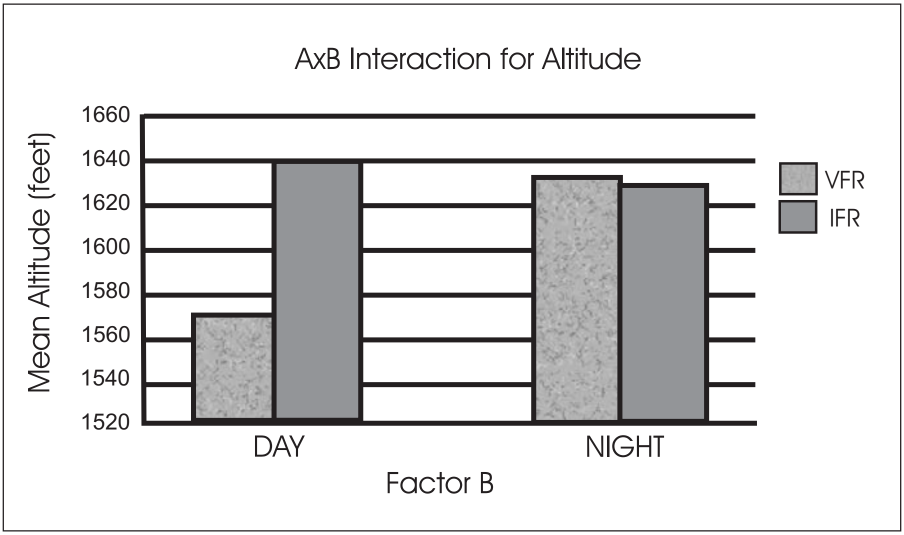

Figure 1. Interaction effect for altitude (above ground level). Factor A = Pilot Type (VFR-only, IFR-rated).

To supplement the 2x2x2 mixed factors ANOVAs, the between-subjects factor, Pilot Type (A), was removed such that separate ANOVAs could be conducted for each pilot group. One significant result was found for the IFR-rated group for flight path angle on day versus night operations (p = 0.003). The mean approach angle for the IFR-rated group was -2.28 degrees (SD = 0.05) during daytime and -2.25° (SD = 0.05) during nighttime. ANOVA for the VFR-only group did not yield the same significant result for flight path angle on Day/Night (p = 0.509). The mean approach angle for the VFR-only group was -2.30 degrees (SD = 0.06) during daytime and -2.29° (SD = 0.06) during nighttime.

Workload

The Kolmogorov-Smirnov Test was performed to test the hypothesis that VFR-only pilots would have greater workload than IFR-rated pilots. The test indicated that there was no significant difference in workload, as measured by the MCH rating scale, between VFR and IFR pilots ($16D_{8,8} < C_{.05}$). Thus, considering all conditions, the Kolmogorov-Smirnov Test did not indicate an *overall* increase in VFR workload compared to IFR workload. The Mann-Whitney Test was conducted to check for workload differences between VFR and IFR pilots for *each* specific condition and revealed that VFR workload was not significantly greater than IFR workload for any of the specific conditions and was actually significantly less than IFR workload for the control condition (static, clear weather during daytime) (*p* = 0.0229).

The Wilcoxon Signed Ranks Test was used for workload comparisons within the VFR pilot group. One statistically significant result was found. VFR workload was found to be greater with dynamic weather during daytime when compared to static weather during daytime (with alpha level = 0.055). Using the same test for the IFR group, no statistically significant differences in workload were found within the IFR group for any of the conditions.

Situation Awareness

The Kolmogorov-Smirnov Test was performed to test the hypothesis that VFR-only pilots would have reduced situation awareness compared to IFR-rated pilots. The test did indicate that VFR-only pilots had significantly lower situation awareness than IFR-rated pilots, as measured by the SART rating scale ($16D_{8,8} > C_{.05}$). Considering all conditions, the Kolmogorov-Smirnov Test indicated an *overall* decrease in VFR-only pilot situation awareness compared to IFR-rated pilot situation awareness. The Mann-Whitney Test was conducted to check for situation awareness differences between VFR and IFR pilots for *each* specific condition and revealed that VFR-only pilot situation awareness was significantly less than IFR-rated pilot situation awareness for each of the specific conditions ($p < 0.05$) except static, clear weather at nighttime (*p* = 0.0571).

The Wilcoxon Signed Ranks Test was used for situation awareness comparisons within the VFR-only pilot group. Two statistically significant results were found (alpha level = 0.055). VFR-only situation awareness at night was significantly reduced compared to VFR-only situation awareness during the day when weather was static and clear.Also, VFR-only situation awareness with dynamic weather was significantly reduced compared to VFR-only situation awareness with static weather, during daytime. Using the same test for the IFR-rated pilot group, two statistically significant differences were found (alpha level = 0.054). IFR-rated pilot situation awareness with dynamic weather was significantly reduced compared to IFR-rated pilot situation awareness with static weather, during daytime *and* during nighttime.

Discussion

Any one of the 13 objective flight-performance variables recorded by the flight simulator by itself is not necessarily a good indicator of performance for a landing approach. Rather, using the set of the measures together can provide an assessment of flight performance. To support the hypothesized performance differences between VFR-only and IFR-rated pilots, significant differences across several of the variables were expected. However, MANOVA and ANOVA revealed few significant differences between the VFR and IFR pilot groups, between day and night approaches, or between weather conditions as measured by the 13 objective flight-performance variables during the approach to the Roanoke Regional Airport. The significant difference for pilot type on ILS localizer CDI was expected as only IFR-rated pilots were assumed to know how to use the ILS and the significant results for altitude and flight path angle by themselves are inconsequential in terms objective flight performance. Therefore, our hypothesized performance differences between the VFR-only and IFR-rated pilots for night operations and poorer weather conditions as measured by the objective flight-performance variables were not supported.

Considering the IFR group only, we hypothesized that IFR pilots would exhibit poorer performance at night than during daytime. This hypothesis was based on previous accident statistics that suggest single pilot IFR accident rate during nighttime is almost eight times the accident rate of day IFR approaches (Bennett & Schwirzke, 1992). However, the results of this study do not support this hypothesis. One could argue that since IFR pilots rely solely on their instruments during an approach, we would not expect to see a difference between nighttime and daytime approaches. After the pilot reaches the decision altitude during an approach, he/she switches to visual, and if the runway is visible, proceeds with the landing. The accidents statistics cited by Bennett and Schwirzke (1992) likely relate to this final visual portion of the landing since the authors cite the lack of daytime visual cues during night operations as the probable cause for the higher accident rate. In contrast to daytime versus nighttime approaches, we hypothesized that there would be no significant difference in flight performance across weather conditions for IFR pilots. This hypothesis was supported by ANOVA for the flight-performance measures.

Considering the VFR group only, we hypothesized that VFR-only pilots would experience poorer flight performance during night operations and during deteriorating weather conditions. However, the ANOVA did not support this hypothesis, as VFR performance as measured by the objective flight-performance measures did not significantly differ during nighttime and during deteriorating weather as compared to the control (daytime, clear weather).

The overall lack of significant differences in terms of the objective flight-performance measures suggest that piloting of the aircraft itself is unaffected when flying conditions become more difficult, or that the tasks in this simulation were not sufficiently challenging to cause significant changes in performance. While pilots demonstrated their ability to control and land the aircraft during these conditions, there were several cases, however, where perceived workload was found to be increased and situation awareness reduced.

VFR-only pilots were hypothesized to experience greater workload when conducting approaches compared to IFR-rated pilots, especially during nighttime and during deteriorating weather conditions. This hypothesis was based on previous literature that suggests that there is less risk during the approach and landing phase of IFR flights as compared to VFR flights (Bennett & Schwirzke, 1990; Bennett & Schwirzke, 1992). This hypothesis was not supported. IFR pilots have the advantage of being able to rely solely on the aircrafts' instruments during an approach, no matter what external conditions may exist. However, the act of flying by instruments seems to demand greater workload than flying by outside visual references. This was indeed the case with the control condition for the laboratory experiment. The previous literature that suggests higher risk for VFR pilots during an approach uses accident statistics to measure risk. However, the accident statistics do not seem to correlate well with workload, at least during ideal conditions. For this experiment, VFR workload was found to be significantly less than IFR workload during daytime and when weather conditions were favorable. This result is consistent with previous research (e.g., Wilson, 2002). When nighttime and deteriorating weather conditions were introduced, no significant differences were found between VFR and IFR pilots for workload. Workload was constant for IFR pilots across conditions. However, VFR workload was significantly greater during deteriorating weather than VFR workload during the control condition, but not significantly different from IFR workload during deteriorating weather conditions or during nighttime. Figure 2 illustrates these trends.

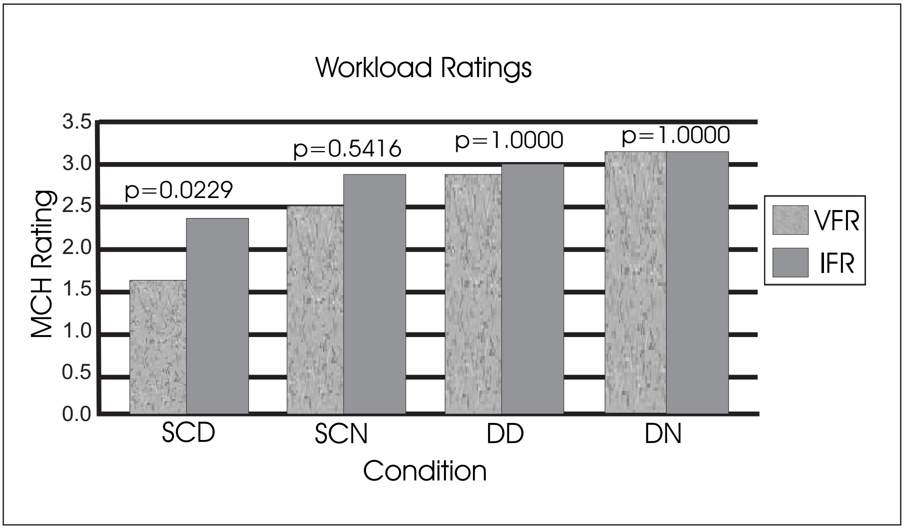

Figure 2. Workload ratings, VFR-only and IFR-rated pilots. Static, clear weather during daytime = SCD; static, clear weather during nighttime = SCN; dynamic weather during daytime = DD; dynamic weather during nighttime = DN.

We hypothesized that VFR-only pilots would experience greater workload during night operations and during deteriorating weather conditions. This hypothesis was only partially supported, while as VFR-only pilots did experience significantly greater workload during deteriorating weather, they did not experience significantly greater workload during nighttime, as compared to the control condition (SCD). Since workload was not found to be significantly different across conditions for IFR-rated pilots, the hypothesis that workload would be greater during nighttime was not supported, but the hypothesis that IFR workload would not differ across weather conditions was supported. Since IFR pilots rely solely on their instruments during an approach, the piloting tasks during the approach are the same regardless of the external conditions, and thus it seems reasonable that workload should not differ significantly across conditions for IFR pilots.

Although defined differently than mental workload, since situation awareness is found to be correlated with workload (e.g., Selcon, Taylor, & Koritsas, 1991), the same hypotheses that were made relating to workload were inversely made relating to situation awareness. That is, an increase in workload would suggest a reduction of situation awareness. Thus, we hypothesized that VFR-only pilots would have reduced situation awareness compared to IFR-rated pilots during an approach in deteriorating weather conditions and during nighttime. This hypothesis was supported by statistical analysis of the subjective SART ratings (Figure 3).

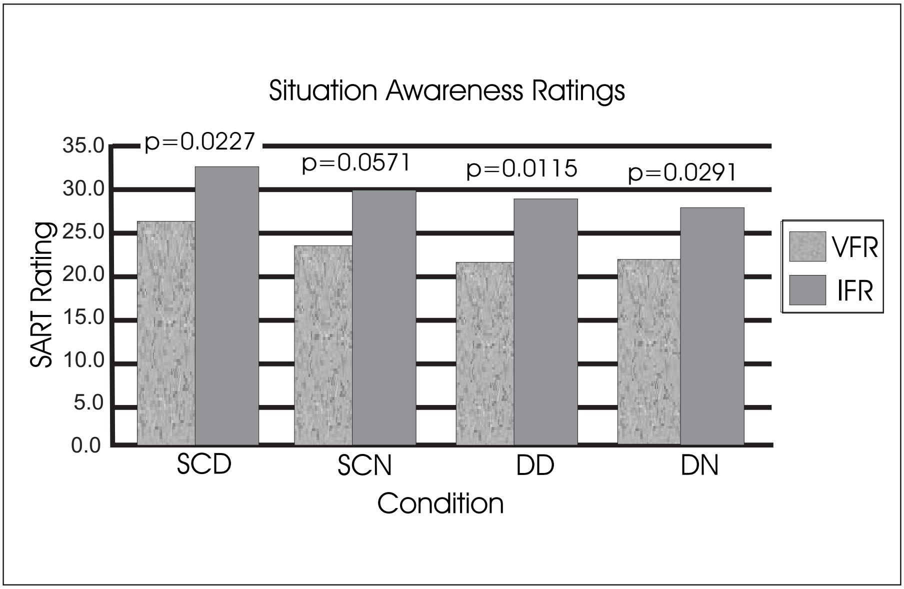

Figure 3. Situation awareness ratings, VFR-only and IFR-rated pilots. Static, clear weather during daytime = SCD; static, clear weather during nighttime = SCN; dynamic weather during daytime = DD; dynamic weather during nighttime = DN.

Within each pilot group, there was a trend for decreasing situation awareness as external conditions became more "difficult." Within the IFR pilot group, situation awareness with dynamic weather was significantly reduced compared to situation awareness with static weather, during daytime and during nighttime. Within the VFR group, situation awareness at night was significantly reduced compared to situation awareness during the day when weather was favorable. Also, situation awareness in deteriorating weather was significantly reduced compared to situation awareness with favorable weather during daytime approaches, but not nighttime approaches. Situation awareness for the VFR pilot group was unchanged between dynamic weather during daytime and dynamic weather during nighttime. That is, when weather conditions were poor, with visibility deteriorating to two miles; it made no difference if it was daytime or nighttime. During daytime approaches with low visibility, the VFR pilot seemed to have already lost the visual cues that are normally absent in nighttime flying.

Finally, VFR-only pilots tended to continue into deteriorating weather conditions and land the aircraft rather than abort and divert out of the poor visibility. As with previous research (Goh & Wiegmann, 2001), some of the pilots may not have perceived the visibility to be below the VFR minimum. However, five of the eight VFR-only pilots were aware of the visibility deteriorating past marginal VMC to IMC for at least some of the approaches by monitoring current weather conditions through the Roanoke Automatic Terminal Information Service (ATIS). However, they chose to continue with the landing regardless (the flight simulator displayed current weather conditions in text format along the top of the monitor when the pilot tuned the radio frequency to Roanoke ATIS). Those pilots who did not tune the radio to Roanoke ATIS may not have been aware that this function was available through the flight simulator. It seems that, at least for this study, participants exercise different judgment in a simulator than during an actual flight, as the consequences of crashing a simulated flight are obviously dramatically different from the consequences of crashing an actual flight. In reality, Roanoke ATC would not have permitted visual landings in IMC. However, ATC communications were not simulated in the laboratory, and thus the behavior observed from the pilots may have been more applicable to an uncontrolled airport environment.

Results of this study should be interpreted with the presence of certain limitations. Situation awareness is a difficult construct to measure and no single tool is certain to completely capture pilot situation awareness. Also, comparison of workload and situation awareness between VFR and IFR flights should be interpreted with caution, as VFR flight calls for a different set of skills and awareness than does an IFR flight. For example, a pilot may have a measure of situation awareness that is acceptable for a VFR flight, but not acceptable for an IFR flight. In other words, measured differences in situation awareness in one condition may relate to elements that are not relevant to the successful performance of the task in the other condition.

Conclusions

There were few differences between VFR-only and IFR-rated pilots, or within each of the two pilot groups, in terms of objective flight performance. Whether conditions were night or day, clear weather or deteriorating weather, pilots were able to control the aircraft and land it successfully. However, key differences in workload and situation awareness were exhibited between VFR and IFR pilots, and within the two pilot groups, when conducting an approach under these varying environmental conditions. For both pilot groups, there was a trend for workload perception to increase and situation awareness perception to decrease as environmental conditions became less favorable in terms of nighttime and deteriorating weather. Between the two pilot groups, there was no difference in workload perception except during the control condition, where IFR-rated pilots rated workload significantly greater than VFR-only pilots. However, there was an overall significant difference in situation awareness ratings between the two groups, where VFR situation awareness was found to be less than that of IFR pilots. Finally, VFR-only pilots demonstrated a tendency to continue from marginal VMC into IMC during an approach. That is, VFR pilots tended to continue into deteriorating weather conditions and land the aircraft rather than abort the landing and divert out of the poor visibility, even when pilots were aware that visibility had deteriorated to IMC. These findings demonstrate key differences in performance observed in pilots during VFR and IFR, which can help inform the design of aviation technologies to meet the demand of future aviation systems.

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Control of U.S. Airlines: An Exploration of Operational Factors and Performance Among Dispatchers

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Abstract

The purpose of this study was to identify the factors that influence the job performance of the Dispatcher. Throughout airline history, the dispatch function has not received the attention it has deserved in comparison to other professions in the air carrier industry. Today, the aviation industry, including the Airline Dispatchers Federation (ADF) and its members, is searching for the factors that have the greatest effect on the job of the airline Dispatcher. Preliminary research was undertaken to determine factors that may enhance or hinder the performance of the Dispatchers. A total of 19 Dispatchers were interviewed from both a major carrier and a low-cost carrier. The results of the interviews suggested that Dispatchers would like a stronger backing by management, as well as improved technology in the workplace.

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Introduction

In the United States (U.S.), the term "dispatcher" is fairly generic; there are many types of dispatchers, such as taxi, police, and bus dispatchers. For a U.S. airline to function properly, an airline employee whose job performance is critical is the airline Dispatcher. The functions the Dispatcher fulfills on a regular basis are demanding and impose a variety of stressors, similar to those experienced by other critical airline employees, day in and day out.

The job of the U.S. air carrier Dispatcher plays a major, legal role in the operation of an airline. The primary job of the airline Dispatcher is to work within the Airline Operations Center (AOC) and provide for flight safety (Rossmore, 1986). Flight Dispatchers, working within the AOCs, face intense pressures such as severe time constraints, flight/work overload, in addition to external pressure from their superiors. When poor weather prevails, and other factors compound the situation (e.g., in-flight emergencies), the job of the Dispatcher intensifies. Nevertheless, in combination with the Captain, who has direct control of his/her aircraft, the flight Dispatcher must play an equally important legal role in the safety of every flight.

In addition to the flight dispatch function, the AOCs typically house numerous other departments; these comprise crew scheduling, some form of maintenance dispatch, load control, and the management and protection of traffic/revenue. The flight Dispatcher is at the heart of coordination of all AOC departments for safe, efficient flight operations; the workload can be high. At one major U.S. airline, Dispatchers may be responsible for handling up to 30 flights at a time (Tim Antolovic, personal communication, August 4, 2003). Other major U.S. airlines anecdotally report similar workloads, leading to the generalization that the dispatch function within the AOCs of major airlines can be hectic. The roles of flight Dispatchers include additional factors to be discussed during the following investigation.

In light of the fact that there has been a dearth of literature describing the dual mandate of safe and economically efficient performance required of the Dispatcher, this qualitative study has explored a variety of operational factors affecting the individuals currently holding airline flight dispatch positions.

Review of the Literature

"The profession of the Flight Dispatcher has evolved with the many changes that the aviation industry has undergone" ("A Brief History," 1998, ¶ 1). In the early stages of aviation, pilots of commercial airlines often had to load mail, passengers, and cargo into their airplanes ("A Brief History," 1998). There was very little navigation equipment, no communication equipment and there was no way for the airlines to track aircraft in the early days of aviation. Accidents increased over the years, lives were being lost, and a tremendous amount of money was vanishing due to equipment losses.

"In 1938, the Congress of the United States passed the Civil Aeronautics Act" ("A Brief History," 1998, ¶ 2). This bit of legislation set forth regulations to make certain that all the nations' air carriers operated with the highest degree of safety. "One result of this regulatory action was the creation of a new Airman Certificate. The Aircraft Dispatcher was created" ("A Brief History," 1998, ¶ 2).

"The Aircraft Dispatcher was and is a ground based, certificated individual who, according to the regulations, shares responsibility with the pilot for the safe conduct of each flight" ("A Brief History," 1998, ¶ 3). Today, the concept of shared responsibility for the safe operation of a flight remains a shared responsibility between the Captain and the Dispatcher. Over the years, Aircraft Dispatchers have been known by many names such as Flight Dispatchers and Flight Superintendents, as well as Flight Controllers. "No matter what the name, the function is the same: ensure compliance with all applicable regulations and the pursuit of the highest possible level of air safety" ("A Brief History," 1998, ¶ 3).

The Code of Federal Regulations Title 14 Aeronautics and Space (Title 14 CFR) Parts 119 and 121 require all scheduled airlines, that have aircraft with more than nine passenger seats, to maintain an appropriate number of dispatch centers staffed by FAA certificated Aircraft Dispatchers ("A Brief History," 1998). Dispatching has come a long way since the early years of aviation. The industry safety record has spelled it out.

Today, at most U.S. airlines, Dispatchers work in a dynamic flow environment within an AOC. (System Operations Control [SOC] and Operations Control Center [OCC] are similar labels for the AOC facility.) The proper functioning of this control center is vital to the smooth operation of the airline. An AOC is the central control point for all daily operational issues involving security, emergencies, weather, aircraft crew coordination, aircraft maintenance routing, and overall operational coordination. A key point to mention about the AOC is that it is not required by regulation; AOCs have been implemented by airlines to improve efficiency.

Flight Dispatch is responsible for developing and disseminating the flight plan or dispatch release. The dispatch release contains all the information a Captain needs to operate his/her assigned flight from one city to the next. The 14 CFR Part 121 regulations require a dispatch release. "A dispatch release document is required to be prepared by the Dispatcher by 121.633" (Holt & Poynor, 2002, p. 154).

The dispatch release incorporates the call sign of the flight, tail number of the airplane, the departure fuel load, the route and altitude to be flown, the origin airport, the destination airport, and (if required) the alternate airport. Additional items to be taken into account when planning a flight are special Air Traffic Control (ATC) situations and what are known as NOTAMs. NOTAM is an abbreviation for "Notices to Airmen." A NOTAM is an advisory issued by the FAA, an airport, or airline company that alerts operators to local operating anomalies; for example, airport construction or a taxiway closed due to maintenance. Other information in the flight plan includes current and forecasted weather at the airports to be used, as well as enroute weather conditions like thunderstorms, turbulence, and/or icing conditions. For example, the typical Dispatcher can now see lightning strikes denoting severe weather in real-time across the U.S. and divert planes accordingly.

"Flight dispatch is a pivotal function performed at American Airlines . . . , and is responsible for the day-to-day, minute-to minute operation of the airline" (Kudwa, 2000, p. 8). Within the airline operations centers (AOC), "Flight Dispatchers, meteorologists, crew schedulers, and other specialists work as a team to ensure safety and efficiency" (Wells & Wensveen, 2004, p. 260). Accordingly, Figure 1 is an illustration of the coordination and shared responsibility that flows from within the AOC to ATC and the flight crews during a typical U.S. air carrier's 24/7 operations.

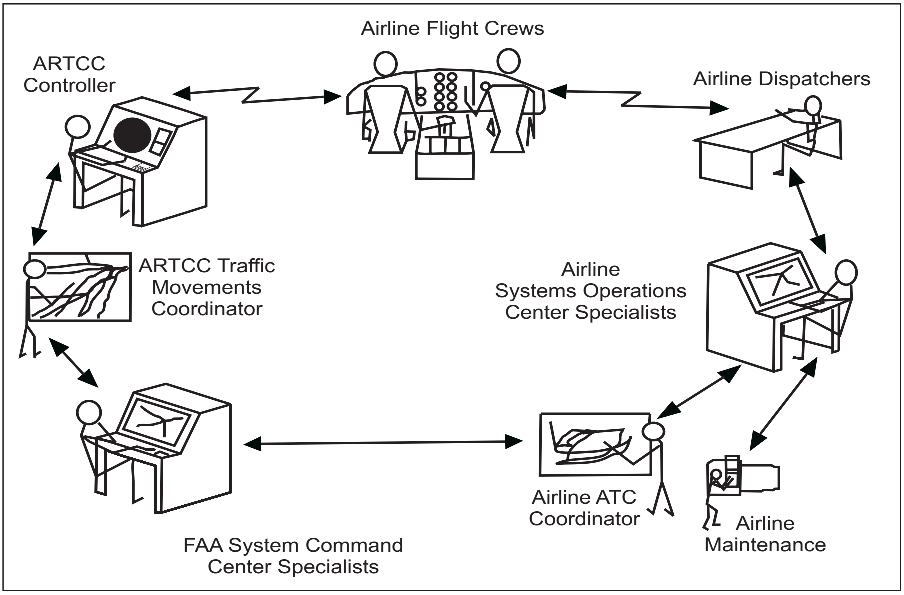

Figure 1. Adapted from: Billings, Shared Responsibility.

An AOC plans every flight and keeps track of every detail – from the moment that a plane initially pushes back from the gate until the aircraft parking brake is set at the gate at the destination. Much of the information incorporated into the product that the Captain receives occurs as a result of coordination of several departments and outside agencies. The Dispatcher reviews and confirms the accuracy of the data and ensures that the operation is in compliance with all FAA regulations. The responsibility of planning is shared between the Dispatcher and Captain. The Dispatcher electronically signs his/her name to the flight plan. If the Captain concurs with the flight plan, he/she signs the plan and operates the flight. However, should the Captain have any questions or concerns about the flight plan, he/she will confer with the Dispatcher via telephone or radio communications regarding possible changes before agreeing to a final plan.

Once the flight commences, the Dispatcher "flight follows" it from gate departure to gate arrival. If something unanticipated occurs during the flight that could impact the safe operation of the flight, the Dispatcher and the Captain have the responsibility to inform each other and develop a revised flight plan. The revised plan will address the unanticipated event, where possible, to allow the flight to continue operating in a safe manner. In addition to the above responsibilities, a Dispatcher is also responsible for the coordination of ground support activities associated with mechanically delayed airplanes and unscheduled landings.

To perform their duties, flight Dispatchers must have an FAA aircraft Dispatcher's certificate. This is the proof of a comprehensive knowledge of aviation operations. In addition to knowing the Federal Aviation Regulations (FARs) and company rules and regulations, they have acquired extensive knowledge of weather, air traffic control, and the National Airspace System (NAS).

A formal Dispatcher training program and record keeping system is generally established in accordance with the FARs, complemented by even higher company standards. Formal ground training consists of indoctrination, initial, transition, and recurrent training. Specialized training is also provided as necessary for certain subjects or areas of operation. In addition, cockpit familiarization flights are accomplished and competency checks are administered.

There are a number of other departments within a typical AOC. The Navigational Aids department is responsible for the worldwide geographic flight database for the air carrier as well as for other users of their operating system. Twenty-four hour coverage is provided to insure accuracy of the data (which includes airways, routes, Navigational Aids, airports, SIDS, STARS, etc.) and to construct and revise, as necessary, all routes in the air carrier's flight planning system. In addition, domestic and international NOTAMs are updated and maintained.

Load control is comprised of load planners who are responsible for planning the payload of the air carrier's flights. For example, each member of the weight and balance team may work between 42 to 50 flights from as many as 10 cities during his/her 8-hour shift (American Airlines, 2001). The planners are tasked to plan and calculate payloads that will produce the maximum amount of revenue for the company while simultaneously providing its customers with a high level of service. Additionally, the planner's strategy must always include the goal of maintaining the aircraft's center of gravity in an optimal position so that aircraft performance is maximized. All this must be done while working under aggressive time constraints and in a manner that assures the safety of the aircraft, its passengers, and its crew.

The responsibilities of a crew-scheduling department are another critical area for the efficient operation of a major air carrier's flights. Depending upon the type of aircraft, there are typically between 5 and 15 crewmembers on a given flight (cockpit crew and flight attendants combined). A crew-scheduling department is accountable for:

1. Development of a monthly manning plan.

2 Development of crewmember annual vacations, training plans, and new hires.
3 Building flight allocations.
4 Creating and awarding monthly trip selections.

Once all of the above is in place, a crew-tracking department is normally brought into the picture. This group monitors the daily flight operations to insure the correct numbers of qualified crewmembers are onboard each flight (pilots and flight attendants). If shortages exist, utilization of standbys or reserve crewmembers becomes necessary. Everyone in this scheduling group must be cognizant of crew staffing at all times to guarantee that the efficiency and dependability of all flights is not compromised.

Over the years, the airline AOCs, through contracted services, have assisted thousands of aircrews and ground operations staff in meeting their operational control and training needs. Some of the areas of specialty are to:

- Provide Operational Control Solutions for the FAA, the International Civil Aviation Organization, the Civil Aviation Authority, and the Transport Canada regulated carriers.
- Make recommendations to airlines regarding methods and standards in their flight operations control functions including organization, job functionality, technical procedures, and training.
- Develop training curriculum outlines and record keeping systems for initial and recurrent training in operational controls and dispatch functions.
- Provide initial and recurrent ground school instruction to customers on subjects such as basic dispatch duties, operations control duties, and practical use of the air carrier's Flight Operating system.
- Develop and publish manuals for customers such as standard operating procedures and emergency procedures.
- Make recommendations for designing an AOC and develop procedural process flow documentation and training.

There are several key points that must be remembered for an AOC to maximize its functionality: (a) Decision-making, (b) minimal supervision, (c) analyzing ability, (d) teamwork, and (e) networking.

Emphasizing the rapidly changing environment within an AOC, Weatherson (2001, p. 16) stated, "The dynamics of the situation changed minute to minute and as the number of diversions mounted, airports became saturated not only by our diversions but by other airlines' as well." AOC personnel, as well as Dispatchers, must deal with these situations everyday. Dispatchers have a challenging job working in a fast-paced, pressure-filled environment.

A key point to remember is that every air carrier's AOC differs to some degree. Each AOC is characterized by the organizational culture of each airline. A recognized definition of organization culture is: "The values, beliefs, assumptions, rituals, symbols and behaviors that define a group, especially in relation to other groups or organizations" (Helmreich & Merritt, 2001, p. 109).

Human performance is also a major factor in all areas of aviation. "In aviation [sic] human error is closely associated in the eyes of the public – and in reality – with incidents and accidents" (Hawkins, 1987, p. 27). Dispatchers as well as many other professionals make errors. However, in the case of the Dispatcher, the errors may prove deadly.The importance of the airline Dispatcher cannot be over emphasized.

At each U.S. airline, there are three work groups consisting of FAA-certificated individuals: the pilots, the Dispatchers, and the mechanics. Although all three groups are critical to U.S. airline operations, the scheduling and duty hours are regulated by the FARs for only the pilots and the Dispatchers. Despite the obvious importance of the Dispatcher, this is one individual who has not been covered in the textbook used for the core aviation human factors course within the Master of Science in Aeronautics at Embry-Riddle Aeronautical University (Garland, Wise, & Hopkin, 1999).

The scope of this study was to explore the Dispatcher's work environment. The research questions to be answered were twofold: (a) What is the relative degree of importance to the U.S. air carriers' operations of the dispatch function? And (b) What are some of the operational factors for certificated Dispatchers within U.S. air carriers?

Research Design

Exploratory in nature, the study was designed to elicit information related to the Dispatcher and act as a springboard for further related research. Research concerning the operational factors among Dispatchers has rarely been undertaken throughout the global air carrier industry.The researcher's intern experience in the dispatch-training department of a major airline led to an interest in the flight dispatch operation. The researcher noted some of the issues associated with the Dispatcher's job function, and given the opportunity, decided upon the research project of investigating flight dispatch factors.

Researching and noting the many factors that affect the job of the Dispatcher has been highly recommended by the Airline Dispatchers Federation (ADF – a dispatch organization), several National Aeronautics and Space Administration researchers, and the Dispatchers themselves. Acting upon the desires of the dispatch community, this researcher developed a list of interview questions to ascertain what factors directly affected the Dispatcher's job performance. The purpose of this qualitative query evolved to the exploration of any problem(s) within flight dispatch operations, and the recommendations for improvement(s).

Survey Population

The time and resources available permitted two U.S. airlines, a major carrier, and a low cost carrier, to provide a combined sample of 19 Dispatchers who agreed to be interviewed for this project. All participants were FAA certificated Dispatchers; a requirement to be included in the sample was to have been in possession of the certificate for a minimum of 1 year.

The Survey Instrument

A brief list of interview questions was designed that would produce a qualitative response. It was not desirable to limit the responses to a small, set number of choices, thus all questions were designed in the open-ended format.

The first 10 items were designed to gather data relating to factors, which affect the performance of the Dispatchers, while the last six questions dealt with gathering demographic data. All participants were verbally advised, in advance of conducting the interview, that participation was voluntary and that all responses would remain confidential. The instrument was designed to be completed within a time frame of 15 minutes, which would give the participants ample time to accomplish the interview.

Pretest

Prior to conducting the interview, the questions were submitted for review to one university-level academic professional, as well as an individual from industry to determine the construct validity.This project's advisor, a retired Captain from a major U.S. airline, was the first individual to review the instrument. Sound insight from a 32-year veteran of the industry resulted in some minor changes to the interview format to provide for more efficient responses. Secondly, a Ramp Manager for a major U.S. airline examined the interview questions. This individual performed a thorough review of the instrument and recommended a few subtle changes to the format of the questions, the implementation of which improved the overall quality of the data-gathering instrument.

After accomplishing the recommended revisions, the instrument was tested on three aviation students at Embry-Riddle Aeronautical University in Daytona Beach, Florida. Although these students were not Dispatchers, they were asked to answer the questions with their current job in mind. The pretest was successful, as participants had little or no difficulty in understanding or answering any of the questions. No further changes were made prior to administering the instrument to the Dispatcher interviewees.

Immersion within the Dispatch Community

The interviews were administered via a combination of telephone conversations and face-to-face encounters. Those interviews conducted in person eluded more thorough responses, probably as a result of the interviewee's increased trust of, and confidence with, the physical presence of the researcher.As the personal relationship developed between the interviewer and interviewee, the Dispatcher would provide more complete responses.

The researcher was invited to present his preliminary data at the ADF Symposium in Kissimmee, Florida during October 2003. This symposium resulted in 2 days of personal contact with numerous Dispatchers, an airline historian, and several researchers who were also involved with the operational factors of air carrier flight dispatch. With invitations, the researcher also traveled to the operations centers of three U.S. airlines during September and October 2003 to observe the live 24/7 operational factors.

Treatment of Data

After completing the interview processes, the data were assembled, sorted, and analyzed. The demographic data were quantitative, as were the replies to one item dealing with hours of sleep. The data that resulted from the open-ended items were qualitative. The quantitative data from the 19 respondents were entered into a statistical package database for electronic analysis. The qualitative data were sorted and analyzed with paper and pencil techniques. Quantitative and qualitative results are presented below.

Demographic and Interview Data

The gender breakdown of the sample was 79% male and 21% female. The mean age of all participants was 46.3 years, with a range of 26 years (36 years being the youngest individual and 62 being the oldest individual). The mean years of formal education for the 19 participants was 14.4 (16 years being a 4-year, or baccalaureate, degree). The mean number of years of experience in aviation for the participants was 23.7. The average number of years that each participant had held a FAA Dispatcher certificate was 18.6.

The questions and the responses for items #1-10 follow.The most common answers (*f* = a qualitative summation) to the following questions were grouped together according to their commonalities – an accepted reduction and display treatment of data resulting from exploratory research (Miles & Huberman, 1994).

Question #1: The results of ranking the replies to the first item (What is the most difficult part of your job?) are:

- Racing the clock (*f* = 6).
- Prioritizing information/information overload (*f* = 5).
- Dealing with bad weather (*f* = 5).
- Multi-tasking (*f* = 4).

The Dispatchers felt that racing the clock was extremely difficult in the aviation environment; the information overload tied into racing the clock. Dispatchers felt that time was wasted looking up information that should be more readily available. Dealing with bad weather and the ability to multi-task also presented difficulty.

Question #2: What do you like most about your working environment? Least?

Most:

- Diversity of the job (*f* = 7).
- Ability to make decisions (*f* = 5).
- Teamwork concept (*f* = 5).

The Dispatchers seemed to enjoy the diversity that the job offers. They liked the differences involved with each day on the job. Dispatchers also liked the ability to make decisions, affording them a greater importance to the overall operation of the airline. The ability to work in a team environment was also a favorite of the Dispatchers.

Least:

Pressure to meet safety/economic goals (*f* = 8).

Lack of physical space (*f* = 4).

Lack of response from management (*f* = 4).

Pressure to meet economic and safety goals was not well liked. It placed a great deal of pressure upon the Dispatcher. The lack of physical space added to an already stressful environment. Dispatchers also had very negative feelings when they did not receive an adequate response from management; they felt they deserved an open communications environment with members of management.

Question #3: What changes to the work environment do you think would improve individual performance?

Trust/strong backing by management (*f* = 7).

Improved technology (*f* = 6).

Reduced Dispatcher to flight ratio (*f* = 4).

The Dispatchers felt that having a strong backing by management would help to improve their individual performance. If they had support, then they would feel much better when making important decisions. Improved technology would also play a major role in improving individual performance. Dispatchers also wanted to reduce their flight load. During stressful times, the current flight loads required of the Dispatchers was deemed too high.

Question #4: What shift do you prefer to work?

In general, the morning shifts were most preferred (*f* = 15).

Times: 5a.m.-1p.m., 6a.m.-2p.m., etc.

The morning shifts were most preferred by the Dispatcher in order to have time after work for personal matters. In summer, the a.m. shifts were also preferred due to lower probability of convective activity in the morning.

Question #5: In your view, what is the single most important aspect of your job?

The vast majority stated "safety" – immediately (*f* = 17).

The few who did not inferred it in their answers.

A lot of factors tie into safety: Weather, maintenance, etc.

Safety proved to be the most important aspect of the Dispatcher's job. All Dispatchers had a high regard for the safety of the overall operation.

Question #6: What factor(s) have the greatest effect on your day-to-day job?

Weather (*f* = 15).

Maintenance (*f* = 8).

ATC with respect to central flow control (*f* = 7).

Weather was a major factor affecting the Dispatcher's job. ATC's flow control tied into the weather issue. Improved communication with maintenance operations centers was also a major factor.

Question #7: How many total hours of sleep do you usually receive between shifts?

The average approximated 7 hours.

The Dispatchers were receiving a fair amount of rest, although 7 hours is still under the recommended sleep duration of 8-10 hours.

Question #8: Do you prefer to sit or stand while working? If standing is preferred, why?

The majority stated "sit" (f = 13).

The ones who said "stand" prefer to do so because it improved circulation (f = 6).

Most Dispatchers preferred to sit while working. However, a number wanted the choice of sitting or standing. (For health reasons it is good to stretch one's legs periodically, and it is not healthy to sit for too long of a duration.)

Question #9: Describe the type of attributes that a preferred fellow Dispatcher displays.

Common sense (f = 8).
Detail oriented (f = 6).
Proactive (f = 6).

The Dispatchers felt that common sense was most definitely an attribute that one should possess. They also felt the need to have an individual who paid close attention to detail, and someone who was proactive – one who identified potential problems and rectified them before they occurred.

Question #10: Discuss one or more individual qualities that the Dispatcher should possess.

A sense of humor (f = 6).
The ability to multitask (f = 5).
Working well under stress (f = 5).

The Dispatcher should possess a good sense of humor. (Humor alleviates some of the stresses of the job.) Multitasking popped up again as another important quality.

Discussion

The salient response that safety was the single most important aspect of the Dispatchers' jobs should be considered proper and comforting. Since safety is the number one consideration in air carrier operations, it was rewarding to discover that the Dispatchers prioritize the concept. The balance between safety and economics goes hand-in-hand, so while the Dispatchers did state that safety was their major concern, occasionally commercial pressure became a factor.

Overall, most Dispatchers liked their job because it gave them the ability to work in a team environment as well as make their own decisions. Many Dispatchers said that when management let them make more of their own decisions, they felt more involved in the overall operation and prided themselves accordingly.The Dispatchers also enjoyed the high level of variety within their jobs; one day has never been the same as the next. On the negative side, the Dispatchers felt that management was putting too much pressure on them with regards to economic considerations. They felt that at times the pressures of efficiency competed with considerations for safety, and that members of management were not responding to their concerns. The Dispatchers expressed their desire for a better working relationship with management, which would improve safety and the overall operation of the individual airline.

The factors that present the greatest effect on the Dispatchers' day-to-day job – weather, maintenance, and ATC central flow control – were major issues and at the top of a list of desires for improvement. With regard to weather, the Dispatchers would like to see better equipment implemented at their workstations in order to receive more accurate and efficient meteorological information. Increased communications and collaboration between the Dispatchers and their respective operations' centers and the maintenance control function was desired to improve efficiency.ATC flow control has been an issue at U.S. airlines for a number of years. It appears that the Dispatchers and each airline's ATC coordinator (if the airline has that position) should also maintain close communication and collaboration with ATC. As stated by many of the Dispatchers, "communication is vital."

As with many jobs, Dispatchers felt that fellow colleagues should possess common sense. They also felt that they should be very detail oriented and proactive. In regards to the proactive, one Dispatcher interviewed said, "If an individual is at his desk sitting there twirling his/her thumbs, then he or she is probably not doing his job right." The data indicated that the Dispatcher should be able to anticipate problems, and rectify them before they occur. In addition, the Dispatcher should possess a sense of humor to help alleviate some of the tension during stressful situations. Several of the interviewees said that multitasking was a necessity.

Conclusions

Since the early years, aviation has advanced considerably as a result of multiple research efforts. To date, the airline industry and the research community have been emphasizing the human performance issues of the pilots. As stated earlier in the report, the job of the airline Dispatcher in the U.S. is no less important than that of the pilots, or any job at an airline.

Today, the U.S. airlines are beginning to note the benefits of having an efficient Dispatcher workforce, prompting the question of whether the time for the devotion of more resources to researching the dispatch function had arrived. The resultant exploratory study was undertaken to note some of the human factors associated with the job performance of the Dispatchers and to gather some qualitative data that could be useful to further research efforts. The largely qualitative procedure and results of this study strongly suggest that there is a need for more research in the area of U.S. airline dispatch and Dispatcher performance.

Recommendations

The U.S. air carrier industry is now recognizing the important role that the Dispatcher plays in the operation of an airline. Upon analysis of the data from this study's interviews, it is clear that there are a variety of factors that affect the Dispatcher. For example, weather, maintenance issues, and relations with management affect the Dispatcher's job performance.

It is recommended that management at each airline take a closer look at the job of the Dispatcher and evaluate what areas need improvement in an attempt to rectify critical issues. Dispatchers also need to stress the significance of their roles in the quality and safety of the operation to members of management during attempts to achieve change and improvement. Doing so on a regular basis may tighten the relations and bonds between the management and non-management workgroups, thereby improving the overall operation.

More emphasis needs to be placed on human factors since human error is often the cause of accidents. "In aviation human error is closely associated in the eyes of the public - and in reality - with incidents and accidents" (Hawkins, 1987, p. 27). The presentation of information to the Dispatcher needs to be improved, and the Dispatcher/flight workload needs to be examined. In general, research into, and improved design models for, the Dispatcher's workstation is recommended.

Upon review of the data, numerous variables could have been introduced into the interview to elicit more decisive information. First, it would have been desirable to attach more "why" solicitations at the end of most questions. This would have helped solicit a more thorough response to many of the questions, and elicit knowledge of why the Dispatcher answered each response in the manner that he or she did. In essence, it would have provided a more complete picture of the data.

In retrospect, it would have been helpful to obtain more quantitative data from the sample. While the qualitative data does provide a great deal of information, it is usually not as decisive as the quantitative data might have been. If further research is undertaken in this area, it is highly recommended that a more quantitative approach be used. This study sampled two airlines; future research should consider sampling of the Dispatchers at regional carriers and cargo carriers. This would paint a better picture of the U.S. Dispatcher population.

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Discovering the Non-flight Hazards and Suggesting a Safety Training Model

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Abstract

Aircraft accidents still occur periodically as a result of human errors contributed from either flight or non-flight activities. Yet, while human factors training is mandatory for flight crews in the United States (US), such training remains optional for non-flight labor (i.e., aircraft maintenance technicians and ramp agents). To examine the level of threat from non-flight error affecting aviation safety and verify the government's decision-making, this paper first identified the causes of airline accidents and consequently provided a quantifiable figure showing the relative criticality between the operation of flight and non-flight employees. Secondary data analysis was adopted and 189 final government reports were reviewed pertaining to FAR Part 121 scheduled operation (dated between January 1999 and May 2004). The finding revealed that there were 68 (35.97%) accidents related to non-flight error vis-à-vis 24.34% from flight operation. The non-flight error was found to be the most significant direct hazard affecting airline safety. The discovered accident causes (direct hazards) were categorized into ten (10) groups-Flight Operations, Ground Crew, Turbulence, Maintenance, Foreign Object Damage (FOD), Flight Attendant, Air Traffic Control, Manufacturer, Passenger, and Federal Aviation Administration-associated with 36 root factors prepared for an error-elimination model using Fault Tree Analysis (FTA). With the FTA, a more cost-effect safety training for non-flight workers was provided.

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Introduction

Air transportation is an efficient and effective mode of transportation in today's global economy. Developed countries, such as the United States (US), United Kingdom, Australia, Japan, and Germany, as well as developing nations like Taiwan and Korea, rely heavily on air transportation for shipping freights and transferring passengers between cities. Although global air transportation was adversely impacted after the 9/11 attacks and the outbreak of Severe Acute Respiratory Syndrome (SARS), it is gradually recovering and will continue to grow vigorously (FAA, 2004; Lu, 2003; Michaels & Pasztor, 2001).

Since the disastrous 9/11 terrorist attacks, many governments in the world have contributed more advanced efforts and progressive measures to enhance aviation safety and airport security. Although the US Department of Homeland Security has developed a national security alerting system that provides a warning to the nation, it may not specifically inform the public about the potential threats leading to terrorist attacks. Although the US Federal Aviation Administration (FAA) has been responsible for fostering and encouraging civil air commerce and auditing and promoting aviation safety since its birth in 1967 (Adamski & Doyle, 1999; Rollo, 2000; Wells, 1999), the government's "dual-mandate" responsibility has resulted in criticism regarding the lack of sufficient ability to accomplish safety surveillance (Carlisle, 2001; Carmody, 2001; Donnelly, 2001; Filler, 2001; Nader & Smith, 1994; Stout, 1999). It is especially true that the mishap of ValuJet Flight 592 in 1996, resulting in 110 fatalities, could have been avoided if the FAA had concentrated more on promulgating safety instead of bolstering the low-cost aviation enplanement. As a matter of fact, the Airline Deregulation Act of 1978 was originally an attempt by the government to promote aviation by reducing airfare and to elevate the level of air transportation safety based on the doctrines of free market competition (Wells, 1999). However, it is controversial to assert that airline deregulation had upgraded actual safety performance (Marks, 1999). So, what went wrong? How can we fully eliminate potential hazards leading to accidents?

Literature Review

During the past decade, several leading media reports—the *Wall Street Journal* (Dahl & Miller, 1996, July 24; Goetz, 1998) and *USA Today* (Stoller, 2000 March 13)—have tried to rank airline safety relying on a single element, *the accident rate*. In 2001 and 2004, Bowen and Lu initiated their safety measurement mechanism, Aviation Safety Rating (ASR). This study reviewed airline safety performance (Bowen & Lu, 2001) and discovered the individual performance sensitivity (the percentage change of overall safety score due to the percentage change of a specific safety factor) of seventeen (17) selected safety factors (Bowen & Lu, 2004a). The ASR study was an application of the National Airline Quality Rating (AQR) and simultaneously embraced the use of Analytical Hierarchy Process (AHP) software and the Delphi technique. Based on the calculation of performance sensitivity (Sp) of each selected safety factor, the authors prioritized factors that impacted safety performance substantially. The result showed that *Accident and Management Quality* were two most weighted categories in relation to safety performance. Fatality rate, average fleet age, and accident rate were the three most critical factors affecting the overall safety performance.

Although prior studies had proposed a mechanism for measuring airline safety performance, they did not reveal the causes of accidents that ultimately contributed to an airline's safety performance vis-à-vis their business rivals. Meanwhile, the precursors of causes of accidents were not identified either. This situation not only prevents airlines from targeting on the critical human error in relation to accidents, but also opens a window for a further research.

Human Factors Is Everyone's Concern

In 1976, NASA launched the first Crew Resource Management (CRM) program for airline flight crews (Krause, 1996; Orlady & Orlady, 1999), mainly for pursuing error-free and safety-laden commercial flight operations. CRM training has delivered massive benefits to flight safety and surely to the flying public. Since 1990, the FAA has regulated CRM training in Federal Aviation Regulation (FAR) Part 121 Subpart N for major air carriers and for Part 135 regional commuters under SFAR 71 (Aviation Supplies & Academics [ASA], 2001). Despite the immediate goal of recovering needed revenue after 9/11, maintaining a risk-free aviation environment is believed by the airline industry to be another top priority pertaining to their daily operations. According to an annual report from Boeing, "Worldwide Commercial Jet Airplane Accidents," cockpit crew error was the primary factor causing accidents (Boeing Commercial Airplanes Group, 2000). Yet, this same Boeing report also revealed that more than five percent of overall commercial aviation accidents resulted from non-flight activities such as aircraft maintenance (Boeing Commercial Airplanes Group, 2000). This number could become more significant as commercial air transportation expands greatly in the next two decades. If airlines support the government's advocacy of "zero-accident" aviation, five percent is indeed too large a figure to be ignored. For example, there were several headlined aircraft disasters caused by maintenance flaws (non-flight) such as the crash of American Airlines' DC-10 in 1976, Aloha Airlines' B-737 in 1988, United Airlines' DC-10 in 1989, and Alaska Airlines' MD-82 in 2000. Investigations of these disasters showed that maintenance safety should be treated with a greater sense of urgency before similar accidents happen again (Goglia, 2000).

Today, CRM addresses NASA's research findings in human factors, and, is strongly upheld by FAR 121 and SFAR 71. Yet we should be aware that NASA's human factors research also developed maintenance resource management (MRM) training for aircraft maintenance personnel. Nevertheless, the MRM training did not share the same credit as that of CRM for flight crews because MRM training is not mandatory at the present time.

The FAA's Rulemaking Rationale

If MRM training is critical for non-flight workers, why is it on a non-mandatory basis? In his study in 2003, Lu investigated the Federal Aviation Administration's

(FAA) rulemaking rationale and the status of a non-regulatory Maintenance Resource Management (MRM). Lu interviewed the FAA's Aviation Rulemaking Advisory Committee (ARAC) members, who represent different layers of the aviation industry for commenting on the FAA's rulemaking. The results of the research showed two policy barriers from the industry plaguing MRM regulation: budgetary constraints and the lack of quantifiable evidence from cost-benefit analysis (i.e., low probability of non-flight error that may lead to accidents vs. the possible high cost of a mandatory training to non-flight workers).

In Lu's study, he also compared the regulatory requirements among European Union's Joint Aviation Regulation (JAR), Canadian Aviation Regulation (CAR), and the US FAR regarding maintenance human factors training. He found that the United States is the only country that does not require such training for aircraft technicians or ground crews. In addition, without such a regulatory enforcement, the airline's implementation of an optional MRM training to aircraft technicians was sporadic. In addition, the current training alternatives of ground safety, such as the FAA's voluntary Air Transportation Oversight System (ATOS) and Aviation Safety Action Program (ASAP), for non-flight workers were implemented by some major airlines only. Regional and small airlines did not have sufficient budget to participate in the program. In the long run, this situation could endanger the overall operational safety (Lu, 2003).

The Goal of Zero-Accident and Cost

In fact, the aviation safety net consists of flight crews, maintenance personnel, air traffic controllers, airplane dispatchers, flight attendants, ramp agents, airport security, and related professionals. All aviation practitioners should work closely together because any flawed portion of the net could result in an unrecoverable safety breakdown and, thereby, human injuries or fatalities. By the virtue of the "Swiss-cheese" safety model, aviation accidents could happen when possible unsafe acts or operators were present and line up simultaneously (Reason, 1990; Wood, 1997). Therefore, it is unwise to simplify aviation safety training as a flight-oriented discipline simply because flight operation is only a slice of "the cheese."

Take airport security for an example. In the late 1980s, despite the high-pitched outcries for tightened airport security from the public, the media, and academia after the bombing of Pan Am Flight 103 in December 1988 at Lockerbie, Scotland (Finder, 1999; Wald, 2000), the airlines and the FAA were still unable to eliminate the potential dangers facing airport security. The reasons were threefold: First, from the air carriers' standpoint, the main concern of elevating airport security performance was the possible skyrocketing cost (Hahn, 1997; Ott, 1997). Second, for airport security, airlines have a preoccupied mindset and perception impeding them from conducting more effective security programs because the returns of this safety investment are unpredictable (Duke, 1999; Hahn, 1997; Ott, 1997). And third, the FAA's tight embracement of quantifiable figures has deluded safety inspectors into thinking that airport security levels are acceptable because of the extremely low probability of aircraft hijacking (Del Valle, 1997). This compromised ideology unfortunately was adopted, and the

FAA's self-consciousness in regard to airport security had been weakened (Woellert, 1998). As a result, with its conservative manner, the FAA has halted most security-enhancement proposals due to the perceived high costs involved (Morris, Rigavan, Whitelaw, Glasser, Strobel, & Eltahawy, 1999; Morris, 2001). Alas, the FAA's empirical reasoning on airport security was destroyed on September 11, 2001. The global economy was thereafter overturned. Until today, the aviation industry as a whole is still suffering (Archibold, 2001; Eisenberg, 2001; Kluger, 2001).

Research Questions

As aforementioned, human factors training is beneficial and should be provided to all aviation workers. Yet the resistance from industry is stiff due to a low possibility of maintenance errors and, of course, a concern of high costs (Lu, 2003). While human factors training is mandatory for flight crews, is it appropriate that it remains optional to non-flight personnel? Is non-flight error less critical than a flight operation error? In addition to identifying the importance of human factors training for aviation employees, and to verify the ARAC's assertion and the FAA's rationale, this study aimed to: 1) identify the direct hazards leading to accidents, 2) recognize how safety factors contributed to the causes of accidents, and 3) determine if non-flight error was significant or not.

Question 1: What were the primary causes of aviation accidents in the U.S under the FAA FAR Part 121 operation between January 1999 and May 2004?

Question 2: What were the essential factors leading to the causes of aviation accidents in question 1 in the U.S under the FAA FAR Part 121 operation between January 1999 and May 2004?

Question 3: What was the level of criticality pertaining to non-flight errors?

Definition of Accident Causes

In this study, the causes leading to an accident were categorized and defined as the following for a better understanding of research findings:

- Flight operation: an accident was caused by cockpit crews
- Turbulence: an accident was caused by turbulence (in-flight, clear air, wake turbulence)
- Maintenance: an accident was caused by aircraft maintenance personnel
- Ground crew: an accident was caused by ground crews (truck driver, beltloader or tug operator, ramp agents, etc.)
- Foreign object damage (FOD): an accident was caused by birds, animals, and any objects that do not belong to the aircraft itself
- Flight attendant: an accident was caused by flight attendant's inadequate emergency actions
- Air Traffic Control (ATC): an accident was caused by air traffic controller's misjudgment
- Manufacturer: an accident was caused by a manufacturer's design, official inspection manuals, etc.
- Passenger: an accident was caused by passengers themselves

· FAA: an accident was caused by FAA's discretionary function regarding certificate approval, inspection, etc.
· Non-flight error: a combination of maintenance and ground crew's operational mistakes.

Research Techniques

To prepare a comprehensive picture for aviation safety training programs, this study revisited and analyzed government's accident final reports and categorized the causalities behind each mishap. Fault Tree Analysis (FTA) was followed after the identification of accident factors in order to explain how the root factors and accident causes were interrelated and to suggest a safety-training model for contemporary aviation.

Databases. Accident data (between 1999 January – 2004 May) were retrieved from the US National Transportation Safety Board (NTSB) Accident Docket Databases targeted on FAR Part 121 scheduled US air carriers.

Coding. Data coding is always an indispensable and taken-for-granted process for qualitative and quantitative data analysis (QDA) (Gough & Scott, 2000). Coding is a systematic procedure for synthesizing the significant meanings of texts by references and comparisons across different records (Maxwell, 1998; Miles & Huberman, 1994). Based on the aforementioned analytical highlights of data coding, this study categorized accident causes into eight (8) main groups. They are: (1) name of air carriers, (2) date of accident, (3) aircraft type, (4) fatality, (5) injury (both serious and minor), (6) aircraft/property damage (7) causes of accident, and (8) factors of accident causes.

Fault Tree Analysis (FTA). FTA is used to examine an extremely complex system. It uses an inductive approach (from general series of events to a specific top event). To accomplish a holistic view of a hazardous system, it tracks upstream and identifies causal factors that lead to accidents or incidents. FTA can be used to ground a determined outcome, in this case, an accident. Therefore, FTA will help researchers structure a foundation (recommendation-basis) for developing an industrial accident prevention program from bottom-up. Because FTA may encompass possibly hundreds of root factors of accident causes, this study focused on a mini-FTA structure that is sufficient to describe and prepare an accident-prevention program (Gloss & Wardle, 1984; Vincoli, 1993).

Reliability and validity. The governmental information databases help researchers secure data reliability and validity pertaining to a qualitative research (Creswell, 1998). With this in mind, the NTSB's database contains highly reliable and valid information that can be adopted to satisfy both reliability and validity criteria (Berg & Latin, 1994; Creswell, 1998; Lincoln & Guba, 1985).

Findings

The research time-period of data retrieval and analysis was between June 18 and October 3, 2004. There were total 189 final accident reports available from the NTSB's Docket System dated between January 1, 1999 and May 31, 2004. The findings were listed herein based on a numerical order.

Question 1: What were the primary causes of aviation accidents in the US between January 1999 and May 2004?

The primary causalities leading to FAR Part 121 air carriers' accidents between January 1999 -May 2004 were ranked and categorized as follows (See Table 1):

Table 1
The Primary Causes of Airline Accidents

Rank	Cause	Number of Cases	% of Cases
1.	Flight Operations	46	24.34%
2.	Ground Crew	43	22.75%
3.	Turbulence	40	21.16%
4.	Maintenance	25	13.23%
5.	Foreign Object Damage (FOD)	15	7.99%
6.	Flight Attendant	8	4.23%
7.	Air Traffic Control (ATC)	4	2.12%
8.	Manufacturer	4	2.12%
9.	Passenger	3	1.59%
10.	FAA	1	0.53%

The flight operation error resulted in 46 accidents (24.34%), which was the most critical individual cause of accidents. There were 43 accidents resulting from ground crew error followed by turbulence (40 cases), and the error of maintenance (25 cases), FOD (15 cases), flight attendant (8 cases), ATC (4 cases), manufacturer (4 cases), passenger (3 cases), and the FAA (1 case).

Question 2: What were the essential factors leading to the causes of aviation accidents in question 1 in the US between January 1999 and May 2004?

The factors leading to cockpit crew errors were: 1) lack of situation awareness, 2) misjudgment (ground clearance), 3) weather (snowy and icy runway), 4) ineffective communication, 5) operational deficiency (supervision, misjudgment, preflight inspection), or lack of training (heavy landing, go-around procedure, unfamiliar with regulations, and decision-making), 6) non-compliance with standard operational procedures (SOPs), 7) over-reaction (evasive maneuvers, abrupt reaction to Traffic Collision Avoid System (TCAS) warning), 8) physical fatigue, and 9) weather and airport information ignorance (weather briefing, turbulence report, Notice to Airmen [NOTAM], Minimum Equipment List (MEL), outdated Runway Visual Range [RVR]).

The factors leading to ground crew errors were: 1) poor situational awareness (clearance, airstair/jet bridge/vehicle operations), 2) ineffective communication (tug/truck/beltloader driver-pilots-wing walkers), 3) lack of supervision/quality assurance, 4) ramp agents' ignorance of safety criteria, 5) physical fatigue, and 6) personal health and medication.

Most accidents due to turbulence resulted in flight attendant injuries. The factors that led to injuries or fatalities resulting from turbulence were: 1) lack of weather awareness (pilots or dispatchers' poor discipline pertaining to weather evaluation), 2) inadequate training of cabin crews when encountering turbulence (inaccurate cabin reaction procedures, ineffective crew communication, late public announcement), and 3) passengers' inability of cooperating with cabin crews due to emergency situation.

The factors that led to the cause of maintenance errors (equipment contamination, corrosion, engine failure, etc.) were: 1) the lack of quality assurance and supervision on performance, 2) non-compliance of standard maintenance procedures (SMPs), 3) FAA's incorrect data, 4) lack of training and knowledge, 5) rushed service, and 6) operational ignorance.

The factors leading to FOD were bird and geese strikes and deer collision. The FOD frequently occurred during: 1) take-off and lading phase, and 2) night flights around remote non-hub airports.

The factors leading to the cause of flight attendant's mistakes were: 1) unfamiliarity with safety procedures during evacuation, 2) poor communication (between pilot, flight attendants, or ramp/gate agents), and 3) inadequate training with abnormal emergency conditions.

In addition, the factors leading to the cause of ATC errors were: 1) improper ATC service (the result was pilot's abrupt maneuver) and 2) a failure to provide adequate in-flight separation.

The factors leading to the cause of manufacturers' errors were: 1) inadequate manual information (e.g., gearbox maintenance manual), and 2) improper material and imperfect design.

The factors leading to the cause of passengers and their injuries were: 1) passengers' non-compliance with regulations during emergency situation, and 2) unruly behaviors.

The factor leading to the cause of FAA's error was FAA's improper issuance of airworthiness certificates and Airworthiness Directives (ADs) for specific parts.

Question 3. What was the level of criticality regarding non-flight factors contributing to airline accidents?

The relative criticality of non-flight error leading to accidents was determined by percentage. The findings showed that there were 68 accidents resulted from ground crew and maintenance flaws compared to 46 cases due to flight operation errors. The percentage of the non-flight error contributed to accidents was around 35.98% compared with 24.33% associated with flight operation errors. Appendix A lists all the accidents that resulted from ground crew or maintenance errors (See appendix A).

FTA Accident Prevention Model

The findings revealed that there were ten (10) main causes, along with 36 associated root factors, which led to accidents. Each accident cause contained from one (1) to nine (9) contributory factors. Every individual factor may form a category of cause that led to an accident such as inadequate flight performance, poor quality assurance, carelessness, air-rage, or unpredicted turbulence. The mini-FTA, showed in Appendix B, framed the inductive relationship among accident causes and root factors (See Appendix B).

Discussion and Conclusion

This study discovered the ten (10) essential causes leading to accidents and the 36 root factors behind each accident cause. Although the air transportation industry asserted that non-flight error insignificantly contributed to airline accidents, this statement was challenged. In addition, the root factors of accident causes were unveiled, by using Fault Tree Analysis. Aviation safety practitioners can use Fault Tree Analysis to design a more effective safety training program aiming to prevent errors from the bottom-up. Yet, routine (if not mandatory) ground safety trainings for non-flight employees must be in place. This study is concluded as the follows:

1. Non-flight Error Is More Critical—As an individual cause, flight operation error contributed to most accidents (24.34%). Yet non-flight (the dyad of ground crew and maintenance) error contributed 35.98% of the overall accidents. Apparently, the criticality level, based on a relative comparison about accident percentage, showed that non-flight error is higher than that of flight operation. Furthermore, the factors falling under the category of non-flight error included situational awareness, medication, teamwork, communication, physical condition, ignorance, quality assurance, incapability, and unfamiliarity with procedures. Without a doubt, maintenance, human factors, or MRM training for non-flight employees is an urgent need.

2. Fault Tree Analysis and Safety Training Model—In addition to pilot error and non-flight discrepancies, turbulence (21.16%), FOD (8%); and flight attendant error (4.23%) also played a crucial role. Although ATC, the manufacturer, and the FAA do not cause accidents as often, once it happens, injured people or victims' families may still file lawsuits against government employees if such an accident was a case of willful misconduct. Thus, it is important to understand mini-FTA analysis because it helps safety practitioners (government or airlines) to effectively and efficiently remedy accident postulates by implementing strategic

safety prevention programs from the bottom-up. In this study, any of the root factors can form a "cut-set" (a chain-of-events that can result in an accident or system failure) or trigger the "Domino Effect" leading to accidents. Hence, by structuring an FTA accident prevention model, eliminating the root factors could be more cost-effect for management personnel. This is true because the modes of a hazard prevention program include engineering redesign, administrative supervision, or effective work practice controls. If re-engineering and administrative controls are normally too costly to implement, work practice control (safety training) is the least-expensive means to prevent accidents with effectiveness (Brown, 1976; Gloss & Wardle, 1984; Vincoli, 1993).

3. Cost Consideration and Rulemaking—Cost is always the major concern regarding rule-makings. However, in the aftermath of 9/11 attacks, the US federal government petitioned many proposals in favor of tightening airport security such as the Aviation and Transportation Security Act of 2001, Homeland Security Act of 2002, Department of Homeland Security Appropriations Act 2004, and Vision 100-Century of Aviation Reauthorization Act of 2004 (Bowen & Lu, 2004b). These laws include budget increases for airport security and safety screening, safety manpower expansion, federalized safety inspectors, and relevant airport safety regulations and objectives (Roth, 2001). Interestingly enough, the potential high-cost concern does not seem to be an issue now. Without a major crisis, there would be no room for the federal government to increase its regulatory presence pertaining to airport security.The US government seems to have a long history of passively learning lessons from fatalities caused by discretionary function, regulatory deficits, or implementation deficiencies (Bowen & Lu, 2000; Lutte, 2000). Based on these findings, this study showed that non-flight error caused most accidents. A lack of mandatory MRM or adequate ground safety training is questionable. Because we do not want accidents to force the FAA reactions, the aviation community needs a more proactive rulemaking activity pertaining to maintenance safety.

Aviation accidents are still a threat to the flying public, because accidents still occur and will claim lives again. From the public standpoint, each accident will become a metaphor of either the government or the airline failure to protect its "clients." The public needs safer airline operations-a true foundation for Safer Skies.

Future Study and Comments

Although this study revealed root factors and causes leading to airline accidents, a future study could focus on the investigation of the status quo regarding the non-mandatory MRM training conducted by the contemporary air carriers. In addition, in order to reduce the cases of aircraft accidents resulting from turbulence and bird strikes/Foreign Object Damage (FOD), the aviation community needs to put more efforts on meteorological, technological, and biological understandings.

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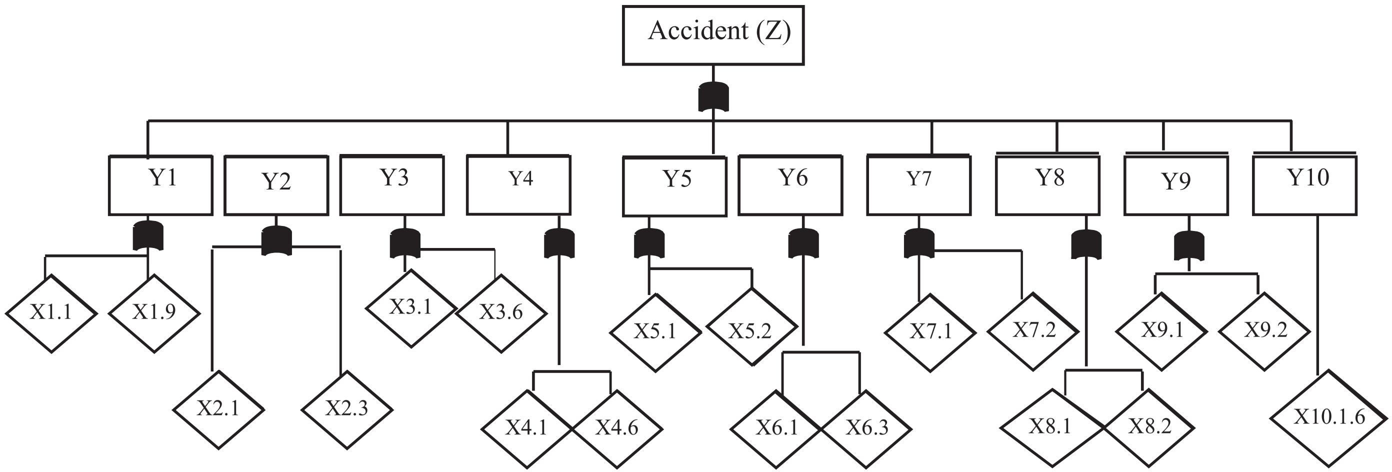
Appendix A
Non-flight (Maintenance and Ground Crews) Errors Leading to Accidents

Air Carrier	Date	Aircraft	Fatality	Injury	Aircraft Damage	Cause	Root Factors(extractedfrom accidentsynopsis)
AA Eagle	5/23/2001	Fokker-28	0	0	Yes	Maintenance	Landing gears failure, QA, maintenance
AA Eagle	10/3/2001	Fokker-28	0	0	Yes	Maintenance	Maintenance procedures, QA
AA Eagle	6/24/2003	EMB-135	0	0	Yes	Ground crew	Tug driver, awareness, communication
Air Midwest	6/29/2004	Beech 1900	21	1	Yes	Maintenance	Incorrect rigging of control system, QA, weight-&-balance, manufacturer, FAA assumption
Air Wisconsin	3/20/2000	Dornier-328	0	0	Yes	Maintenance	RLG failure, not down-and-lock after touch down
Airtran	1/20/2002	DC-9	0	0	Yes	Ground crew	Tug driver, awareness, training, communication
Airtran	8/8/2000	DC-9	0	13	Yes	Maintenance	Unauthorized procedures
Airtran	11/29/2000	DC-9	0	13	Yes	Maintenance	Phase-to-phase arc in the left heat exchanger cooling fan relay
Airtran	3/26/2003	B-717	0	23	Yes	Maintenance	Engine, mechanical
Airtran	8/1/2004	B-717	0	0	Yes	Ground crew	Awareness, training, clearance, communication, vision block-out
Alaska	1/31/2000	MD-83	0	0	Yes	Maintenance	Horizontal stabilizer, jack screw lubrication, nut thread
Alaska	3/17/2002	MD-82	88	0	Yes	Ground crew	Windwalker, awareness, training, communication, snow
America West	7/24/1999	B-757	0	0	Yes	Ground crew	Tug driver, pilot, communication, SOPs, training, awareness
America West	10/15/1999	A-320	0	0	Yes	Ground crew	Tug driver, wing walker, communication, training, awareness
America West	6/12/2000	A-320	0	0	Yes	Maintenance	Failure to refasten engine cowling door
American	2/21/2000	Fokker-28	0	7	Yes	Ground crew	Fuel truck driver, awareness, MRM, sleep apnea, hypersomnolence
American	3/6/2002	Fokker-28	0	0	Yes	Ground crew	Deicing, QA, procedure
American	10/4/2003	B-737	0	0	Yes	Ground crew	Driver misused luggage vehicle leading to unwanted movement
American Eagle	8/13/1999	ATR-42	0	1	Yes	Ground crew	Ramp service encountered with prop, awareness, communication
American Eagle	9/29/2000	SAAB-340	0	0	Yes	Ground crew	Beltloader driver, awareness, training
American Intl'	2/19/2000	DC-8	0	0	Yes	Maintenance	Engine inspection, QA, SOPs, MRM, training
American Trans	1/13/1999	B-727	0	1	No	Maintenance	Failure of adjust load of cargo door (injury to ramp agent)
American Trans	8/16/2000	B-727	0	0	Yes	Ground crew	Failure tow-bar
American Trans	5/11/2002	B-757	0	0	Yes	Ground crew	Awareness, training, tug driver, communication, wingwalker
Atlantic Coast	9/2/2003	Donier-328	0	1	No	Ground crew	Failure air stair and passenger assistance
Business Express	4/12/1999	SAAB-340	0	0	Yes	Ground crew	Belt-loader driver, SOPs, safety and procedure training

Comair	1/8/2001	Bombardier CL-600	0	2	Yes	Ground crew	Trucker driver awareness, training
Comair	5/7/2003	Bombardier CL-600	0	0	Yes	Ground crew	Beltloader operator's incapability
Continental	9/12/1999	B-737	0	0	Yes	Maintenance	Poor inspection of high pressure turbine
Continental Express	7/28/1999	ATR-42	1	0	Yes	Ground crew	Station manager failed to maintain clearance and encountered with prop, awareness, SOPs
Delta	11/27/1999	B-727	0	0	Yes	Ground crew	Tow bar failure, inspection, QA, training
Delta	12/27/2001	B-767	0	1	No	Ground crew	Awareness, jet blast
Delta	4/5/2002	B-767	0	0	Yes	Maintenance	QA, maintenance
Emery Worldwide	2/16/2000	DC-8	3	0	Yes	Maintenance	Elevator control tap, inspection, maintenance, visual inspection overlook
Emery Worldwide	4/27/2000	DC-8	0	0	Yes	Maintenance	Value failure, engine cowling separation, QA, inspection
ERA	4/10/2003	DH-6	0	0	Yes	Ground crew	Wingwalker awareness
FedEx	8/7/1999	DC-10	0	0	Yes	Maintenance	No tie-down after passenger release, SOPs, training
FedEx	3/1/2000	DC-10	0	0	Yes	Ground crew	Tug driver operated by amp, training
FedEx	1/2/2002	B-727	0	0	Yes	Ground crew	Tug driver, awareness, training, communication
Great Lake	6/2/2003	EMB-120	0	0	Yes	Ground crew	Awareness, communication, training, procedures
Gulfstream Intl'	3/18/2000	Beech 1900	0	1	Yes	Ground crew	Tug driver, heavy raining, no light but reflectors, communication
Mesa	9/21/2003	DH-8	0	0	Yes	Ground crew	Awareness, tug driver, truck released, wing walker, communication
Mesaba	7/16/2002	SAAB-340	0	1	Yes	Ground crew	Awareness, clearance, communication
Mesaba	7/21/2002	SAAB-340	0	0	Yes	Ground crew	Truck driver, awareness, training, awareness
Midwest Express	7/2/1999	DC-9	0	0	Yes	Ground crew	Lavatory service driver, training, SOPs, no-backup personnel
Mountain Cargo	7/29/2004	Fokker-27	0	0	Yes	Maintenance	Failure of MLG
Northwest	12/27/2000	DC-9	0	0	Yes	Maintenance	Material fatigue, QA, inspection
Northwest	3/23/2001	B-727	0	1	No	Ground crew	Powerback coordinator, SOPs, training, jet blast
Northwest	5/1/2001	DC-9	0	2	Yes	Ground crew	Tug failure
Northwest	6/3/2002	DC-9	0	0	Yes	Maintenance	SOPs, training, maintenance, QA
Northwest	9/22/2002	DC-9	0	0	Yes	Maintenance	Maintenance procedures, QA
Northwest	1/19/2003	B-757	0	7	No	Maintenance	Ignorance, SOPs, training, QA
Piedmont	8/5/2001	DH-8	1	0	No	Ground crew	Hyperthyroidism, medication
Pro Air	9/15/2000	B-737	0	0	Yes	Ground crew	Tug driver, awareness, training, communication, night ops
Seaborne Aviation	8/7/1999	DH-6	0	0	Yes	Ground crew	Failure to verify a release procedure/directive, and removal of a second airplane's tie-down

Seaborne Aviation	8/7/1999	DH-6	0	0	Yes	Ground crew	Corrosion inboard training edge bolt
Skywest	2/25/2001	EMB-120	0	1	No	Maintenance	Contamination elevator trim actuator
Sun Country	5/28/1999	B-727	0	0	Yes	Ground crew	Tug driver, wing walker, communication, training, awareness
Sun Country	9/10/2000	B-727	0	0	Yes	Maintenance	Maintenance procedures, QA
TWA	8/9/2001	B-717	0	0	Yes	Maintenance	NLG malfunction, QA, wheel chock not removed
United	9/12/1999	B-737	0	0	Yes	Ground crew	Lavatory service driver, training, SOPs, no-backup personnel
United	3/2/2002	B-757	0	0	Yes	Ground crew	Truck driver, awareness, training, communication
United Express	10/24/2004	Bombardier CL-600	0	5	Yes	Ground crew	Truck driver, awareness, training
US Airways	2/3/2001	MD-81	0	0	Yes	Ground crew	Tug driver, awareness, training, communication

Appendix B
Fault Tree Analysis (FTA)



Note: Y1: Flight operation; Y2: Turbulence; Y3: Maintenance; Y4: Ground crew; Y5: FODs; Y6: Flight Attendant; Y7: ATC; Y8: Manufacturer; Y9: Passenger; Y10: FAA; X1.1: situation awareness; X1.2: misjudgment; X1.3: weather; X1.4: communication; X1.5: operational deficiency; X1.6: SOPs; X1.7: over reaction; X1.8: physical fatigue; X1.9: weather ignorance; X2.1: weather awareness; X2.2: inadequate training; X2.3: passengers' non-compliance; X3.1: SMPs; X3.3: FAA's incorrect data; X3.4: training; X3.5: rushing service; and X3.6: ignorance; X4.1: awareness; X4.2: communication; X4.3: QA; X4.4: ignorance; X4.5: fatigue; X4.6: health and medication; X5.1: birds; X5.2: deer; X6.1: evacuation; X6.2: communication; X6.3: training; X7.1: ATC service; X7.2: flight separation; X8.1: manual; X8.2: design; X9.1: non-compliance; X9.2: late respond; X10.1: air-worthiness certificate and Airworthiness Directives (ADs); Domino effect X→ Y→ Z; ■ is a logic symbol of "OR" gate in system safety program.

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The Effect of GPS and Moving Map Displays on Navigational Awareness While Flying Under VFR

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Abstract

Sixteen pilots rated their navigational awareness to be significantly higher when navigating using a GPS and moving map display than when navigating using pilotage. The same sixteen pilots then were asked to fly, as accurately as possible, over a circuit consisting of six checkpoints in an unfamiliar area. Eight pilots navigated between the checkpoints using pilotage (i.e., a sectional chart). The remaining eight pilots were given the same sectional chart and a GPS receiver featuring a color moving map display. Navigational accuracy was recorded at each checkpoint for all sixteen pilots. The GPS/Moving Map group navigated more accurately than the Pilotage group, although both groups performed within standards. Upon completion of the circuit, pilots were asked to fly the same circuit again, only this time without any navigational resources. Navigational accuracy was again recorded for each checkpoint. The GPS/Moving Map group performed significantly worse than the Pilotage group when navigation resources were taken away. Two pilots using GPS and the moving map were unable to find their way to the starting point of the circuit. Other GPS pilots made large errors in navigating to individual checkpoints. When asked to reassess their own estimations of navigational awareness during the second circuit, the Pilotage group raised their estimates while the GPS group significantly lowered them. These findings call into question unqualified beliefs and claims that advanced avionics systems enhance pilots' navigational awareness, and point to a need to teach pilots about the potential human factors pitfalls associated with advanced avionics systems.

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Introduction

GPS receivers with moving map displays are often claimed to increase pilots' navigational awareness (Avidyne, 2005; Garmin, 2003). These claims are partly justified by some obvious advantages offered by GPS and moving maps. One only need consider the problem of locating the nearest suitable airport in the event of an emergency. GPS receivers pinpoint the position of the aircraft while moving maps instantly present the answer to the dire question of where to go. Many systems can also display the available runways, runway lengths, field elevation, and communications frequencies. In the case of an emergency, it is hard to imagine a more timely and useful information resource.

With examples such as this in mind, it is tempting to think of GPS and moving maps as having a supplemental effect on pilot awareness: further empowering already-aware pilots with more detailed information about their surroundings. However, the research literature tends to contradict this belief. Empirical studies have demonstrated a cost associated with not having to actively perform mental calculations and discriminations that are made automatically by a computer. Memory and awareness of information that is passively monitored has been shown to be significantly poorer than information that human operators generate themselves using mental problem solving and rehearsal (Slamecka & Graf, 1978; Glenberg, Smith, & Green, 1977; Craik & Lockhart, 1972). Observational studies of humans working with automation, in the aviation domain as well as others, have demonstrated poorer awareness among human operators who perform tasks with the assistance of automated systems (Uhlarik & Comerford, 2002; Savage, 1999; Billings, 1997; Endsley, 1996; Endsley & Kiris, 1995; Parasuraman, 1987). These studies draw a common conclusion: in an effort to make the human operator more aware by providing more information through automation, we sometimes make the human less aware. Wiener (1989) refered to this phenomenon as the *paradox of automation*.

This study attempts to answer two simple questions about the navigational awareness of pilots while flying under visual flight rules (VFR):

1. Do pilots believe they are more navigationally aware when flying with GPS and moving maps?
2. Does pilots' navigational performance agree with or contradict these beliefs?

Comparative verbal estimates of navigational awareness were collected from pilots as a measure of what they believe about GPS, moving map displays, and navigational awareness.

A simple comparative technique was used to determine whether or not pilots' performance matched their beliefs about navigational awareness. Two groups of pilots were asked to fly a circuit of checkpoints on a cross-country flight through an unfamiliar area. One group of pilots used pilotage (i.e., a paper sectional chart and visual references) to find their way to each checkpoint. The other group of pilots had the same sectional chart and visual references, but also used a GPS and moving map display. Navigational accuracy was recorded at each checkpoint. Upon completion of the circuit of checkpoints, all pilots were asked (unexpectedly) to fly the circuit again, this time, without the use of any navigational resources. That is, the pilots were asked to fly the circuit using only whatever familiarity with the area they had acquired during the first time around the circuit. Navigational accuracy was again recorded and compared.

Previous research suggested a simple hypothesis. Pilots using pilotage actively perform the navigational task. When asked to fly through the circuit of checkpoints a second time with no navigation resources, these pilots should enjoy a more detailed awareness of the area acquired during their first pass through the circuit. Pilots using GPS and a moving map display, on the other hand, serve as passive monitors while computers automatically perform the navigational task for them. When these pilots are asked to fly over the same circuit of checkpoints again, they should experience more difficulty because they maintain a lesser awareness.

Method

Participants

Sixteen pilots who met the following three criteria were selected on a first-come-first-served basis at a local airport. All pilots were legally qualified to act as pilot in command in the experiment airplane. All pilots had basic familiarity with GPS receivers and moving maps. All pilots reported that they did not have significant familiarity or experience with the area in which the data were to be collected.

Apparatus

The experiment airplane was a Diamond DA40 (Diamond Star) equipped with a panel-mounted GPS receiver and a color moving map display.All pilots were furnished with a current San Francisco sectional aeronautical chart that covered the area through which the experimental flight was conducted. The experimenter had access to an additional GPS receiver that was hidden from pilots' view.

Procedure

The sixteen pilots were told that they had to complete a cross-country flight that consisted of a series of nine checkpoints. It was explained that the first three checkpoints were intended as practice checkpoints as pilots made their way out to a circuit of six additional checkpoints, located in an unfamiliar area, that were of interest to the experimenter. The last six checkpoints formed a circuit as shown in Figure 1. The most distant checkpoint was approximately 105 nautical miles from the origin airport.

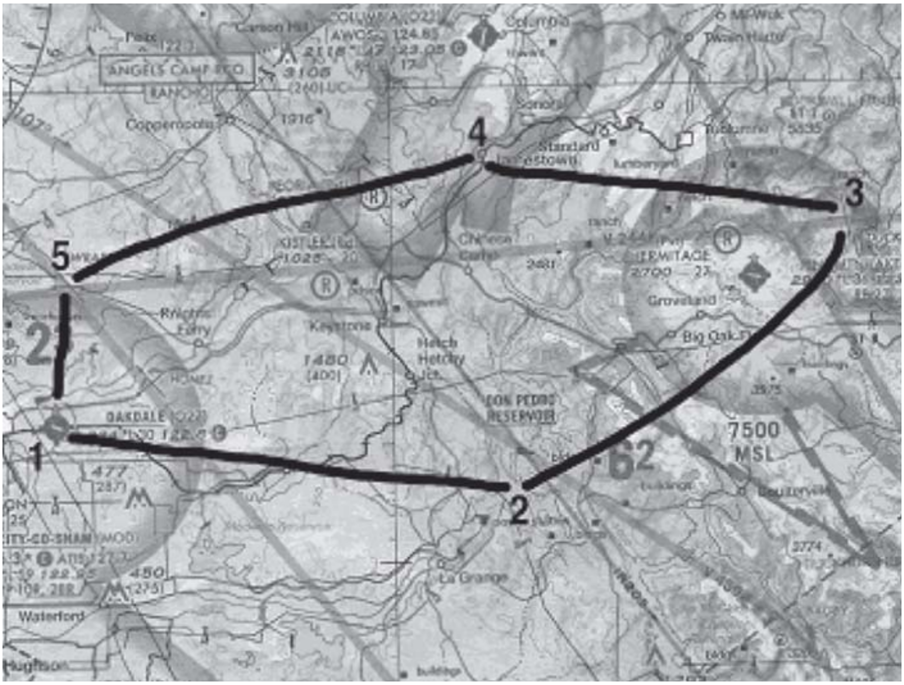

Figure 1. Sectional chart showing circuit of checkpoints.

Pilots had to find their way to Oakdale Airport, then fly over a series of four other checkpoints, and end up back at Oakdale. Pilots were instructed to fly as closely as possible to each checkpoint, and to report when they believed that they were directly over each checkpoint. Pilots were briefed on the route prior to engine start at the origin airport. A sectional aeronautical chart was used to point out the route including each of the nine checkpoints.

Pilots navigated between all nine checkpoints along the flight in one of two different ways.

Eight pilots were randomly assigned to the Pilotage group. These pilots were given a San Francisco sectional aeronautical chart and were told that they would have to navigate by means of *pilotage*. Pilotage is a technique in which the pilot must find his or her way by correlating geographical features depicted on a chart with geographical features seen out the window of the airplane. These pilots were not permitted to use timers, calculators, plotters, or any other device that could facilitate navigation techniques other than pilotage (e.g., dead reckoning).

Eight pilots were randomly assigned to the GPS/Moving Map group. These pilots were given the same San Francisco aeronautical chart, but also used a panel-mounted GPS receiver that featured a moving map display. It was verified that each pilot was familiar with the basic features of the GPS and moving map prior to departure. The route consisting of all nine checkpoints was programmed into the GPS prior to takeoff.

Upon departure, pilots were asked to verbally estimate their navigational awareness in two different situations: (1) navigating using only a sectional chart; and (2) navigating using a sectional chart and a GPS receiver with a moving map display. Note that each pilot in each group rated themselves in the situation in which they were currently flying, and in the situation experienced by pilots in the other experimental group. Pilots estimated their navigational awareness using a 0-to-10 scale: 0 representing a total lack of awareness, and 10 representing perfect awareness.

All sixteen pilots flew over the nine checkpoints as instructed. All pilots were asked to announce when they believed they had reached each checkpoint. Upon each pilot report, the experimenter used a GPS receiver, hidden from the pilot's view, to note the actual distance from the checkpoint. This measure represented the pilot's navigational error.

Upon reaching the last checkpoint in the circuit, the experimenter intervened and announced a revision to the original plan for the flight. Instead of returning home, all sixteen pilots were asked to once again fly the circuit consisting of the previous six checkpoints, only this time, without any navigation resources available to them. In the case of the Pilotage group, the experimenter took away the sectional chart. In the case of the GPS/Moving Map group, the experimenter took away the sectional chart and turned off the GPS and moving map display.

After the first checkpoint, the experimenter asked each pilot to rate his or her own navigational awareness in the current situation: flying with no navigational resources other than any knowledge about the area and airspace that he or she had collected during the first time over the checkpoints.

Each pilot also was asked to provide bearing and distance estimations to what he or she believed were the two nearest airports.

The sixteen pilots flew over the loop of six checkpoints once again, reported crossing each checkpoint, while the experimenter again noted the navigational error at each checkpoint.

On the return leg, after the data were collected, all pilots were briefed on the purpose of the study and were made aware of prior human factors research pertaining to flying with automated systems.

Results

Navigation Error

The mean navigational errors for the two groups of eight pilots during the first pass through the circuit are shown in Figure 2.

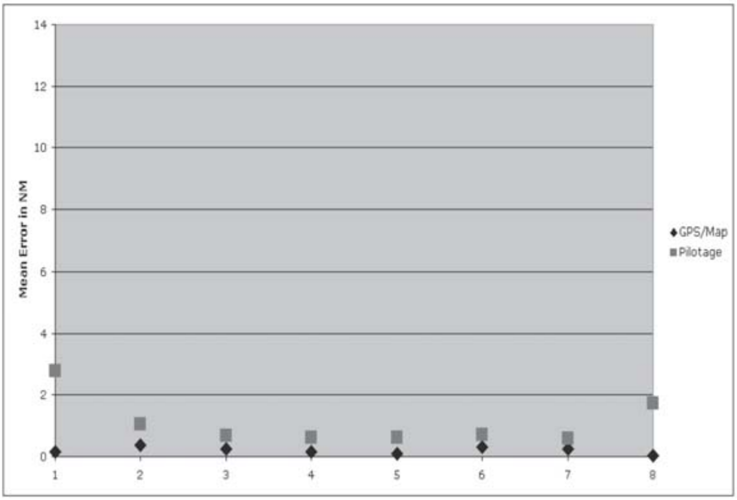

Figure 2. Navigational accuracy with all navigational resources available.

The mean navigational error and standard deviation for the Pilotage group was 1.1 NM (1.5 NM), while the mean and standard deviation for the GPS/Moving Map group was 0.2 NM (0.3 NM). Although the means for both groups fell well within the general 3 NM navigation standard for pilotage and dead reckoning cited in the Private Pilot Practical Test Standards (FAA, 2002), the GPS/Moving Map group achieved a significantly higher degree of navigation accuracy, $t = 3.74$, $p < 0.01$.

The mean navigational errors for the two groups of eight pilots during the second pass through the circuit, when pilots had no navigation resources available to them, are shown in Figure 3.

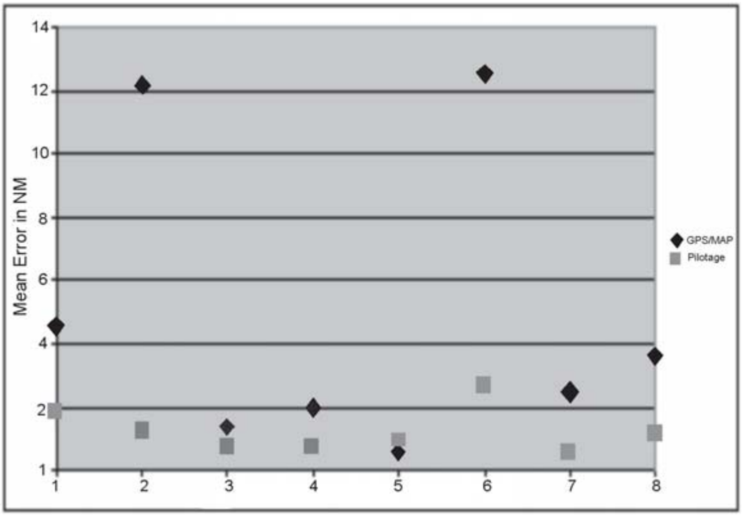

Figure 3. Navigational accuracy with no navigational resources available.

The mean navigational error and standard deviation for the Pilotage group was 1.3 NM (0.7 NM), while the mean and standard deviation for the GPS/ Moving Map group was 4.9 NM (7.9 NM). Again, there was a significant difference between the two groups, only this time the situation was reversed: the Pilotage group performed significantly more accurately ($t = 2.17$, $p < 0.05$).

Error measures and statistics aside, there was a categorical difference in performance between the two groups. All eight pilots in the Pilotage group performed within the 3 NM minimum standard suggested in the practical test standards, while only one-half of the pilots in the GPS/Moving Map group met the standard. Regardless of how one chooses to statistically consider the two large average errors shown in Figure 3, these two cases have a practical significance. These two pilots were wholly unable to find their way back to point where they started, reporting this checkpoint to be 25 NM and 41 NM away from its actual location.

Figure 4 summarizes, in a single graph, the navigational performance of both groups in both conditions.

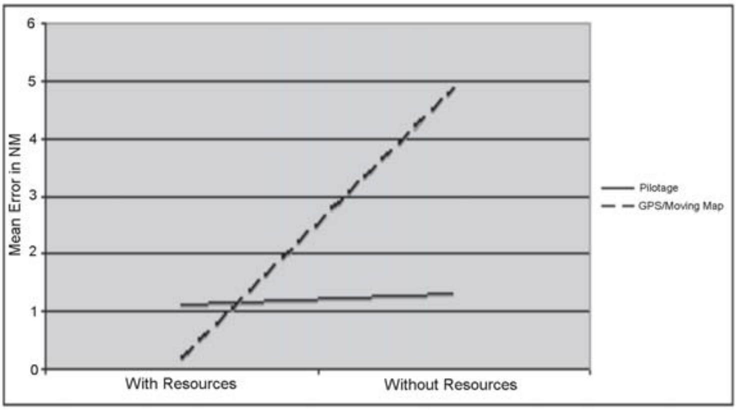

Figure 4. Navigational accuracy for both groups in both conditions.

It is also interesting to compare navigational accuracy within each of the two groups: that is, to compare pilots' performance with and without their respective navigational resources. Taking away the sectional chart had no significant effect on the performance of pilots in the Pilotage group. In fact, the variance in performance slightly decreased when the sectional chart was not available. Taking away the GPS and sectional chart from the GPS/Moving Map group had a significant effect on the mean navigational error ($t = 2.82$, $p < 0.01$).

Bearing and Distance Estimations

Fifteen of the sixteen pilots were able to identify the two nearest airports. One pilot identified the nearest airport and the third nearest airport.

The errors in bearing and distance estimations to the two closest airports for the two groups of eight pilots are shown in Figures 5 (a) and (b).

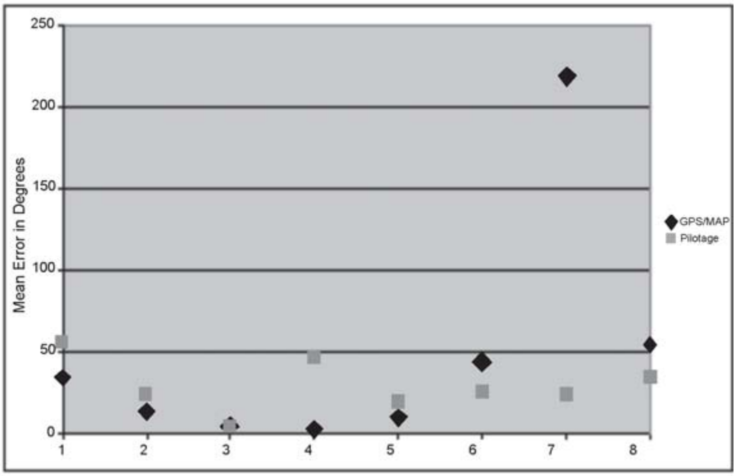

Figure 5(a). Mean error in bearing estimates for closest airports.

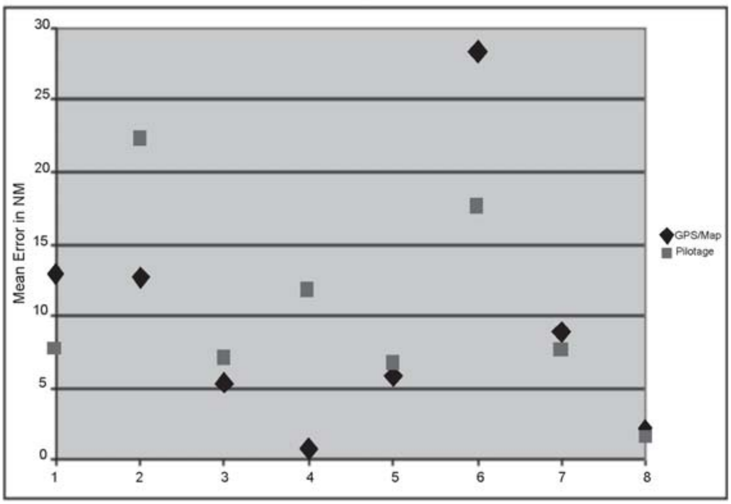

Figure 5(b). Mean error in distance estimates for closest airports.

There were no differences between the two groups. One explanation of this result is the observation that people tend to initially acquire "route-based" representations of an area. Route-based representations support basic wayfinding tasks but do not support "survey map" type tasks such as determining direction and distance between known points (Thorndyke & Hayes-Roth, 1982). This finding also casts doubt on the use of "freeze-and-probe" methods of measuring navigational awareness: techniques that focus on asking questions about navigational surroundings rather than challenging pilots with realistic navigational tasks (several studies reviewed in Uhlarik & Comerford, 2002). In this case, no difference in question-answering performance was observed between the two groups even though there was a significant difference in navigational performance between the groups.

Self-Ratings of Navigational Awareness

Every pilot was asked to rate his/her navigational awareness in three different situations:

1) Prior to traversing the circuit of checkpoints, every pilot was asked to rate his/her navigational awareness in the situation he/she was currently flying. That is, the Pilot group was asked to rate awareness when using a sectional chart, while the GPS/Moving Map group rated awareness when using a GPS, moving map, and sectional chart.
2) Prior to traversing the circuit of checkpoints, every pilot was asked to rate what his/her navigational awareness would be if he/she was flying in the other experimental condition. That is, members of the Pilotage group hypothesized what their awareness would be if they had the GPS and moving map available, while members of the GPS/Moving Map group rated themselves using only a sectional chart.
3) While traversing the circuit of checkpoints for the second time, every pilot was asked to rate awareness in his/her current situation: with no navigational resources available.

Table 1 shows the navigational awareness ratings given by pilots in both groups.

Table 1
Subjective self-estimates of navigational awareness

	Using Pilotage	Using GPS/Moving Map	Using Neither
Pilotage Group	7.625	9	8.125
GPS/Moving Map Group	6.625	9	4.875

Pilots in both groups rated awareness to be significantly greater when a GPS and moving map were being used ($t = 3.47$, $p < 0.01$). The interesting result is the significant difference between the two groups when they were confronted with the task of flying the circuit for the second time, with their navigation resources taken away. The Pilotage group rated themselves significantly higher than the GPS/Moving Map group, and these ratings matched their performance. The GPS/Moving Map group not only rated themselves significantly lower than the Pilotage group ($t = 3.38$, $p < 0.01$), but also significantly lower than themselves when flying with the GPS and map display available ($t = 4.25$, $p < 0.01$).

Performance and Total Flight Time

It is also interesting to compare pilots' performance with their total flight time. Table 2 shows the correlation coefficients between total flight time and mean navigational error at all checkpoints.

Table 2

Correlations between total flight time and navigational error

	With Nav. Resources	Without Nav. Resources
Pilotage	-0.31	0.58
GPS/Moving Map	-0.28	-0.45

Although the pilot sample used here is small and strong conclusions are not warranted, the two larger correlation coefficients suggested the need for further investigation.

Higher flight time was associated with poorer pilotage performance when the sectional chart was taken away (r=0.58). One explanation for this effect might be that pilots rely less and less on pilotage as they acquire more flight experience.

Higher flight time was associated with better performance when the GPS and moving map were taken away. This might suggest that more experienced pilots were less likely to suffer from the out-of-the-loop phenomena when GPS and moving maps are used.

Conclusion

The results of the study provided clear answers to the two research questions. One, the pilots believed that their navigational awareness was higher when flying under VFR with GPS and moving map displays. Two, pilots' navigational awareness, using the measures described here, appeared to be significantly lower when flying with GPS and moving map displays.

With regard to the first research question, pilots' beliefs about navigational awareness warrant further investigation. It may have been that pilots responded to the question about navigational awareness without considering the possibility of an equipment failure. Furthermore, pilots may consider navigational awareness to extend beyond what the pilot is aware of in the traditional sense. That is, pilots may have considered the information stored inside the computer to be part of their awareness. This raises an important question: should we regard information stored in a computer as part of a pilot's navigational awareness? Or should this awareness be required to remain, in the traditional sense, in the pilot's head?

With regard to the second research question, the results raise the practical question of how to help pilots maintain navigational awareness when flying with advanced avionics, and how to prepare pilots for the situation in which avionics systems become inoperative during flight. Some have proposed the idea of emergency training, similar to partial panel instrument training required of all instrument rating applicants today. In the case of a vacuum system failure, pilots must rely on alternate sources of information about aircraft attitude. The results of this study suggest that this type of training would not be effective in preparing pilots for equipment outages. The data clearly showed that, unless there is another type of navigation equipment on board, there may not be another source of navigation information in the cockpit upon which to rely. Unlike vacuum systems failures, the problem with an inoperative GPS and moving map is not only a lack of information technology – it is also a lack of information. Using pilotage, our pilots had a backup navigational resource when their charts were taken away – their own knowledge of their positions, routes, and terrains. In the case of the pilots using GPS, this knowledge was not always present. We could always suggest or require that every pilot or aircraft carry an additional form of navigation equipment to help save the day (e.g., a handheld GPS). Again, there is no guarantee that this equipment will function when needed.

A promising first step toward safe use of GPS and moving maps suggested by our data is to make pilots aware of this and other cockpit automation-related human factors phenomena. These problems have been recognized and openly discussed among airline operators for twenty years (Hopkins, 1983; Manning 1984; Melvin, 1983; Oliver, 1984, cited in Wiener, 1988). The recent appearance of high-tech avionics in general aviation aircraft suggested the need to provide general aviation pilots with the same safety-related information derived from twenty years of research and operational experience. Training materials currently available for technically-advanced aircraft and equipment seldom reflect an understanding of these known breakdowns that occur when human pilots work with cockpit automation systems. Perpetuating the common belief, these documents commonly refer to the idea of "situational awareness" as something provided to the pilot by high-tech avionics. These training practices may help to magnify, not to mitigate, the unique challenges to safety presented by emerging cockpit technology.

In addition to making pilots aware of automation-related phenomena, some automation-savvy operators teach practices to help keep pilots in the loop when using automation. Cross-checking position using pilotage or radio navigation equipment is one example technique. Backing up or cross-checking calculations performed by the computer with the pilot's own mental calculations is another (Bulfer, 2004).

As a final note, it is important to note that the significantly degraded performance observed in this study occurred over a circuit of checkpoints that in no way represents the most challenging situations to be found in the national airspace system. The area used in this study was small and dense with airports and blatantly obvious geographical features (e.g. the Pacific Ocean and Sierra Mountains). Furthermore, the checkpoints were relatively close together. One only needs to imagine flying greater distances over open stretches of the Rocky Mountains or the Great Basin Desert, where the terrain can look similar in all directions for hundreds of miles. Situations like these surely raise both the challenges and the stakes in the game of finding one's way home.

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Astronauts as Audiences: Characteristics of the First Space Communities

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Abstract

The United States National Aeronautics and Space Administration (NASA) publishes data (2003) which includes the name, gender, town of birth, education and some interests of almost every astronaut who has been launched into space by the dominant space explorer, the United States. This list identifies astronauts from the United States, the former USSR and its subsequently independent states, Europe, Australia and Asian participants. Our analysis of this data, we suggest, revealed the most likely characteristics of the members of the first communities in space. This led us to think about these communities as "audiences," just as earthbound communities have been grouped into audience, or "market," segments by media companies.

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Purpose

This article sets out to demonstrate the relationship between the astronaut selection criteria employed by the United States National Aeronautics and Space Administration (NASA) and the demographic characteristics of the "first communities in space," namely, groups orbiting on the Space Shuttle and on the International Space Station.

Introduction

"NASA picks astronauts that "look like America. Our country has all kinds of people. We are many colors. We are many races. We come from different places. Some of us are male. Some of us are female" (Canright, 2004, pg. 1). In this article, co-researchers on both sides of the Pacific Ocean – in Australia and the US – investigated this selection criterion, some of its outcomes, and how successful the space agency has been in selecting crews, which are representative of US culture. We also posed the follow-up question: "If the first explorers from Earth into space 'look like America', what are the first communities in space going to look like?" It is clear that many people outside the US would be wary of American influence spreading even further than it has already; many within the US also are unsure that this is good policy. Whatever the politics, social scientists, and observers such as the present team of authors owe it to humanity – not to mention extraterrestrial worlds – to scope the situation before any political or cultural force hard-wires the near-universe to "look like itself."

Rationale and Existing Literature

On the back cover of *Space 2100*, Baard, Grierson, Sauls, Fenella, Schultz, and Winters (2003) quoted a basic reason for the human quest to explore and colonize space: "There is another reason to go boldly, of course. A simpler one. We explore. It's what we do." More prosaically, in *Mining the Moon*, Schmitt (2004) noted that the human history of exploration has been fuelled by the desire to seek out new sources of food, precious minerals, and energy supplies. He suggested that the first space colonies will be on the moon for the primary purpose of mining helium-3. Helium-3 has unique qualities that allow it to be used as a fuel for nuclear fusion. Huge quantities of helium-4 and 3 are generated by the sun and sent toward the Earth in the solar wind. However, the Earth's magnetic field pushes it away towards the moon where it is mixed with the dust and rock. Not only is this a practical reason to establish the first space colony, the benefits could be enormous for industrialised nations such as the US, China and Europe. The potential for mining helium-3 also might free the world from its dependence – now reaching alarming rates as the price of oil rises – on fossil fuels.

Space is already attracting interest from tourists and potential space-tourism companies such as Englishman Richard Branson's Virgin Galactic, which aims "by the end of the decade … to make it possible for almost anyone to visit the final frontier at an affordable price."[1] According to a 1995 survey called the *Space Tourism Initiative*[2], 60% of respondents would like to take a holiday in space.

Such holidays look more likely now that the $10 million Ansari X-Prize has been awarded to the SpaceShip One consortium (David, 2004).

In *Space Colonization Basics*, NASA (2004) pointed out that these long-term settlements would be a place for ordinary people. Data in this study indicated that presently, space travel is limited to highly trained and well-educated astronauts from well-defined backgrounds. To become reality, the cost of settlement needs to be inexpensive, while launch systems must be safe, reliable, and capable of delivering thousands of people, perhaps millions.

As one example, the family name "Cokley" (of one of the current co-researchers) has been in space since February 7, 1999, when the NASA *Stardust* mission blasted off on its mission to meet Comet *Wild 2* in 2004. Co-author Cokley, along with approximately one million others[3], registered his name and those of his parents, his son, daughter, and brother for storage on a microchip, which was loaded onto the spacecraft before launch. The microchip was described at the time by NASA as "a public outreach effort (which) allowed people to be personally involved with the *Stardust* mission (and) to promote public interest, awareness, and support of the space program."[4] This was also the first spacecraft designed and dispatched to bring a sample of a comet back to Earth. As this article was being prepared for publication, the *Stardust* spacecraft was orbiting far out into the Solar System, about halfway between Earth and Jupiter, having successfully rendezvoused with the potato-shaped comet on January 2, 2004[5]. It is due back in Earth's atmosphere the same month two years later (2006), hopefully carrying 4.5 billion-year-old particles[6], which NASA says have flown off the nucleus of the comet, as well as samples of interstellar dust[7]; also hopefully to a softer landing than that achieved by the ill-fated Genesis probe on September 8, 2004[8].

The Cokley "virtual journey" to the comet and back is relevant in that it illustrates how space communities will mature: out of personal interest and sheer force of numbers at the launch pad. In the far distant future, "people like us" will indeed populate the heavens, in orbiting stations such as those described by Clarke (1968). But in the not-too-distant future, the population will look like the cast list from Clarke's *2001: A Space Odyssey*: Dr Dave Bowman, Dr Frank Poole, Dr Heywood R. Floyd, Dr Andrei Smyslov, Dr Rolf Halvorsen, and Dr Bill Michaels[9]. Of the fifteen principal characters (including the voice of the HAL 9000 computer), only two are women: Elena and Poole's mother[10]. The data we present supported this picture.

The first two phases of human space travel – an initial period of exploration (1961-1972) followed by a lengthy experiment in orbital habitation (1973-2003) – already have been experienced. The early missions were fully government-funded by the United States and the Soviet Union, relatively short in duration, and filled with considerable risk. Therefore, the first astronauts were predominantly young, male test pilots with engineering or science degrees and military experience. As the missions lengthened and evolved – especially with the advent of the International Space Station after the fall of the Soviet Union – the astronaut

Table 1

The First Century of Space Communities (© Guillermo Söhnlein 2004)

		RETROSPECTIVE		OUTLOOK		
PERIODS	Years	1961-1972	1973-2003	2004-2015	2016-2030	2031-2060
	Description	*Exploration*	*Orbital Habitation*	*Transition*	*Lunar Return*	*Mars and Beyond*
	Focus	* First Humans in Space * U.S. Lunar Landings	* Skylab * Mir * Apollo-Soyuz * Space Shuttle * ISS	* Retire Shuttle * Transfer ISS	* Lunar Colony * Orbital Private Sector	* Mars Colony * Orbital/Lunar Private Sector
MISSIONS	Type	* Test Flights * Exploration	* Science * Research	* Engineering * Administration	* Exploration (public) * Commerce (private)	* Exploration (public) * Commerce (private)
	Duration	Hours-Days	Days-Months	Days-Months	Weeks-Months	Weeks-Years
COMMUNITIES	U.S. Govt	* Test pilots * Young, male, military	* Pilots and scientists * Older, male, military, engineers * More female, civilian, science	* Pilots and scientists * Older, male, military, engineers * More female, civilian, science	* Civil engineers * Geologists * Biologists	* Civil engineers * Geologists * Biologists
	Foreign/Int'l	Only Soviet Union	* Primarily Russia * Other nations * International cooperation	* Primarily Russia * Other nations * International cooperation	* International cooperation	* International cooperation
	Private	None	* Some civilian passengers * Firstspace tourists	* Civilian passengers * Space tourists * Orbital entrepreneurs	* Orbital/lunar tourists * Orbital enterprises * Lunar entrepreneurs	* Orbital/lunar enterprises * Martian entrepreneurs
MEDIA	Delivery	* Print (letters) * Radio (mission)	* Print (letters, magazines, books) * Radio (mission, telephone) * Video (mission)	* Electronic (eBooks) * Multi-media (voice/video) * Internet (email, Web)	* Electronic (audio/eBooks) * Multi-media (voice/video) * Internet (email, Web)	* Electronic (audio/eBooks) * Multi-media (voice/video) * Internet (email, Web)
	Content	* Immediate news	* Local news (home) * Special interest (sports, politics) * Scientific fields (breakthroughs)	* World news	* Space news (other sites) * Industry news	* Space news (other sites) * Industry news

ranks became increasingly diverse. A growing number of older, civilian scientists and engineers found themselves orbiting the Earth, along with the first female astronauts, private civilian passengers, and space "tourists." International co-operation on orbital missions also allowed many nations to send their countrymen into space, joining the ranks of veteran American and Russian astronauts.

We suggest the first communities in space will evolve dramatically during the first century of human space travel (table 1). The astronauts who comprise these communities, or audiences, will change to meet the requirements of new missions, and their media needs will likewise change according to delivery mechanism and duration of mission.

Looking ahead into the second half of this first century of space travel, the changing face of human space communities will be most impacted by the emergence and growth of a vibrant private sector, which we expect will skew sought-after attributes of space community members away from the merely functional and towards the socially beneficial. Another critical factor will be the continuing trend toward international cooperation and multi-cultural mission teams.

The global space community currently is undergoing a transition phase that is prevalent on several levels (and is likely to continue for the next 10 years). First, the American, Russian, and European space programs are slowly shifting their sights from orbital science and research missions to efforts to explore and colonize the Moon and Mars (Sietzen, 2004, Zubrin, 2004, Xinhua, 2004, & Angerer, 2003). NASA officials have set a tight timetable of putting a robot on the Moon by 2008 and a return of astronauts as early as 2015 (Britt, 2004). Also, the European Space Agency (ESA) SMART-1 spacecraft entered lunar orbit in November 2004 (ESA, 2004).

Second, as many other countries ramp up their national space programs, the number of astronauts from other nations and races in each mission is likely to increase. Finally, space entrepreneurs and their investors are just beginning to tap into the economic opportunities afforded by the nascent private space industry.

Beyond this transition period, human space endeavours will evolve along two parallel tracks (government and private) through two more phases: a return to the Moon (roughly 2016-2030) and then a venture to Mars (2031-2060). During these last stages of the first century of human space communities, the primary changes (other than mission focus and duration) will come from the growth and expansion of the private space industry.This industry will follow the trails blazed by the exploration efforts of the international government-funded space programs, first into orbit and then to the Moon, Mars, and beyond. As human beings stretch their reach further beyond planet Earth, the demographic composition of these space communities will evolve to reflect the international and public/private blend of astronauts.

The maturing human space communities will continue to require the services of engineers, scientists, and pilots, especially those with military experience.

However, lunar and Martian colonization expeditions will also consist of geologists, civil engineers, and other professionals necessary to construct human habitats in hostile environments. Also, the growing private space sector will employ a variety of personnel, depending on the particular business enterprise. These may include tourism (orbital and beyond), solar energy, zero-g manufacturing, and asteroid and lunar mineral extraction, among others.

It is fascinating to think that, in the very near future, an international contingent of astronauts on a three-year mission to Mars may actually be just as interested in hearing news about what is happening on a lunar colony or on any one of several orbiting "cities" or "hotels" as they might be about sports scores or political elections in their home countries.

Selection Criteria

NASA publishes extensive material on what it takes to become an astronaut. As well as "frequently answered questions" (2004) and "astronaut selection standards" (2004) for the Space Shuttle Program that includes Pilot Astronaut and Mission Specialist, it also publishes material designed to interest and educate younger readers, the astronauts of the future (Canright, 2004). Here, in simple terms, the agency (Canright, 2004) stated that a "list of musts for astronauts (includes that) they must: work well with people, be able to talk to others, write well, be excited to do the job, be good workers, have good grades, (and) have a college degree."

There are no age restrictions; however, most astronauts (including those who have advanced to management roles) selected now are in the 26 to 46 age range with the average being 35 years. To apply through NASA you must be a US citizen, however, two types of astronaut positions today are not US citizens – the International Astronaut (individuals selected from outside the US for specific tasks) and Payload Specialist Astronaut (not flight crew). Those countries with international agreements with the US select candidates for those positions, thus ensuring an international crew on all shuttle flights. Although there is no requirement for flying experience today, it is encouraged for Mission Specialist (flight crew) candidates. NASA continues to require stringent medical requirements as well as a bachelor's degree from an accredited college or university in the fields of engineering, physical science, biological science, or mathematics. NASA accepts both civilian and military candidates for the US space program.

Today's astronaut profile differs from earlier years. At the beginning of the US Mercury program McNamara (2001) pointed out that the first astronauts selected by NASA were less than 40 years old, were no more than 5 feet 11 inches in height, were mostly test pilots, and had 1,500 hours of flying jet aircraft. None of the initial US astronauts were women. This did not to change until 1978, when NASA advertised for the first women astronauts. On June 18, 1983, Sally Ride became the first US woman to fly in space on STS-7 as a Mission Specialist. Post-Mercury qualifications changed, requiring US astronaut candidates to be US citizens less than 35 years old, less than 72in tall, be graduates from a military test pilot school, hold a bachelor's degree in physical, biological science or the engineering field, and have a favourable recommendation from their employer. Russian standards differed, allowing women to fly in spacecraft as early as 1963.

Semi-permanent communities in space will be characterised firstly by their remoteness and at-least physical isolation from other communities. Astronauts are likely to take universal traits into space with them: Trust/mistrust; religiosity or the absence thereof; openness/closedness; and their various interests (rural, urban, etc). Communications between Earth and base, by necessity, will be almost completely computer-mediated, although the regular, if not-too-frequent, arrival of shuttle craft, and the possibility of space elevators would facilitate some human contact (Boucher, 2004, n.p.).

Other communities of explorers and adventurers have exhibited "audience" characteristics. In the 19th century, travellers from Australia to England published shipboard newspapers (Blainey, 2003):

The ship (the *Great Britain* in 1862) had called at no port and (encountered) only a couple of vessels but gleaned from them no news. Such a ship was like a modern space capsule, but totally out of touch with outside society.The news of importance came from within the capsule itself – from the whims, friendships, and jealousies of the people thrown into each other's company (p. 72).

Communities of explorers and researchers in Antarctica also exhibit "audience" characteristics (Cokley, 2003) and display innovative means of communication. One sample population[1] displayed characteristics of being innovative and well educated, as well as being well supported by a large and well-funded government organisation. These characteristics are already identifiable among the existing population of astronauts. Harrison, Clearwater, and McKay (1991) and Dudley-Rowley, Whitney, Bishop, Caldwell, Nolan (2001) support this.

Members of these new extraterrestrial communities will most likely be selected on the same basis on which astronauts are selected now, and have been since the beginning of humanity's ventures into space.

Cooper (1996), Blume (2000), and Fitts (2000) investigated the engineering issues of designing for human habitability in space. Blume (2000) noted, "poor habitability can impact [on] productivity, safety, well-being, and performance." Cooper (1996) identified problems on long space missions such as anxiety, emotional hypersensitivity, insomnia, irritability, and depression. NASA programs such as the Human Factors centre at Ames Research Centre (Graves, 2004) are seeking countermeasures to these characteristics.

In a NASA "Headlines" article (2002), titled *Space Medicine*, NASA pointed out how tough space travel can be on the body. Muscle atrophy, bone loss, loss of blood volume, radiation, and alterations to the sense of balance will be experienced by the first people to colonize space settlements. Right now the primary countermeasures are simply exercise; at least two hours per day. In addition, this means developing other countermeasure technologies and expert systems that ordinary people can operate effectively to overcome these situations. Some medications, such as biphosphonates to reduce bone loss, and the bone-cancer chemotherapy drug zoledronate (Peplow, 2004), may also prove useful for the first space settlers. Sleep and its effects on future female long-term space travellers are being studied by the European Space Agency (Jost, 2004).

There are cultural considerations under investigation as well, including gourmet cooking to "cheer up" space travellers (ESA, 2004), and making provision for astronauts to vote in terrestrial political elections (AP, 2004).

Caldwell and Taha (1993) noted that, while computer-mediated communications systems can benefit members of small groups in increasing the amount of communication and reducing social isolation, this effect only occurs when the computer-mediation satisfies the needs of the group and involved group processes. Globus (2004) identified some groups who might find advantages to space colonization as:

- The handicapped who would benefit from the zero-g environment and from computer mediation for their existing communication channels;
- Certain religious groups who want to practice their faith away from other competing faiths;
- Governments, seeking new penal colonies;
- People with different forms of political or social norms, similar to the early American settlers.
- Finally, those who see the advantage of "building new land" rather than taking from someone else.

Methodology

NASA published data (2003) which included the name, gender, town of birth, education, and some interests of every astronaut who has been launched into space by the dominant space explorer, the United States. This list identified astronauts from the United States, the former USSR and its subsequently independent states, Europe, Australia, and Asian participants. The list contained several definitions of kinds of astronaut, collectively described as "career astronauts": active, management, former, and international (Wright, 2003, n.p.). "Active" described US astronauts who are currently eligible for assignment, including flight crews; "management" included experienced astronauts who have been promoted to other positions within NASA and astronauts otherwise unavailable for direct assignment; "former" described astronauts who have left NASA or who are deceased; and "international" described astronauts from international space agencies who have trained at Johnson Space Centre and serve as mission specialists with NASA (Wright, 2003). From the list of 347 current, former, and deceased astronauts, the researchers in this project selected only those who had flown three times or more since NASA's manned space flight program began, until the Space Shuttle *Columbia* disaster of January 2003, producing a list of 132 individuals. Only four (11%) of the 36 NASA individuals listed as "management" had flown fewer than three space missions, and the average number of missions among "management" astronauts was 3.6. Louw (2001, pp. 156-157) noted that senior management in an organisation tend to hire and promote others like them, resulting in a process he called "staff cloning." In an outcomes-driven program such as space flight, we suggest that astronauts who have flown the most missions have exhibited traits and skills most suited to the required tasks, and that these traits and skills will be "cloned" into upcoming astronauts who will form the space crews and communities of the future.

Among management astronauts, only 2 (5%) were born outside the US: Costa Rican civilian Franklin R. Chang-Diaz; and Australian Andy Thomas, both of whom have adopted US citizenship. Only 10 (28%) of the management astronauts are female. No female Russian or non-US female astronauts had flown sufficient missions to be included in our final sample of 132, which imposed a limitation on the results: one that we accepted nevertheless. We also examined the 39 "payload specialists" listed separately by NASA and elsewhere and results are presented separately in each case.

Data from the NASA *Astronaut Fact Book* was divided among the research team for tabulation into Microsoft Excel files, and then combined into two master files (astronauts and payload specialists) for analysis by each of the researchers in turn. Analysis took the form of identifying groups of individuals who shared characteristics such as qualifications, occupations, origin, age, and gender.

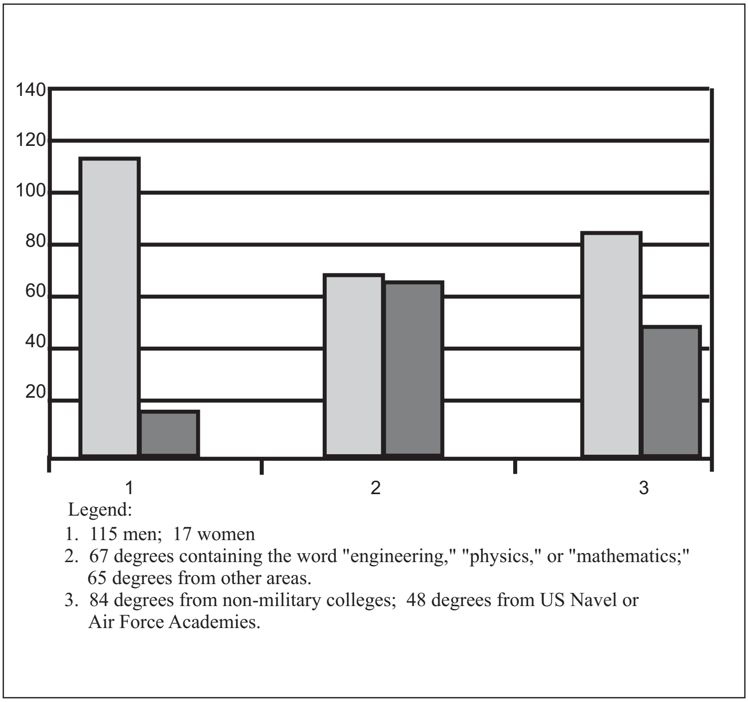

Figure1. Distribution of characteristics among general astronauts. Data source: NASA. (© 2004 William B. Rankin II)

Results

Of the 132 astronauts in the sample, 115 (87%) were males, leaving only 17 (12.8%) females (*figure 1*). In the US general population, however, females outnumber males 1.03:1 (US Census Bureau 2002). NASA stated[2] that by 1993, 180 Caucasian men and 21 women, 6 African-American men and 1 woman, 3 Hispanic men and 1 woman, and 2 Asian men had been selected for the astronaut program. In the general population, individuals identifying as "white" outnumbered the total population of black or African-Americans, American Indians, Alaskan Natives, Asians, and native Hawaiians 4.5:1.

More astronauts in the sample (14 or 10%) lived in Texas than any other state, followed by California (9 or 7%), Florida, and New York (5 or 4% each). Further research (see "Conclusions") will investigate if this has any deeper significance. Of the 28 who had flown the most missions (5-7 flights), 13 identified themselves as residents of Texas (site of the Johnson Space Centre, where most training takes place) and two of Florida (site of the Kennedy Space Centre, where most launches take place). We noted that this is probably a natural result of astronauts moving their homes and families "near work;" however, it showed potential for further research into the cultural, food, music, political and religious preferences of these senior astronauts.

More astronauts in the sample were born in New York or Ohio (8 or 6% each) than any other state, followed by Texas, Illinois and California (7 or 5% each), and Michigan (6 or 4%). Other states or territories featuring less as astronaut birthplaces in the sample were Arkansas, Alabama, Arizona, Colorado, Connecticut, District of Columbia, Delaware, Florida, Georgia, Iowa, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Minnesota, Missouri, North Carolina, North Dakota, New Jersey, Oklahoma, Pacific Islands, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Virginia, Washington, and Wisconsin, indicating that 15 (30%) of the 50 US states had not contributed astronauts to the sample under review. In the US general population, the bulk (35.8%) of residents live in the south, followed by the west (22.8%), the mid-west (22.6) and the north-east (18.8%) (US Census Bureau, 2002).

The majority (75%) of the astronauts' sample had obtained their first university or college qualification in engineering, physics, or mathematics: 67 (51%) for degrees containing the world "engineering"; 23 (17%) containing the word "physics"; and 10 (8%) containing the word "mathematics." In the general population, only 26.7% of US citizens said they had college degrees or higher and only 15.6% of the population was enrolled in higher education in 2002 (US Census Bureau, 2002). More astronauts (48 or 36%) obtained their degrees at the US Naval, Military, or Air Force Academies than any other college or university. Purdue and Auburn Universities and the University of Texas were identified as the next most popular universities among candidates for selection, but together they only supplied 10% of all astronauts in the sample. Other institutions providing more than one astronaut to the sample were Cornell University, Georgia Institute of Technology, Massachusetts Institute of Technology, Stanford University, Syracuse University, University of California (Berkeley), and the Universities of Colorado, Illinois, Kansas and Missouri. Finally, more than half the US astronauts have been in the scouting movement (Canright, 2004).

Among the 39 payload specialists, only 6 (15%) have flown more than one mission and all but one of those multi-fliers (83%) have been US nationals. General traits of the payload specialist population (*Figure 2*) are that 35 (90%) have been male and 4 (10%) female; 22 (56%) have been drawn from the US and 17 (44%) from other countries (no other country featuring more than once); 33 (85%) have been married and 6 (15%) single; and 31 (80%) have had postgraduate degrees; while 8 (20%) have had undergraduate or graduate degrees. The average age of payload specialists has been 43 years. Regarding fields of study, 32 (82%) of the payload specialists have had science or engineering qualifications as their first or second university degree and 22 (56%) have focussed on physical or life sciences in their highest degree. As well as their principal fields of study, 15 (38%) were identified as having been selected on the basis of their professional background in the physical or life sciences. There was no identifiable trend in their employers, although it is worth noting that one was a US teacher, another was a US Senator, another, the prince of the Saudi Arabian royal family, and another an expert in US military intelligence.

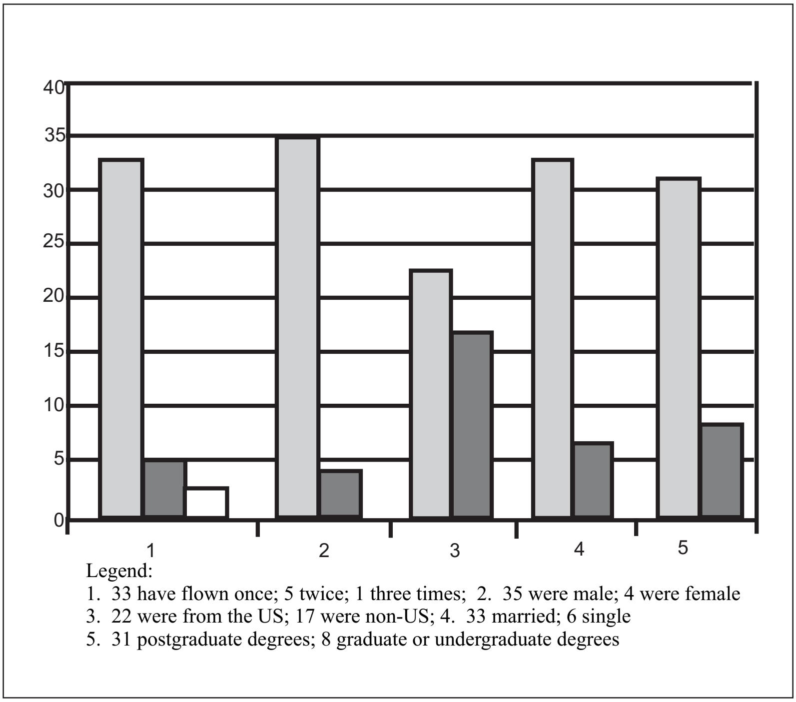

Figure 2. Distribution of traits among payload specialists. Data source: NASA. (© 2004 William B. Rankin II)

Discussion

From our review of the literature and data, there is little doubt that the first space colony will be composed primarily of highly trained and well-educated astronauts. The population most likely will be international, mostly male, and contain both military and civilians alike. Just as Dr. Werner von Braun, the father of space travel, realized in the early days of the US space program, it will take government commitment and substantial financial resources for space colonization to become reality. Materials, energy, transportation, communication, life support, and radiation are but a few of the key issues that will have to be addressed. Space settlement is feasible, but will be very difficult and expensive. For this reason, joint partnerships with private industry might be a feasibility, dependant upon the tremendous business potential in the mining for precious metals and energy resources.

Based on current trends in the data, research in the first space communities will focus on the following fields:

- Astrophysics
- Medicine
- Astronomy
- Geology
- Engineering
- Biology
- Military Research
- Mission to Planet Earth Issues

Conclusions

In the long term, the cost of space settlements needs to be inexpensive to become a true reality for ordinary people. Launch systems will need to be safe, reliable, and capable of carrying thousands, if not millions into space. New uses will grow as the cost is reduced. We reiterate Globus' (2004) suggestion that uses will include:

- Settlements for religious groups who want to practice their faith.
- Penal colonies
- Handicapped that would benefit from the zero-g environment.
- Settlements for people with different political or social norms.
- Finally, those who see the need of "building new land" rather than taking from another.

There is one more compelling reason for mankind to expand beyond the bounds of planet Earth. As the population and its impact on the environment continue to grow, tremendous demands are put on the limited natural recourses of our planet. The moon may become a source of energy from the mining of helium-3, a source of energy that could be exploited without the danger of releasing radiation into the atmosphere. Mars may have water deposits and hold potential chemicals that could be used to produce rocket fuels. In the future, Mars could even become a major resupply colony for ships destined to asteroids and other planets and moons within our solar system. The question is not if we will colonize space, but when we will colonize space. The basic questions left for us to ponder are Who? What? Where? How? Why? and When? Mankind's nature is to explore, it is what we do.

We suggest that our current research can answer the "who," "how," and "why" posited above and we and others are soon to embark upon further research to investigate these unusual audiences from anthropological, psychological and communications perspectives. Firstly, governments and space exploration agencies such as NASA and the ESA need to urgently redress the under-representation among crews and payload specialists of (a) women, (b) non-Caucasian individuals, and (c) intellectuals trained in the humanities and social sciences such as literature, history, communications, and politics. Secondly, those governments and agencies need to investigate why, and if possible redress, the situation in which 30% of the US states have not been represented in the most influential group of astronauts (our data sample), and why only a handful of colleges and universities are attracting potential space-flight candidates.

It also would be wise for nations other than the US to press for a greater role in astronaut training and selection and for the opportunity to make a greater contribution to the colonization of space than they make at present.

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Skill and Trait Identification for Entry-level Airport Operations and Management Personnel

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Abstract

This paper identifies important skills and capabilities required of individuals employed in airport operations and management positions. A total of 106 airport managers and airfield operations personnel responded to a survey seeking the identification of skills and traits deemed important for entry level airport operations personnel. The respondents represented large, medium, small, non-hub and general aviation airports. The results from this study add to the body of research on aviation management curriculum development. The data can be used to establish performance objectives and learning outcomes for training and education programs. It can further assist academicians, human resource directors and trainers, and airport managers in understanding desired skills and traits deemed important for employees engaged in the field of airport operations and safety.

Introduction

Previous journal articles have stated that the skills and knowledge required of individuals for entry into the field of airport operations and management have changed from a decade ago (Fuller & Truitt, 1977; Prather, 1998; Ruiz et al., 2000; Flouris & Gibson, 2002; Quilty, 2003; Quilty, 2004). Based on these studies, the requirements are becoming more diverse, challenging, and technical. Most of the content associated with the knowledge requirements can be obtained through formal education, self-study, or specific training. Knowledge requirements also can be easily assessed in the interview process by testing or questioning candidates. However, of interest to employers, academicians, and students are the skills and traits required by the industry and how those skills can be assessed.

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Lehrer (1992) brought to the attention of the aviation community the increasing emphasis of university and college accrediting bodies to assess the learning that occurs within an aviation program. The establishment of learning outcomes allows for better focus and assessment of the educational or training effort. Learning outcomes are statements of the knowledge, skills, or values that students are expected to demonstrate as a result of their learning effort. They are, therefore, indicators or behavioral markers of whether a student or individual has learned what he or she is supposed to learn. Lehrer raised the question: What skills, knowledge, and values should a well educated aviation graduate possess?

The Council on Aviation Accreditation (CAA), an accrediting body for non-engineering aviation programs, has identified through a series of Industry/Educator (IE) workshops and forums the skills and traits expected of aviation management programs. Table 1 summarizes the traits recommended by CAA (*CAA, 2003. p. 55)*. The skills and traits identified were not specific to airports, but addressed the broader aviation community as a whole. They also were not identified as to their degree of importance. This makes it difficult for educators and industry trainers to identify which skills, traits, and learning outcomes they should focus on within a specific curriculum such as airport, airline, general aviation, or maintenance operations.

Table 1
Fundamental skills and values of aviation graduates

Critical thinking skills
Problem analysis; problem solving
Judgment and decision making
Interpersonal skills
Oral and written communications
Conflict management/conflict resolution
Team building; team maintenance; individual accountability
Values and attitudes
Ethical standards; integrity
Flexibility; versatility; openness to change
Curiosity, imagination, creativity
Motivation
Passion
Dedication

Flouris and Gibson (2002) surveyed undergraduate aviation management students from four universities regarding their perceptions about what skills are of significant to employers. They recommended the need to seek employer perceptions about the skills necessary for aviation management graduates and compare them to their findings on student perceptions.

Quilty (2004) identified five issues facing the academic community related to entry level knowledge and skill requirements for airport operations positions. One recommendation from his analyses was for a study to better identify the specific skills and learning outcomes necessary for graduates of aviation management and operations programs. This suggestion stemmed from the argument that one course in airport management was not enough to adequately prepare college students for today's entry level positions. Quilty felt that additional specific skill-based education was needed because the basis for many current curricula standards was not focused on airport operations specifically.

In his 2004 study and analyses, Quilty reviewed entry level airport operations position announcements from the American Association of Airport Executives job listings for the period January 1999 to December 2003. From a skill and trait perspective, the position announcements showed several common themes, such as communication skills, crisis management skills, computer literacy, use of sound judgment, preparation of and presentation of reports, collection and analysis of data, planning and coordinating activities, and use of effective management skills (Quilty, 2004). These skills and traits point to learning outcomes that are necessary for an overall university aviation curriculum. They help to define the type of developmental activities that should occur within aviation program course offerings or an airport training program.

Quilty (2004) went on to question to what degree should skills and traits be developed, and at what educational level should they be emphasized or taught. He thought that institutions at the associate 2-year degree level could best focus on specific training, but that they do so at the expense of the more general and broad-based education and trait requirements expected by CAA, other university or accrediting bodies, or the airport industry. Baccalaureate degree granting institutions are thought to have technology and management programs that better address the needs and requirements of the industry by providing both specific skill-based acquisition and broader educational development. Still, within airport organizations, airport managers and human resource directors may need to provide better training programs to further develop or maintain the requisite skills and traits. This is evidenced by the number and type of seminars, workshops, and conferences held by trade organizations such as Airports Council International (ACI), American Association of Airport Executives (AAAE), International Air Transport Association (IATA), and the National Air Transportation Association (NATA). This study provided useful data for developing learning outcomes for entry level airfield operations personnel.

A review of job descriptions for entry level airport operations positions indicated skill and personal trait requirements are as essential to satisfactory job performance as having the requisite knowledge. The current research noted previously holds that airport management and operations employees must have effective team, interpersonal, communication, and decision-making skills. They must be leaders, behave responsibly and ethically, have a tolerance for ambiguity, and a host of other personal attributes. The referenced literature review also indicated research is still needed to help validate the degree of importance for these traits, as it applies to specific areas and levels of aviation.

This paper continued the work of others to develop aviation management curriculum by identifying the degree of importance of several skills and traits deemed important by airport managers and employees for individuals seeking or engaged in entry level positions in the field of airport operations. This information formed a basis for establishing both performance objectives and learning outcomes for educational and training programs.

Methodology

The survey instrument used in the study was targeted toward individuals whose job positions are related to the safe operation of the airfield, such as airfield operations, maintenance, and inspection. Individuals having responsibility for the hiring or supervision of airfield operation employees, and individuals employed in operations positions were solicited also for study participation. The study specifically targeted airfield operations rather than terminal or landside operations.

The survey instrument was developed by combining variables from the job descriptions analyzed and used in Quilty's (2004) study; the CAA Accreditation Standards Manual (CAA, 2003); Flouris and Gibson's (2002) survey instrument, and a similar skill list developed for the National Business Aviation Association (NBAA) Corporate Aviation Management Development Committee (Quilty, 1996). The survey was pretested among members of the AAAE Airport Training Committee. The survey was approved further for use by the Human Subject Review Board at Bowling Green State University.

The data were collected from large hub, medium hub, small hub, non-hub, and general aviation airport operators. The airport categories are identified by the FAA National Plan of Integrated Airport System (NPIAS). The hub designation relates to the number of operations and passenger enplanements an airport has over a year's time. For the year 2003, there were 31 large-hub airports, 37 medium-hub airports, 68 small-hub airports, 247 non-hub airports, and 2,961 other airports (other commercial service, reliever, general aviation) in the NPIAS (Department of Transportation, 2004, pg. 5).

An initial mailing of the skill survey was e-mailed to 356 individuals who were identified in the 2003 membership directory of AAAE. Of the initial mailing, 82 e-mail addresses were returned undeliverable and 274 e-mails were successful in being transmitted. Of the 274 valid e-mails delivered, 116 responses (42.3 percent) were received with 106 of those responses (38.7 percent) deemed usable for evaluation.

Demographic information collected for this study included the respondent's position and title; whether the respondent was in supervisory position or entry level position; the number of years a respondent was employed in the airport profession; gender; the level of formal education received; and the size of the airport. The survey presented the skills in a random list generated by the author.

The survey asked individuals employed in airport management and operations positions their perception of those skills important to individuals employed in the field of airfield operations, or those individuals having duties for inspection or safety of the airfield. The survey asked respondents to select and identify from 28 different capabilities only the ten most important skills and traits deemed important for an airport operations employee. The selections were to be based on the respondent's experience and were to be ranked from 1 to 10, with 1 being the most important skill or trait. For the remaining variables that were not ranked from 1 to 10, the mean for the rankings from 11 to 28 (19.5) was assigned to each variable. A mean and standard deviation analysis was then accomplished for all 28 variables from which their overall ranking (1 is highest) was determined. Statistical analysis was accomplished by the Statistical Consulting Center at Bowling Green State University using SAS programming.

Definitions

Skill refers to the ability to use one's knowledge effectively and readily in execution or performance and is the learned power of doing something competently as a developed aptitude or ability (Webster, 1989). Trait means a distinguishing characteristic, quality or feature as applied to an individual employed in airport operations (Webster, 1989).

Study Limitations

This study was limited to AAAE members employed at various airports in the United States. It is unknown how many individuals in management, supervisory or entry level operation positions are not members of AAAE, and therefore were not included in the solicitation. Another limitation is the degree of understanding respondents may have about the meaning behind each of the skills and traits identified, or the degree of semantic bias individuals may have for the various words used to describe the skill or trait.

For instance, the ability of an individual to argue and debate issues well is often viewed as an indication of leadership ability.The variable "argue and debate issues" was intended to have the meaning of discussing and presenting a positive or strong point of view, as in a persuasive argument. Based on the responses, it is possible that a more negative connotation was conveyed–that of argument as an undesired social interaction.

One other limitation of the study was the seasonality of the survey. The survey was conducted in the summer months of July to August and so responses may reflect several seasonal factors such as staffing shortages due to vacations, non-winter operations, or heavy construction activity.

Results

Of the 106 responses, 15 (14.1%) were from airport managers, 59 (55.7%) from airport operations supervisors, and 32 (30.2%) from entry level employees.

The demographic responses were from 86 males (81.1%) and 20 females (18.9%). Responses from large-hub airports comprised 19 (17.9%) of the total, medium-hub airports were 19 (17.9%), small-hub airports were 16 (15.1%), non-hub airports were 26 (24.5%), and general aviation/reliever airports were 26 (24.5%) of the respondents. These demographics provide a cross section of the airport organizations.

Table 2 represents the cumulative ranking of skills and traits deemed important for individuals holding positions in airport operations at airports in the United States of America. The ranking is based upon the means (M). The standard deviation (SD) is provided to give an indication of the range of responses from the mean.

Table 2
Cumulative means ranking of skills and traits

Rank	Skill Variable	M	SD
1	Communicate well with others	5.6	5.2
2	Know what is or is not a hazard to safety	7.5	7.0
3	Have strong work ethic & internal work standards	9.3	7.6
4	Take personal initiative	10.2	7.2
5	Be ethical	11.3	7.7
6	Manage time well	11.6	7.6
7	Plan and organize daily activities and information	11.6	7.5
8	Think independently	12.8	7.2
9	Interact well with contractors and engineering firms	13.7	6.4
10	Understand legal and liability issues	13.8	6.8
11	Be a leader	13.9	7.4
12	Listen to others	14.4	6.7
13	Follow directions from supervisors	14.8	6.7
14	Write reports and present analyses	14.8	6.5
15	Know right from wrong	14.9	7.3
16	Manage stress	16.1	5.6
17	Be courteous and polite	16.1	5.8
18	Operate word processing & records management programs	16.3	5.4
19	Be technically and mechanically inclined	16.7	5.4
20	Manage interpersonal conflict	16.9	5.3
21	Modify personal behavior to suit the situation	17.0	5.3
22	Engage in public relation activities	17.1	5.3
23	Understand politics and power in organizations	17.2	4.7
24	Work with budget and accounting numbers	17.8	4.5
25	Negotiate with others	18.1	4.1
26	Engage in team building activities	18.4	3.8
27	Operate database and/or AutoCAD program	18.9	2.6
28	Argue and debate issues	19.0	2.4

Note. The lower the number, the more important the skill. [A]N = 106

The rankings shown in Table 3 compare the cumulative rankings for all airports to how each of the five different category of airports responded. The low response rate for each airport category did not allow for adequate statistical comparison. However, the data can be of value to airport trainers and human resource directors in helping to identify possible divergence and needs among the different sized airports, primarily for the lower ranked variables since general agreement existed for the higher ranked variables.

Table 3

Skill and trait rankings by airport size as determined by means analysis

Skill	Cumulative Rank$_a$	Large Hub Rank$_b$	Medium Hub Rank$_c$	Small Hub Rank$_d$	Non Hub Rank$_e$	Other GA Rank$_f$
Communicate well with others	1	1	1	1	1	1
Know what is or is not a hazard to safety	2	2	2	2	3	2
Have strong work ethic and internal work standards	3	3	3	4	2	3
Take personal initiative	4	6	5	3	4	5
Be ethical	5	5	10	5	6	7
Manage time well	6	13	6	9	5	6
Plan and organize daily activities and information	7	7	7	6	7	4
Think independently	8	4	4	7	12	9
Interact well with contractors and engineering firms	9	10	9	16	10	8
Understand legal and liability issues	10	16	8	14	8	11
Be a leader	11	9	13	10	11	12
Listen to others	12	14	12	11	15	10
Follow directions from supervisors	13	8	16	8	17	17
Write reports and present analyses	14	11	11	13	14	21
Know right from wrong	15	15	21	17	9	13
Manage stress	16	12	17	19	18	22
Be courteous and polite	17	18	15	21	20	14
Operate word processing and records programs	18	17	14	15	23	19
Be technically and mechanically inclined	19	28	28	12	16	16
Manage interpersonal conflict	20	24	20	18	22	18
Modify personal behavior to suit situation	21	23	18	20	21	20
Engage in public relation activities	22	20	27	22	13	24
Understand politics/power in organizations	23	19	22	28	24	15
Work with budget and accounting numbers	24	25	26	23	19	23
Negotiate with others	25	21	19	25	26	26
Engage in team building activities	26	22	23	26	25	25
Operate database and/or AutoCAD program	27	27	24	27	28	27
Argue and debate issues	28	26	25	24	27	28

Note. The lower the number, the more important the skill. $^A N = 106$; $^b n = 19$; $^c n = 19$; $^d n = 16$, $^e n = 26$; $^f n = 26$

Discussion

Current academic practice and accreditation standards require the establishment of learning outcomes for academic programs. The purpose for establishing learning outcomes is to allow for more focused instructional effort and assessment of that instructional effort. Ultimately, perhaps the best assessment of a college or university program is the initial hiring and continued employment of a graduate, but employers desire better assurances in that process. The determination of industry expectations helps the academic community and industry better understand the skill sets needed by individuals to be successful.

The survey conducted has ingredients of both broad and specific skills and traits. The identification of "communicate well with others" as the most often needed skill was not surprising. The ranking echoed Fuller and Truitt's (1997) findings from airport consultants and Flouris and Gibson's (2002) findings comparing student and employer perceptions on management skills. What was surprising in this study was that the variable did not make the top ten list of all respondents, as evidenced by the SD.

However, the skill is a broad one and encompasses several of the other skills and traits listed. It is possible that some respondents viewed communication's subtraits more importantly than the generalized trait. Being able to communicate well with others includes components of listening skills, being able to write reports, being courteous and polite, managing interpersonal conflict, engaging in public relation efforts, negotiation, engaging in team building activities, interact well with contractors, and being able to argue and debate issues.

The second highest ranking, "know what is or is not a hazard to safety," was to be expected in light of the role airfield operations personnel have at airports to oversee airfield safety, along with the federal regulatory requirements of 14 Code of Federal Regulations Part 139.

The third, fourth and fifth rankings of "having strong work ethic and internal work standards," "take personal initiative," and "be ethical" highlight the importance of value education in today's academic environment. These findings supported Oderman's (2002) justification for ethics education as part of an aviation management program. As a learning outcome trait for today's graduates, value education comes through a dedicated learning environment of role modeling, active engagement and discourse, and social interaction.

The sixth and seventh overall rankings ("manage time well" and "plan and organize daily activities and information") share a similar skill set. They both pointed to the functional management skills of planning and organization, and to the degree of activity that an operations individual is engaged in his or her duties at an airport.

The eighth skill of "thinking independently," reflected the often autonomous decision-making responsibilities and conditions that an operations employee functions under. The ability to think independently can further reflect the basic knowledge requirements that an individual must have to perform his or her job correctly.

Beyond the eighth skill, there was less agreement among the various size airports as to the skills that are important. That is not to say that the remaining skills are not important for an airport operations employee, but rather that the higher ranked skills and traits are viewed collectively as more important or that they are perceived to have a greater job consequence associated with them no matter the airport size.

This can be attributable to the different organizational structures and assigned job duties, among other reasons. For instance, the 19th rated skill, "Be technically and mechanically inclined" was rated higher by small, non-hub and GA airports than by those at large and medium sized airports. This would make sense in light of the larger airports having more specialized departments with employees skilled in those areas, while the smaller organizations would not have dedicated personnel and the responsibility would fall to the airport operations employee.

One could argue that many of the lower rated skills in Table 2 are a necessary ingredient for an airport operations employee, but depending upon the size of the airport and its organization, variations among the tasks at each airport level are being discerned. For instance, engaging in public relations activities or budget and accounting received the most responses from non-hub airports. Non-hub airports tend not to have the dedicated public relation positions that larger airports have.

Within the top ten rated skills, all but one variable received individual rankings of one to ten. "Interact well with contractors and engineering firms" did not receive any individual rankings greater than three. Yet it achieved a ranking of nine, indicating a good degree of importance for many airports. It may be that because the survey was conducted in the prime construction season of July and August, operations employees, who often are the onsite representative of the airport manager to construction and engineering firms, were routinely engaged in interaction with them. Fuller and Truitt (1997), Prather (1998), Ruiz (2000), and Flouris and Gibson (2002) did not include a similar knowledge or skill in their studies.

Rounding out the top ten lists of skills and traits is the ability to understand legal and liability issues. While this also could be deemed to be a pure knowledge requirement, the understanding leads to decision making and judgment about what is right or wrong (the 15th rated skill), ethical behavior (5th rated), and carrying out operational duties of enforcement—a task normally assigned to an airport operations employee.

A final observation of the rankings was the 26th position of "engage in team building activities." In recent years, the nature of academic teaching in management and quality has focused on team building, crew resource management, and quality circles. This author found it surprising then that it was a low rated skill. This may be related to the much higher rated "think independently" and to the notion that many operations individuals work independently as well. However, it does not account for the fact that operations personnel have to interact with the public, airport tenants, and other operations employees on shifts, all of which require skills and traits in team building and working together.

Significance of Study

This paper reports on a study that identified the importance of various skills and capabilities for airport operations positions. From this information, educators can better structure curricula for graduates of aviation management and operations programs at colleges and universities, and trainers can develop material that better addresses the knowledge, skill, and abilities (KSA) needs of airport organizations.

The study should assist academicians, human resource directors, and airport managers in understanding basic skill requirements deemed important for employees engaged in the field of airport operations and safety. From the ranking of skill requirements, learning outcomes can be identified as well as areas for instructional development within organizations. While not to be considered a taxonomy of skills, the data presented lead to generalized learning outcomes for college and university aviation management programs.

While providing support for the skill and trait sets identified by the Council on Aviation Accreditation, this study provides insight into the degree of importance for those skills. Therefore, accrediting bodies can utilize the data in their deliberations and continued improvement processes. It also can be used to compare the expectations of students with the expectation of employers, as suggested by Flouris and Gibson (2002). Lastly, the study can be used to help identify KSA requirements in the industry and assist in the development of learning outcomes.

Recommendations

Based on an analysis of the responses, it is recommended that the following generalized learning outcomes be addressed for airport operations and management curricula and courses at colleges, universities, and airport training programs:

1. That individuals demonstrate competent communication skills and traits in various social domains of interpersonal, group, and organizational communication; as well as skills in writing, public speaking, and public relations.
2. That individuals demonstrate skills and traits that lead to the ability to clarify and assert individual and organizational values, and to understand moral, legal and ethical behavior, and decision-making.
3. That individuals demonstrate management skills and traits in the functional areas of planning, organizing, leading, and controlling.

4. That individuals demonstrate technical and operational skills and traits associated with operating an airport and ensuring the safety of others.

While the assessment of these outcomes would include the normal array of tests, papers, and observation within each of the courses offered by an aviation program, additional or more refined measures are necessary for the benefit of the industry and employing organizations. Therefore, it is recommended that the above generalized learning outcomes be further refined by conducting task analyses, and by identifying or determining specific course topics and knowledge requirements that would be requisite to the skills identified for entry level airport operations positions.

Additionally, for those colleges and universities preparing individuals for entry level positions at airports, a review and modification of their curriculum and courses should be conducted. While all the skills merit inclusion in any curriculum, an emphasis on the top eight variables listed would be of benefit to the airport management field. Accrediting bodies such as the American Assembly of Collegiate Schools of Business (AACSB) and CAA should consider reviewing their accreditation processes to seek assessment of the highly rated skills listed. Airport human resource departments and training officers should consider providing focused training on the skills identified and deemed important by the industry.

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Training Development Papers

The Role of Diplomacy in Dispute Settlement in Civil Aviation

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Abstract

The role of diplomacy is inextricably bound to international politics and extends into the political and economic domain of States when acts of aggression or flagrant violations cross international lines thereby requiring mediation. The United Nations (UN) and its bodies, such as the International Civil Aviation Organization (ICAO), have acted as arbiters in politically contentious issues to uphold and ensure peace through friendship and understanding among nations, principally by recognizing the principles of the Chicago Convention (1944) and the UN Charter. Both Organizations have proven their viabilities and sustainabilities in their roles as managers of international relations, demonstrating objectivity, discretion, and judiciousness. This article draws on the various instances of dispute settlement by ICAO, demonstrating the role played by diplomacy in the Organization's position as the specialized agency of the United Nations addressing issues of international civil aviation.

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Introduction

There would be no need for diplomacy in the world today if there had been no socially and politically recognized units known as States. From the inception of regulated civil aviation in 1944, diplomacy has been inextricable from policy-making and dispute settlement in affairs of aviation. Varied and chronologically sequential instances where the International Civil Aviation Organization (ICAO, 1947) was requested by its Contracting States to address contentious issues relating to civil aviation are reflective of the importance of political considerations that underlie such disputes. Although political contentions may exist between States, which is a natural corollary of Statecraft and international politics, it is not the purview of an international organization to address political motivations of individual States when considering issues referred to it or adjudicating disputes between States. In this regard, and as the instances examined below would reflect, the International Civil Aviation Organization has tread a delicate line between diplomacy and objectivity and has emerged as a shining example of the objectivity and impartiality characteristic of a United Nations specialized agency.

Current political and diplomatic problems mostly emerge as a result of the inability of the world to veer from its self-serving concentration on individual perspectives to collective societal focus. This distorted approach gives rise to undue emphasis being placed on rights rather than duties, on short-term benefits rather than long-term progress and advantage and on purely mercantile perspectives and values rather than higher human values. Another sensitivity is the thin line which exists between international law and international politics, which, when applied to aviation, becomes even thinner.

Against this backdrop, this article posits the fundamental principle that the overriding theme of international civil aviation has been, and continues to be, the pursuit of friendship and understanding among the people of the world with the ultimate objective of ensuring global peace. Toward this end, both the principles of air navigation and aviation economics have to ensure that aviation is developed in a manner that would make sure the world has a safe, reliable, economical, and efficient civil aviation system. In order to justify this thesis, it is necessary to examine the exemplary role played by the United Nations and its specialized agency - the International Civil Aviation Organization - in their pursuit of preventive diplomacy, which has greatly assisted the aviation community in times of dispute and danger.The parallel synergies that emerge from an examination of both these bodies are significant in obtaining an understanding of the role of aviation in current times.

Aviation and Diplomacy

The origins of diplomacy date back to the period of darkness preceding the dawn of history (Nicolson, 1953). It is claimed that anthropoid apes living in caves practised a form of diplomacy in reaching understandings with their neighbours on territorial boundaries pertaining to their own hunting grounds.

The compelling need to ensure the preservation of life of an emissary, on the ground that no negotiation could take place if emissaries, however hostile, were murdered on arrival, gave rise to the practice of diplomatic immunity, which is attributed to Australian aborigines, and is mentioned in the Institutes of Manu and in Homeric poems (Nicholson, 1953). In the modern world, the institution of the permanent diplomatic mission is the cornerstone of international diplomacy and comity, and the diplomat carries out the function of diplomacy, which is generally termed "diplomatic practice" (Vienna Convention, 1961). It is extremely important that nations appreciate diplomatic practice and its significance in their entirety, especially relating to the privileges and immunities of a diplomat, if diplomacy were to be effective. The overall aim and objective of diplomacy is to ensure that peace and justice prevails throughout the world. To this end, the institution of diplomacy is a pre-eminent example of the growth of modern civilization.

The history of diplomacy explains the origin and effects of foreign policies. In the modern sense, diplomacy means "management of international relations by negotiation." International organizations within the United Nations umbrella, such as ICAO, are considered managers of international relations and are therefore accorded diplomatic immunity, based on two headings: functional immunity and absolute immunity. The former category is usually bestowed upon consuls and certain staff at diplomatic missions and organizations whereas the latter category is granted to full diplomats of ambassadorial rank (Reinisch, 2000, p. 362). Generally, functional immunity grants immunity from liability arising out of an act performed in the course of duty. This principle was reiterated in the case of *Arab Monetary Fund* v. *Hashim and Others* described in the 1996 Lloyds Report (as cited in ICAO, 2002b) where the British Court of Appeal held that the plea of immunity could, in the best of circumstances, be applied only to official acts and the fact that the defendant had accepted a bribe for his own personal benefit whilst conducting his official duties for an international organization should not entitle him to diplomatic immunity. It is also arguable that courts would be inclined to apply this principle to diplomats enjoying absolute privilege. The *Vienna Convention on Diplomatic Relations* (1961) listed in Article 31(1) such acts as actions relating to succession, commercial activities outside the scope of employment, and real actions as exceptions to the principle of absolute immunity.

Diplomacy is essentially linked to international relations, particularly in the field of aviation. Therefore, the evolution of diplomacy in aviation is intrinsically based on the endeavour of ICAO to justify the preamble to the Chicago Convention (1944) which stated that the future development of international civil aviation may greatly help to create understanding and friendship among the peoples of the world, yet, its abuse could lead to a threat to general security. This essentially means that peace and security of nations is paramount. For example, the principle of avoidance of conflict between nations, as embodied in the Preamble to the Convention, was personified in ICAO Assembly Resolution A15-7 - *Condemnation of the Policies of Apartheid and Racial Discrimination of South Africa* - adopted by the 15th ICAO Assembly held in Montreal, 22 June-16 July

1965, which drew attention to the world community that apartheid policies in South Africa constituted a permanent source of conflict between nations and that apartheid and racial discrimination were a flagrant violation of the principles enshrined in the Preamble to the Chicago Convention. The ICAO Assembly urged South Africa to comply with the aims and objectives of the Chicago Convention. This is a striking example of aviation and diplomacy traversing through the entirety of international relations, and the scope of aviation being extended to cover attempts at disrupting global peace and harmony and the assurance of human rights.

Another instance where the general involvement of international civil aviation in matters of peace and security was put to the test was at the 17th Session of the Assembly (Montreal, 16 30 June 1970) where Resolution A17-1 *Declaration by the Assembly* urged States to take concerted action towards suppressing all acts which jeopardize the safe and orderly development of international civil air transport. These Resolutions will be discussed in some detail later in this article.

Destruction of Gaza International Airport

A recent manifestation of the link between aviation and global efforts at striving for peace is reflected in the consideration by the ICAO Council of the destruction of Gaza International Airport. At the High-Level, Ministerial Conference on Aviation Security (Montreal, 19 to 20 February 2002), an information paper (ICAO, 2000a) was presented by Arab States Members of the Arab Civil Aviation Commission. Consequent upon the Conference referring this matter to the Council, the Council, at the sixth meeting of its 165th Session on 4 March 2002, was advised (ICAO, 2002a) that, on 4 December 2001, Israeli military forces attacked Gaza International Airport, destroyed air navigation facilities and bombarded runways and taxiways until the airport became unserviceable. It was reported that, when the Palestinian Authority attempted a repair on 11 January 2002, the Israeli military forces once again bombarded the airport and its facilities by aircraft, artillery and tanks, thereby destroying the runway, the taxiways and all facilities.

The Palestinian Authority claimed that the destroyed airport and air navigation facilities were used for the transportation of civilian passengers, search and rescue operations in case of emergencies, transportation of rescue material, including medical equipment, medicines and survival kits for safeguarding human lives.

It was noted by the Council that the airport was developed with voluntary contributions from a number of European countries, which recognized beyond doubt the urgent need for the airport. Nevertheless, the airport was destroyed without paying attention to any humanitarian consideration. This led the European Union to condemn the Israeli actions and reserve the right to demand compensation for the damages. The Council was further advised that the destruction of the civil airport in Gaza was an act deliberately perpetrated by a Contracting State. It was claimed that such destruction took place under the watchful eyes of the international community and was widely covered by local and international media reports, and the Council was requested to consider the ramifications of the act, i.e. contempt of respect for human life, the disrespect of international laws, including the relevant conventions on civil aviation security.

Among the considerations of the Council were relevant provisions of the Chicago Convention (1944), the first being Article 4 which stipulates that *each Contracting State agrees not to use civil aviation for any purpose inconsistent with the aims of this Convention*. Also considered was Article 44 which lays down the objectives of ICAO, particularly to *meet the needs of the peoples of the world for safe, regular, efficient, and economical air transport* (Convention on International Civil Aviation, 1944). Another Convention, the Montreal Convention (ICAO, 1971a) was also considered by the Council, particularly the views of the State parties to the Convention, to the effect that:

> Unlawful acts against the safety of civil aviation jeopardize the safety of persons and property, seriously affect the operation of air services, and undermine the confidence of the peoples of the world in the safety of civil aviation….the occurrence of such acts is a matter of grave concern..for the purpose of deterring such acts, there is an urgent need to provide appropriate measures for punishment of offenders (ICAO, 1971b).

The Council was reminded of Resolution A20-1, adopted at the 20th Session of the Assembly (Rome, 28 August, 21 September 1973), in particular the Resolving Clause (3), where the Assembly solemnly warned Israel that if it continued committing such acts the Assembly would take further measures against Israel to protect international civil aviation. Also recalled was Resolution A33-2, adopted by the 33rd Session of the Assembly (Montreal, 25 September-5 October 2001) where the Assembly stated that *Whereas* acts of unlawful interference against civil aviation have become the main threat to its safe and orderly development; and *Recognizing* that all acts of unlawful interference against international civil aviation constitute a grave offence in violation of International law; the Assembly *strongly condemned* all acts of unlawful interference against civil aviation wherever and by whomever and for whatever reason they are perpetrated. It was noted that the challenge facing this High-Level Ministerial Conference was to take effective measures in order to help States in responding to unlawful interference against civil aviation security and to reject and condemn the use of civil aviation as weapon of destruction against human lives and properties.

Based on its considerations of the issue, the Council, on 13 March 2002, adopted a resolution strongly condemning the destruction of Gaza International Airport and its air navigation facilities. In its Resolution, the Council strongly condemned all acts of unlawful interference against civil aviation, wherever, by whomsoever and for whatever reasons they are perpetrated. It also strongly condemned the destruction of Gaza International Airport and its air navigation facilities while reaffirming the important role of ICAO in facilitating the resolution of questions which may arise between Contracting States in relation to matters affecting the safe and orderly operation of international civil aviation throughout the world. The Council urged Israel to comply fully with the aims and objectives of the Chicago Convention, while strongly urging Israel to take the necessary measures to restore Gaza International Airport so as to allow its reopening as soon as possible. Additionally, the Council requested the President of the Council to attend to the implementation of this Resolution, and to secure the full cooperation of the parties with respect to the application of the Chicago Convention and of the above-mentioned principles. Finally, the Council requested the Secretary General to inform all Contracting States of the Resolution (ICAO, 2002a, p. 2).

There have been several instances where the Council was called upon to consider aerial incidents involving Contracting States. Some of these are discussed below.

Korean Airlines (South Korea – USSR, 1983)

On 1 September 1983, the President of the Council of ICAO received a communiqué from the Minister of Foreign Affairs of the Republic of Korea that Flight KE 007, which was being carried out by a Korean Airlines Boeing 747 passenger airliner, had disappeared off the radar screens after it took off from Anchorage, Alaska, on 31 August 1983 bound for Seoul. The Minister requested ICAO's assistance with regard to ensuring the safety of the passengers, crew, and aircraft (ICAO, 1983a). The diplomatic response of the President was instantaneous and immediate, containing a message to the Minister of Civil Aviation of the USSR. It stated that information had been received by ICAO that an aircraft might have possibly landed in Soviet territory and that ICAO was confident that the Soviet authorities were rendering all assistance to persons and property concerned (ICAO, 1983a, p. 2).

As an initial response to the incident, the ICAO Council met in extraordinary session on 15 and 16 September 1983 at the request of the Government of the Republic of Korea and the Government of Canada and adopted a resolution which averred to the fact that a Korean Air Lines civil aircraft was destroyed on 1 September 1983 by Soviet military aircraft. The Council, by Resolution, expressed its deepest sympathy to the families bereaved in this tragic incident and reaffirmed the principle that States, when intercepting civil aircraft, should not use weapons against them. *Inter alia*, the Resolution also deplored the destruction of an aircraft in commercial international service resulting in the loss of 269 innocent lives and recognized that such use of armed force against international civil aviation is incompatible with the norms governing international behavior and elementary considerations of humanity as well as with the Rules, Standards, and Recommended Practices enshrined in the Chicago Convention and its Annexes. The Council directed the Secretary General to institute an investigation to determine the facts and technical aspects relating to the flight and destruction of the aircraft and to provide an interim report to the Council within 30 days of the adoption of this Resolution and a complete report during the 110th Session of the Council. All parties were requested to cooperate fully in the investigation.

The issue was further discussed under the auspices of ICAO at the 24th (Extraordinary) Session of the ICAO Assembly, which met at Montreal from 20

September to 7 October 1983 with the participation of 131 Contracting States. In the general discussion, much attention focused on the tragedy of the Korean Airlines flight 007 and on the resolutions of the Extraordinary Session of the Council. The Assembly adopted Resolution A24-5, which, while endorsing Council action taken so far, urged all Member States to cooperate fully in their implementation.

During the Assembly, the Delegation of Canada presented a proposal for a new Convention on the Interception of Civil Aircraft (ICAO, 1983a) and the Assembly referred the proposal to the Council of ICAO for further study on the understanding that the Council was empowered to consider the inclusion of this item into the General Work Programme of the Legal Committee.

Pursuant to requests (ICAO, 1992a) from the Governments of Japan, the Republic of Korea, the then Russian Federation, and the United States, where all but the Russian Federation had made direct reference to Article 54(n) of the Chicago Convention (Chicago Convention, 1944), the President quoted Rules 27 d) and 25 b) of the Rules of Procedure of the Council, the former of which provides for an item to be included on the Agenda of a Council meeting where the President, Secretary General, or a Contracting State requests a new subject to be included, and the latter of which provides that any additional subject which fulfils the conditions in Rule 27 (d) should be included in the Work Programme of the Council. Accordingly, the Council decided to include the Korean Air incident in the work programme of the 137th Session of the Council. The subject was documented accordingly (ICAO, 1992b) and subjected to sustained discussion by the Council with attention to detail and with views being expressed by many representatives (ICAO, 1992a). These discussions resulted in the Council, *inter alia*, deciding to complete a fact-finding investigation, which ICAO initiated in 1983, and instructing the Secretary General to request all parties involved in the investigation relating to Korean Airlines Flight KAL 007 to cooperate fully with ICAO in turning over to the Organization, as soon as possible, all relevant materials (ICAO, 1992c, p. 131).

The intervention of the ICAO Council with regard to the Korean Air incident and its instructions to the Secretary General are good examples of the ICAO diplomatic machinery in action. The almost instantaneous galvanizing into action of the ICAO Council, through which the diplomatic voice of ICAO is heard, and the meticulous attention to detail (particularly regarding procedure) reflect a good example of the legal maxim *omnia preasumuntur rite esse acta* (everything is presumed to be done the proper way).

At the Council session, held on 25 and 26 September 1983, the President of the Council succinctly summarized ICAO's role in the investigation of the KAL 007 incident:

> It falls clearly to ICAO ... to focus its attention on gaining a full and complete technical understanding of how this tragic event occurred and to examine every element in ICAO's existing technical provisions for promoting the safety of air navigation ... (ICAO, 1983c, p. 4).

At its 138th Session, the Council examined the interim report of the ICAO investigative team into the KAL 007 incident as well as progress made in collecting facts regarding the shooting down of the aircraft. The Council noted the excellent cooperation provided to the ICAO investigative team by the Contracting States concerned and noted that a final report on the ICAO investigation would be placed by the Secretary General before the Council at its 139th Session.

The completed report of the Secretary General was presented to the Council during its 139th Session (ICAO, 1983e, p. 69) and the Council closed the matter of KAL 007 on 14 June 1993. From a diplomatic perspective and irrespective of the findings of the Report - which are not relevant to this article, it must be noted that the outcome of the Report and discussions that ensued in the Council endorsed the usefulness of the Council. As reflected in the Statement issued in Council by the Republic of Korea:

The Council must once again make it clear to the world that, while reaffirming the principle of prohibition of the use of arms against civil aircraft, it unreservedly condemns the destruction of a civilian aircraft simply because it strayed into the airspace of another country (ICAO, 1983e, p. 69).

The role of the ICAO Council was aptly brought to bear by the United Kingdom during the Council's deliberations on KAL 007, which was supported by several other States, that the Council should not seek to endorse the conclusions and recommendations in the Report since it was not a tribunal seeking to reach a judgment on the facts (ICAO, 1984, p. 72). The significance of the Council's role as a diplomatic tool in international civil aviation is borne out by the Summary of the President of the Council which formed the substance of the Council Resolution that followed and which, *inter alia*, expressed appreciation for the full cooperation extended to the fact-finding mission by the authorities of all the States concerned. The President appealed to all Contracting States to ratify Article *3 bis* to the Chicago Convention, which approved the fundamental principle of general international law that States must refrain from resorting to the use of weapons against civil aircraft.

Libyan Airlines (Libyan Arab Jamahiriya, United States, 1973)

The KAL 007 investigation and the ICAO approach to the issue of dispute resolution was clearly a reiteration of the position taken by the Council in its earlier determination of the Libya-Israel dispute in 1973. The incident concerned the shooting down of a Libyan Airlines Boeing 727 aircraft by Israeli fighter aircraft on 21 February 1973 over Israeli occupied Sinai territory. One hundred and ten persons were killed in the incident and the Boeing 727 aircraft involved was completely destroyed. As an immediate response, the ICAO Council convened the 19th Session (Extraordinary) of the Assembly, at which speakers generally condemned the act of destruction. An investigation was called for and the Assembly proceeded to adopt Resolution A19-1 that stated that the Assembly, having considered the item concerning the Libyan civil aircraft shot down on 21 February 1973 by Israeli fighters over the occupied Egyptian territory of Sinai, condemned the Israeli action, which resulted in the loss of innocent lives.

Convinced that such an action adversely affected and jeopardized the safety of international civil aviation and therefore, emphasizing the urgency of undertaking an immediate investigation, the Assembly directed the Council to instruct the Secretary General to institute an investigation in order to undertake fact-findings and report to the Council. The Assembly also called upon all parties involved to cooperate fully in the investigation (ICAO, 1973a).

Consequently, the Secretary General of ICAO presented his report (ICAO, 1974), which was in effect a report of the Secretariat investigative team containing, *inter alia*, a draft resolution (ICAO, 1977) developed by numerous ICAO Contracting States. Pursuant to sustained discussion in Council, the Representatives on the Council agreed upon a Resolution, which was adopted by the Council. The Resolution, while recalling United Nations Security Council Resolution 262 of 1969, which condemned Israel for premeditated action against Beirut International Airport resulting in the destruction of 13 commercial and civil aircraft, expressed its deep conviction and belief that such acts constitute a serious danger against the safety of international civil aviation, and recognized that such an attitude is a flagrant violation of the principles enshrined in the Chicago Convention.

The above statement of the ICAO Council truly typifies the quintessentially diplomatic approach taken by ICAO on contentious issues between ICAO Contracting States. If one analyses the first part of the Council Resolution as given above, it is difficult not to note that the Council has skillfully restated an already adopted resolution of the United Nations, ensuring that, while avoiding being judgmental, it nonetheless conveys to the international aviation community its position on the issue at hand.

In the second part of the Resolution, the Council proved to be even more dexterous, in courageously taking a stand by strongly condemning the Israeli action, which resulted in the destruction of the Libyan civil aircraft and the loss of 110 innocent lives, and urging Israel to comply with the aims and objectives of the Chicago Convention. The mastery of the Council, in encompassing, into a single resolution, a compelling precedent established by a United Nations resolution together with its own resolute position, is diplomacy at its most astute. The dexterity of the Council in this instance must not be mistaken for tendentiousness nor deviousness as the Council Resolution is clearly forthright.

USA - Cuba, 1996

On 24 February 1996, two United States registered private (general aviation) civil aircraft were shot down by Cuban military aircraft, which resulted in the loss of four lives. Consequent upon information received from the United States authorities of the incident, the President of the ICAO Council, on 26 February 1996, wrote to the Government of Cuba expressing his deep concern and requesting authentic and authoritative information pertaining to the incidents (ICAO, 1996a). Further developments ensued on 27 February 1996 when the United States formally requested that the Council of ICAO consider the matter under Article 54(n) of the Chicago Convention, and, on the same day, the United Nations Security Council issued a statement through its President deploring the shooting down, by Cuban military aircraft, of the two United States registered aircraft. The Security Council also alluded to Article 3 *bis* of the Chicago Convention and the Montreal Protocol of 1984 both of which provide that States must refrain from the use of weapons against civil aircraft in flight and must not endanger the lives of persons on board and the safety of aircraft. The Security Council requested the ICAO Council to look into the matter and to expeditiously report to it (I.L.M., 1996). For its part, Cuba, in its communications to the President of the Council, chronicled a series of chronological violations by United States registered aircraft. This was followed by a further communication on 28 February 1996 from the Cuban Ministry of Foreign Affairs addressed to the Secretary General of ICAO alluding to a series of violations, which had allegedly increased over a twenty-month period, of Cuban airspace by civil aircraft registered and based in the United States. The Government of Cuba urged ICAO to carry out an extensive investigation into the violations, repeated over the years, of Cuban airspace by aircraft coming from the United States, including the incidents of 24 February 1996.

The communications received by ICAO with regard to the incidents of 24 February 1996 clearly required the Organization, under Article 54(n) of the Chicago Convention (1944), to investigate two issues:

a the incidents of 24 February 1996, an investigation which was requested both by the United States and Cuba; and
b repeated violations of Cuban airspace by aircraft registered and based in and coming from the United States, alleged by Cuba, which requested an investigation.

When the above-mentioned issues were addressed by the ICAO Council on 6 March 1996, the position taken by the United States was primarily based on Article 3 *bis* of the Chicago Convention, whereby the United States claimed that there was a duty incumbent upon every State to refrain from resorting to the use of weapons against civil aircraft in flight. Accordingly, the United States claimed that the Cuban action was a blatant violation of international law and that firing on unarmed, known civil aircraft could never be justified. The United States claimed that, consequently, as required at international law, the Cuban Government should pay appropriate compensation to the families of those whose lives were lost (ICAO, 1996b, pp. 68-71).

In response, the Cuban Delegation claimed that Cuba had been a victim of violations of its sovereignty and territorial integrity for many years which involved aircraft coming from the territory of the United States and that, over the previous 20 months, as many as 25 such incursions and violations had been detected by Cuba. Cuba also counterclaimed that, in response to the reference by the United States of Article 3 *bis*, there was a stipulation in the Article obliging every civil aircraft to comply with orders of the subjacent State making the State of origin of the aircraft obligated to ensure compliance with such orders. Another argument adduced by Cuba was that paragraph (d) of Article 3 *bis*, which stated that each Contracting State was required to take appropriate measures to prohibit the deliberate use of any civil aircraft registered in that State, *inter alia*, for any purpose inconsistent with the Chicago Convention, was applicable to the instances concerned.

The overall trend in the Council, when the US-Cuba dispute was taken up, was indicative of a consensus that action taken by Cuba was deplorable (ICAO, 1996c, pp. 9-92) and, in the words of the United Kingdom, which seemingly echoed the general view: "The principle is simple. Weapons must not be used against civil aircraft in international and civil aviation" (ICAO, 1996d, p. 88). On the issue of violation of airspace, which was brought up by Cuba, many States voiced the view that there was indeed an obligation on the part of all States to refrain from violating the sovereignty of States, while some States focused their attention on Article 4 of the Convention which requires that civil aviation must not be used for any purpose inconsistent with the aims of the Convention.

Due to its inherent complexities, this was clearly one issue that demanded that ICAO's diplomatic fabric be tested to its limits. The wisdom and diplomacy of the President of the Council proved invaluable when he advised the Council of the three alternatives available to Council in its pronouncement: resolution; decision; or conclusion. The President further advised the Council that whether the Council pronounced by resolution, by decision, or by conclusion, any one of these would be binding in terms of implementation. Consequently, the President of the Council presented a revised version of the draft Resolutions presented by both the United States and by Cuba, for consideration by the Council. The draft Resolution suggested by the President, while recognizing that the use of weapons against civil aircraft in flight is incompatible with elementary considerations of humanity and the norms governing international behaviour, reaffirmed that States must refrain from the use of weapons against civil aircraft in flight and that, when intercepting aircraft, the lives of persons on board and the safety of the aircraft must not be endangered. For action, the draft Resolution required that the Secretary General initiate an investigation without delay into the shooting down of the aircraft, in particular with reference to the request of the United Nations Security Council Resolution, and that the Report of such investigation should be made available to the Council within 60 days in order to be transmitted to the United Nations Security Council (ICAO, 1996e, pp. 102-103).

As to the relevance of including a reference to Article 3 *bis* in the Resolution, the President of the Council advised that Article 3 *bis* merely recognized a principle of customary international law and there was an addition to the principles embodied in the Convention. As such, it was the President's view that there was no need for the Resolution to reaffirm an Article, which in effect was an affirmation of the humanitarian principles already incorporated in the text (ICAO, 1996f, p. 103). It is noted that, by effectively precluding the express mention of a principle of customary international law as incorporated into the Chicago Convention, the Council played its ultimate role in diplomacy and political rectitude, by staying within the parameters of its own jurisdiction and avoiding incursions into judgment prior to facts being properly ascertained.

The final Resolution of the ICAO Council, adopted on 27 June 1996 following the Report of the Secretary General, embodies two critical principles. These were that the Council recalled and recognized the principle that every State has complete and exclusive sovereignty over the airspace above its territory and that the territory of a State shall be deemed to be the land areas and territorial waters adjacent thereto; and that States must refrain from the use of weapons against civil aircraft in flight and that, when intercepting civil aircraft, the lives of persons on board and the safety of the aircraft must not be endangered. Integral to the Resolution was also the principle that each Contracting State should ensure that appropriate measures are taken to prohibit the deliberate use of any civil aircraft registered in that State or operated by an operator who has his principal place of business or permanent residence in that State for any purpose inconsistent with the Chicago Convention. The Council's condemnation of the use of weapons against civil aircraft involved the explicit mention of Article 3 *bis* at this advanced stage of the resolution making process, which, when examined from a diplomatic perspective, is seemingly appropriate and purposeful.

The Council Resolution was an example of the comprehensive manner in which the Council addresses issues referred to it under Article 54(n). Additionally, the Resolution masterfully indicates the views of the Council by recognizing that, while on the one hand it should be recognized that all States have complete and exclusive sovereignty over the airspace above their territories and that such sovereignty should not be encroached upon, on the other hand States do not have the right to use weapons against aircraft endangering the lives of those on board, no matter what the circumstances.

In the consideration of ICAO's role as a specialized agency of the United Nations, which is from time to time called upon to address contentious issues at the request of its Contracting States, it is inevitable that some determination must be made on whether ICAO should refrain from transgressing the parameters of international politics within its diplomatic efforts. The USCuba issue was clearly one where the ICAO Council traversed the diplomatic rope with a balanced sense of purpose and dedication to its role. The duality of sovereignty and protection of its territory by a State balanced well with the somewhat peremptory admonition that whatever the rights of a State may be, the use of weaponry could not be condoned under any circumstance.

The Iranair Incident - IR 655 (Iran, United States 1998)

The extent to which ICAO will be exposed politically in issues addressed by the Council is perhaps best illustrated by the consideration of the Council, in 1988, of the Iran Air incident. This concerned the shooting down of an Iran Air Airbus A300 (IR655) carrying commercial passengers on a scheduled flight from Bandar-Abbas (Iran) to Dubai. The aircraft was brought down by the *U.S.S. Vincennes* over the Persian Gulf, resulting in the death of all 290 persons on board the aircraft. The incident, which occurred on 3 July 1988, was considered by the Council at several of its meetings, notably on 7 December 1988 when the Council adopted its decision. The Council decision, while recalling the event of 3 July 1988, acknowledged the fact finding investigation report of the Secretary

General of ICAO, and urged all States to take all necessary actions for the safety of navigation of civil aircraft, particularly by assuring effective coordination of civil and military activities. The Resolution went on to refer to the fundamental principle of general international law - that States must refrain from resorting to the use of weapons against civil aircraft - and urged States to ratify Article 3 *bis* expediently, if they had already not done so.

One of the emergent features of the ICAO Council, which became clear at its deliberations, was the Council's resolve to address its deliberations to purely technical issues pertaining to the incident, while stringently avoiding political issues and diplomatic pitfalls. This is certainly true of all incidents discussed above, where the Council restricted its scope to technical issues as applicable to the principles embodied in the Chicago Convention.

Although ICAO has so far successfully avoided underlying political contentions brought to bear by the issues it addressed, the question has been asked as to whether ICAO could continue to divorce aeronautical or technical issues from underlying political nuances. The answer would seem to lie in the environment within which ICAO functions and the principles upon which, under the Chicago Convention, ICAO could work. Primarily, ICAO's objective is to develop principles and techniques of air navigation and to foster the planning and development of international air transport so as to insure the safe and orderly growth of air navigation (Chicago Convention, 1999). When this fundamental postulate is applied to the Preamble of the Chicago Convention, which provides that the abuse of international civil aviation can become a threat to the general security, ICAO's mandate becomes clear.Taken together, those two principles bring to bear the fundamental truth about ICAO – that the Organization has to ensure safety and orderly (economic) growth and, at the same time, ensure that civil aviation not be abused to the extent of becoming a threat to general global security. What this generally means is that ICAO has to ensure adherence by States to the principles of aviation as adopted within the ICAO regulatory umbrella.

In this context, the principles of the Chicago Convention and its Annexes become relevant, as pointed out by member States during discussions in Council on the issues addressed above. However, the responsibility is not merely onesided. ICAO cannot, and will not turn a blind eye on the non-aviation practices of a State if it would endanger the objectives of civil aviation. For example, and as mentioned earlier, at its 15th Session in June/July 1965, the Assembly adopted Resolution A15-7 (no longer applicable) – *Condemnation of the Policies of Apartheid and Racial Discrimination of South Africa* – which recognized that the then apartheid policies of South Africa constituted a permanent source of conflict between the peoples and the nations of the world and that the policies of apartheid and racial discrimination are a flagrant violation of the principles enshrined in the Preamble of the Chicago Convention. The Resolution urged South Africa to comply with the aims and objectives of the Chicago Convention. A similar initiative was seen later when, at its 17th Session in June 1970, the Assembly adopted Resolution A17-1 – *Declaration by the Assembly* – which recognized that international civil air transport helped to create and preserve friendship and understanding among the people of the world and to promote commerce between nations and requested Contracting States to take concerted action towards suppressing all acts which jeopardized the safe and orderly development of international air transport. In this context, the most forceful example of ICAO's role can be seen in Resolution A20-2 – *Acts of Unlawful Interference with Civil Aviation*, adopted in March 1973 by the Assembly, which reaffirmed ICAO's role as facilitating the resolution of questions that may arise between Contracting States in matters affecting the safe and orderly operation of civil aviation throughout the world (ICAO, 1973b, pp. 1-3).

It may be noted that an inevitable corollary to the establishment of ICAO by the world community, as a "club" of States, is that most problems, which are directed at the ICAO Council, could involve or be generated by intractable political disagreements or conflicts between States. As such, it would be naive for ICAO not to be aware of the nature of conflicts before its Council. However, ICAO remains a specialized agency of the United Nations with a specific agenda as embodied in the Chicago Convention. In this regard, one must bear in mind the observation of a former Secretary General of the United Nations, Javier Pérez de Cuellar, when he said that the world must be cautious not to blur, mix, or separate specific functions of the main organs and specialized agencies by treating them as interchangeable platforms for pursuing the same political aims (ICAO, 1986, pp. 148-149). States bear an enormous responsibility in not letting this happen.

Conclusion

When dealing with issues of aviation to which diplomacy is applied, it is important to remember that, in the past, a nation's air power was the sum total of all its civil and military aviation resources (van Zandt, 1944). After World War II, the importance of aviation toward maintaining peace was recognized since civil aviation holds the key to the power and importance of a nation and therefore it must be regulated or controlled by international authority (van Zandt, 1944). Furthermore, Lord Beaverbrook, at that time, stated in the British Parliament that:

> Our first concern will be to gain general acceptance of certain broad principles whereby civil aviation can be made into a benign influence for welding the nations of the world together into a closer cooperation...it will be our aim to make civil aviation a guarantee of international solidarity, a mainstay of world peace. (Flight, 1944, pp. 97-98)

The intensely political overtones that moulded the incipient global civil aviation system immediately following the War incontrovertibly established the relevance of diplomacy, international politics and international relations in civil aviation, as exemplified in the statement of Warner, the first President of the ICAO Council:

> It is well that we should be reminded...if the extent of the part which diplomatic and military considerations have played in international air transport, even in periods of undisturbed peace. We shall have a false idea of air transport's history, and a very false view of the problems of planning its future, if we think

of it purely as a commercial enterprise, or neglect the extent to which political considerations have been controlling in shaping its course (as cited in Lissitzyn, 1942, p. V).

This statement reflects what civil aviation stood for at that time and, more importantly, that is still viable in the present context. Civil aviation has had to serve the political and economic interests of States and, as such, ICAO has alternated between two positions - its unobtrusive diplomatic role and its more pronounced regulatory role (Sochor, 1991). It must be recalled, however, that the United Nations was neither conceived as a legislative body nor a policing agent of the world, and therein lies the dilemma.

An inherent characteristic of aviation is its ability to promote both international discourse and goodwill as well as to develop "a feeling of brotherhood among the peoples of the world" (Schenkman, 1955). The problems of international civil aviation constitute an integral part of the universal political problems and therefore resolution cannot occur without the involvement of the global political and diplomatic machinery (Schenkman, 1955). It is at these crossroads that the United Nations mechanism in general, and ICAO in particular, is profoundly involved, and, consequently, have dispelled feelings that the United Nations is now rendered impotent as the last resort and bastion of freedom and democracy.

Through its mechanism, the United Nations has clearly demonstrated that laws and regulations could be democratized and that nations have the opportunity to voice assent and dissent. Its charters and governing instruments are primarily aimed at recommendations for coordinating or harmonizing the activities of its Member States and these States can utilize these resolutions since they are party to the discussion, negotiation, and adoption process, on the basis of sovereign equality assigned to each State at public international law.

Doubts as to whether the integrity of the UN Charter could possibly be compromised or impaired by political considerations are easily dismissed since States have the discretion to accept or refuse interpretations of the Charter when weighing their own national interests of security and safety, thereby effectively precluding retrogress caused by polarization and ensuring the veto right of a minority dissenting group. Furthermore, the International Court of Justice ensures that a single State, through its abstention, cannot annul a desirable adaptation by the Council.

Given this broad spectrum of global governance, the United Nations Security Council has exercised its position, after the events of September 11 for example, in ordering all States to take or to refrain from taking specific action in a context without disciplining a particular country. Resolution 1273 of 28 September 2001 adopted this approach dispelling the belief that the United Nations could not legislate international law when required, nor could they impose sanctions or restrictions on all States, including non-Member States. Furthermore, Article 2(7) of the Charter permitted the United Nations to intervene in the domestic jurisdictions of a State and apply enforcement measures if there is an occurrence of acts of aggression, a threat to the peace or breach thereof. Consequently, the principles of international law are recognized as an integral part of maintaining peace and security.

Clearly, the role of the United Nations has neither been diminished nor threatened as evidenced in September 2000 when it adopted Resolution A55/2 – *United Nations Millennium Declaration*, which recognizes that States have a collective responsibility to uphold the principles of human dignity, equality, and equity at the global level, notwithstanding their separate responsibilities. This Resolution has reaffirmed States' commitment to the United Nations Charter and its relevance and capacity to inspire nations and peoples.

The United Nations has demonstrated its beneficial and coercive influence in international mediation. In the particular context of ICAO and its Council, the main consideration is the careful extrapolation of the applicability of legal rules to international politics, which, in modern times, means the politics of one single State or pluralistic States (now called *international society*) or, *an anarchical society*, which is a group of States that do not adhere to the call of a *common power* but remains a collective social unit sharing common interests, values and principles of governance (Bull, 1977). However, such collective national units cannot function in isolation and inevitably recognize that global policy is dictated through international organizations such as ICAO. In such an environment, the distinction between both international law and politics becomes blurred and individual interests no longer prevail in absolute form.

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AirportNet and the Airport Industry

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Abstract

This paper discusses the services available to the airport industry through AirportNet, the e-government website of the American Association of Airport Executives. Through the AirportNet, local governments, policy makers, lobbyist, suppliers, vendors, and many more are linked together through this premier airport management website. Discussions on what services are available to the airport industry and how local governments may improve the airport services they offer using electronic technology are discussed. A discussion of what social cost, if any, is included.

AirportNet and the Airport Director

The American Association of Airport Executives

The American Association of Airport Executives (AAAE) is the largest professional organization of airport officials in the world, representing thousands of directors and managers at publicly operated airports worldwide. As pointed out by AAAE (2004), the primary goal of the AAAE is to assist local government officials in fulfilling their responsibilities in the operation of airports in the communities they serve.

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The membership of the AAAE is truly representative of airport management throughout the United States. Equal emphasis is placed on large, as well as small airports and communities, including large, medium, small, non-hub, and general aviation airports. In addition, the membership is composed of federal, state, and local officials, and anyone else who might have an interest in airport management.

Founded in 1928 to represent managers of U. S. airports, the organization holds an annual meeting to bring aviation officials throughout the world together to discuss the latest problems, issues, and emerging technologies in airport management. In 1954, the annual conference was expanded to include an exhibitor's showcase of new services, products, and equipment. That same year the AAAE adopted professional standards for member accreditation. Since then, no one has been awarded the designation of Accredited Airport Executive (A.A.E.) without meeting the established requirements of the Board of Directors.

Since the organizations inception, AAAE has continued to grow and move forward, not only in size and in expertise, but also with an interactive e-government website, known all over the world for delivering information and services to the airports it serves. AirportNet, the name of the AAAE website, is a powerful website viewed by industry and government leaders alike. The website brings unity of strength to the airport industry for the members of the AAAE. It also brings the efficiencies of computer-based information technology to thousands of managers and government officials worldwide, replacing other slower forms of communications used in the past.

According to Jones, George, and Hill (2000), managers cannot plan, organize, lead, and control without access to information. Information is their source of knowledge and intelligence from which to make correct decisions. Data are the raw facts such as compensation paid, sales, landing fees, and any number of related and unrelated facts. Information is data that is organized in a fashion that makes meaningful sense to the manager, such as a graph or a chart showing changes, trends, or comparisons. Data by itself does not tell the manager anything useful. The comparison between data and information is important, because websites like AirportNet must transform data into information that is organized to assist managers in making decisions. Data collected by the AAAE and put on AirportNet must, therefore, be accurate, reliable, timely, complete, and relevant for it to be useful to the airport official. AirportNet is the information technology that AAAE uses to acquire, store, manipulate, and transmit airport information worldwide. For airport officials, AirportNet servers to assist in three distinct areas: making effective decisions, controlling the activities of their organizations, and coordinating activities of the members relative to the airport industry.

According to Dessler (2001), managers at different levels in different organizations need different types of information. First-line managers need information that focuses on day-to-day operations. Middle managers need information on intermediate range issues, such as tactical plans and short-term forecast. Finally, top managers need information systems that allow them to explore executive level issues and keep abreast of industry developments. They also need transaction processing capabilities, such as listing for position vacancies, business opportunities, and other similar services. For these reasons, AirportNet has become the premier e-government information technology tool for airport officials in the U.S. and abroad.

AirportNet Content-Specific Sub-sites

As pointed out by AAAE (2004), AirportNet is divided into five content-specific sub-sites. Each sub-site consists of unique features that are discussed separately.These sub-sites are:

1. AAAE Home
2. AAAE Membership
3. Aviation News
4. Government Issues
5. Products and Training

AAAE Home

The AAAE Home page includes sections on aviation news, meetings and conferences, daily quiz, and spotlight. The aviation news section lists the current news for that day.The meeting and conferences section provides a list for the current and upcoming month. Left clicking on items in these sections takes the reader to details on that particular section. The daily quiz section asks a new multiple-choice question each day. Each month, the member with the most correct responses receives a prize from AAAE. Finally, the spotlight section highlights various links included on AirportNet, as well as a link for member questions, comments, and suggestions.

AAAE Membership

The content sub-site for the AAAE Membership provides a detailed listing for the board of directors, committees, regional chapters, members, and staff, along with contact information and biographies of each member.The membership area also includes a "Corporate Yellow Pages" section with listings and contact information for all the airport vendors and suppliers willing to pay a small fee for inclusion. This section also allows airport officials to identify prospective bidders for airport projects. Each year,AAAE conducts a survey of airport construction and planning plans. This survey was developed especially for corporate members. This survey gives airport suppliers and vendors information regarding construction and purchasing plans for each AAAE member airport for that year.

A section for membership specials list car rental companies that provide member discounts and a travel agency that forwards ten percent of their gross income to the AAAE Foundation. The AAAE Foundation provides scholarships to members of AAAE and their family attending accredited colleges or universities.

This sub-site also includes the new "ACE and ARFF Programs" developed to provide training certifications for airport employees in the areas of operations, lighting maintenance, security, airport communications, and airport fire fighting and rescue. These programs were designed to assist airports in meeting federal regulations for training contained in 14 FAR (CFR) 139 (Title 14 Code of Federal Regulations part 139).

Finally, this content sub-site includes a section on the AAAE Liability and Workers' Compensation Programs. By joining forces with AIG Aviation, Inc. as the exclusive underwriter of its Airport Liability and Workers' Compensation Insurance Programs, AAAE offers local governments' liability insurance, workers' compensation, and loss prevention and claims management services at lower than normal group rates. Additionally,AAAE offers liability seminars focused on specific issues that affect airports. Seminars are provided by the law firm of Dombroff & Gilmore.

Aviation News

The sub-site for Aviation News is one of the more important sub-sites for airport officials. This sub-site contains sections on Airport Magazine, Airport Report and Airport Report Express, request for proposals and business opportunities, career center, and Airport News and Training Network(ANTN) – the most important and unique feature of the AAAE website.

Airport Magazine is a quarterly publication of the AAAE. It contains member as well as professionally written articles on current topics of interest to airport and other local government officials. Airport Magazine is the only trade journal specifically devoted to airport issues in the U.S.

Airport Report is a bi-weekly online newsletter distributed by the AAAE. It contains news articles, position openings, and business opportunities, which become available on a bi-weekly basis. For those airport and local government officials desiring a weekly update, Airport Report Express is distributed online on a weekly basis for a small fee.

Request for proposal and business opportunities is a section where airport officials can list current request for proposals and bids, as well as business opportunities at their respective airports. This site is available to anyone with computer internet service who has an interest in submitting a proposal or bidding on a project listed on the website. History has demonstrated that this section reaches more prospective bidders than both local newspapers and the F.W. Dodge Report

Career center is one of the most useful sections for airport and local government officials. Cities, counties, private businesses, and the federal government all have access to this site where they can list job opportunities available in their offices, businesses, or communities. It is not strictly limited to airport position vacancies, but can be used to advertise a variety of positions for a small fee. This section also contains a registry where airport and others interested in finding an aviation job can unload their current resume. Once an opening is posted, a person can send their resume electronically to a prospective employer for consideration. This is one of the most widely used sections on AirportNet.

This last, but most important section of this sub-site is ANTN. By subscribing to ANTN, airport and local government officials' acquire satellite feed directly to the Washington DC headquarters of AAAE. From their office computers, airport and local government officials have instant and direct access to news, videos, and request for proposals and business opportunities as they become available at the AAAE headquarters. More importantly, they can burn CDs of the telecast to build their digital libraries, or use the telecast to inform local leaders of breaking news events. ANTN also provides scheduled programming used specifically for employee training purposes, as well as taped videos of presentations on airport issues recorded at conferences and seminars worldwide.

Government Issues

The Government Issues sub-site is another very important and useful sub-site. It is broken down into sections on legislative affairs, security, regulatory and environmental affairs. AAAE (2004), points out that the AAAE Legislative Affairs Department represents airports throughout the country in Washington, DC on airport issues before Congress, the White House, DOT/FAA, DHS/TSA, E PA, NTSB and other agencies with aviation jurisdiction. Together, with airport and local government officials, this department helps shape federal policy governing aviation. It also assures that the airport perspective is included as legislation and regulations are developed.

The legislative affairs section contains a "This Week's Features" page where current alerts, congressional hearing reports, headline news, and video updates can be viewed on a real time basis. The security central section contains the same features, with the addition of an Email update feature for current member postings.

On Tuesday, September 14, Department of Homeland Security Secretary Tom Ridge testified before the House Select Committee on Homeland Security where he commented on a number of aviation issues.

Airport Alert: Airport Alert: Update on DHS/DOT Spending Bills (Members Only)

Last Updated: 09/30/04 18:05 PM

Hearing Report: Joint hearing on Disrupting Terrorist Travel

Last Updated: 09/30/04

Latest Headline: Dulles Among Busiest Airports - Washington Post

Last Updated: 09/30/04 8:46 AM

Video Update: Aviation News Today - Featuring: AAAE's Vice President of Transportation Security Policy, Carter Morris, interviews Carol DiBattiste, Deputy Administrator of the Transportation Security Administration.

Last Updated: 09/24/04 16:15 PM

Figure 1. This Week's Features, Friday, October 1, 2004

Source: AirportNet

The regulatory affairs section contains a variety of current documents of interest to airport and local government officials. As of October 1, 2004, the section contained documents on letters from FAA officials, airline bankruptcy filings, airport signage issues, FAA request for comments on grant assurances, and program guidance letters, among others.

This section also contains the airport firefighter certification program. The FAA requires firefighters to maintain a satisfactory level of proficiency by regulation. Under this program, firefighters can earn the "Certified Firefighter" and "Certified Master Firefighter" training designations. An ARFF Review Board of Certified Master Firefighters from member airports administrators the program.

Finally, this section contains a page on non-hub and general aviation issues of interest to AAAE members and government officials. Links to various general aviation and non-hub airport websites are offered.

Products and Training

This sub-site is the heart of the AAAE interactive computer-based video training system developed by the AAAE. Of all the products offered, the AAAE interactive training system and on-site training has saved airports and local governments thousands, if not millions of dollars in meeting regulatory requirements of the federal government. An overview on the website by AAAE (2004) is as follows:

> AAAE has developed an interactive computer-based video employee training system that provides training customized to your airport. AAAE, through its ANTN subsidiary, comes to your airport to film the training. ANTN edits it, makes it interactive and loads it on specialized, dedicated computers that are then installed in your airport.
> AAAE's IET systems to date have trained more than 135,000 employees. The following airports have IET systems in place and operational—Salt Lake City, Seattle/Tacoma, Washington's Reagan National and Dulles, Northwest Arkansas, Boston Logan, Pittsburgh, Providence, Tampa, Savannah, San Jose, Port Columbus, Baltimore/Washington, Birmingham, Dayton, Phoenix, Bradley, Palm Springs, Portland, Westchester and Pasco.
>
> Overview
>
> Imagine an easy-to-use, comprehensive and customized, on-site airport employee training system that can simultaneously train multiple people 24 hours a day, 7 days a week—and keep track of your training records for you.
>
> You don't have to imagine anymore. AAAE's Interactive Employee Training (IET) System does all of this for your airport.

The IET is patented-technology that provides you with all of the hardware and software you need to train airport personnel on important topics, including:

- SIDA
- Basic Airport Security Awareness
- Driver Training
- Runway Incursion
- Aircraft Familiarization
- Other programs developed in conjunction with the airport upon request

Development Process

Step 1: Together, AAAE and your airport will develop a customized script for your airport's IET training program(s). The script can be written in English, Spanish and/or other languages of the airport's choice.

Step 2: AAAE travels to your airport to conduct a site survey and to film the training.

Step 3: In consultation with the airport, AAAE lays out the scenes, develops instructional scenarios for trainees and matches the script to the video.

Step 4: AAAE installs the IET System at your airport and trains appropriate airport personnel on how to operate and utilize all the functions of the system

What your airport gets with an IET System

- Intel-based PC with touch-screen monitor that runs on Microsoft Windows 2000 Professional with Service Pack 1
- Dell Pentium Processor
- Computer consoles, desks, chairs and stereo headsets
- Out-bound internet access to a secured site where training records are stored and can be accessed 24 hours a day, 7 days a week
- Comprehensive annual maintenance/service program

On-Site Training

Why should your airport take advantage of AAAE's customized on-site training programs?

- AAAE has established an industry-leading reputation, training thousands of personnel at airports in the U.S., Canada, Grand Bahama and South Korea
- Training programs are adapted specifically to your airport's requirements and are brought to your airport when it's convenient for you.
- Taught by well-respected, experienced aviation management professionals, including airport directors and aviation consultants
- AAAE provides innovative, thorough and current course materials
- Economical way to train several airport personnel at once in as little as one or two days while eliminating travel costs for your staff (www.aaae.org)

Conclusion

As can be seen, AirportNet is a powerful e-government tool for the airport director and local government officials. Divided into four content-specific sub-sites, AirportNet provides instant, reliable, and timely information to airports and the communities they served. AirportNet is not only an information tool, but can be used by local governments to advertise position vacancies, publish request for proposals and bids, as well train airport and other employees. For airport officials, AirportNet servers to assist in three distinct areas: making effective decisions, controlling the activities of their organizations, and coordinating activities of the members relative to the airport industry.AirportNet is periodically updated to reflect trends in the airport industry. I do not see any social cost attributable to AirportNet.

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Book Review

Aircrew Security: A Practical Guide
by Clois Williams and Steven Waltrip
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The authors have provided a thought-provoking book concerning post September 11, 2001 security issues facing aircrews and flight attendants on commercial aircraft. The overall intent of this book is to give readers "insight and knowledge that will be helpful in protecting him or her, other crewmembers, passengers and the aircraft from attack from hijackers or terrorists" (p. xvi). By virtue of the secrecy veil that surrounds aviation security issues, the authors do not discuss specific training or tactics, airline policies, or TSA guidance for flight crews involved in attacks by hijackers or terrorists. The obvious audience for this book includes commercial airline companies and their flight crews. Aircrew Security is appropriate for a much wider audience including the traveling public, universities with aviation programs, and aviation security organizations because it provides an insight into the new world of commercial aviation.

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The authors have divided the book into three main sections. The first section deals with identifying the current threats to commercial aviation ranging from disruptive passengers through chemical, biological, and radiological weapons. This section contains extensive examples of recent (1998 through 2003) sky rage incidents, worldwide hijackings, and explosive incidents. The chapter on terrorism, specifically understanding terrorists as weapons systems, does not necessarily provide previously unknown information but it does clearly gain the reader's attention as to the new enemy of the air transportation industry.

Section two is dedicated to flight crews and how to prepare for the range of threats they may encounter.This section deals with a variety of issues specifically for the cabin crew but also involving the flight crew to a lesser extent. The chapter on awareness deals with a level of consciousness model developed by Marine Colonel Jeff Cooper and modified for used in aviation. The WHITE, GREEN, YELLOW, RED, and BLACK phases of awareness provide an easy to understand correlation between human states of activity and associated states of awareness. Although the focus of the model is designed to improve the security awareness of cabin crews, it also provides an interesting insight for aircraft accident and incident investigators dealing with human error situations.

The last section provides flight crews with a variety of suggestions on how to deal with threats. The chapter on profiling does not focus on pending airline profiling technologies but instead offers advice for flight crews on how to look for "Absence of the Normal" and "Presence of Abnormal" (p. 336). Two true stories provide somewhat chilling examples of profiling in action. Chapters on flight crew survival tactics and unconventional self-defense are not designed to provide officially sanctioned techniques to counter hostile passengers but rather to provide some measure of confidence to potential victims that they can fight back.

Aircrew Security: A Practical Guide is a valuable resource for at least three reasons. First, it is probably the only book on this specific topic and certainly the most up-to-date book on the subject available. Second, the authors are highly qualified to discuss the topic. The combined credentials of the authors include extensive airline flight crew experience, military flying and other duties, a law enforcement background, active participation at CRM and security conference, firearms instruction, and security consultants. The third reason this book worth reading is that identifies a new reality in commercial aviation – the potential of another 9/11 attack has created a new physical and psychological between the flight deck and passenger cabin. The flight crew must ensure the cockpit is not broached and therefore are expected to lock down the cockpit if an unknown disturbance erupts in the passenger compartment. On the other hand, flight attendants are tasked with passenger safety as well as defending the cockpit against attack by hijackers, terrorists, or disruptive passengers.

The authors have done an excellent job in meeting their stated purpose for writing this book. It is well organized and well written with a wealth of valuable information. It is somewhat regrettable yet totally understandable that the majority of the references in this book have come from the popular press. There is an obvious problem in finding scholarly research on the subject of aviation safety in general and aircraft security in particularly since the events of 9/11.

Flight-crew members, airline passengers, and readers interested in aviation security will find this book informative and thought provoking. Although the authors occasionally diverge momentarily to discuss why pilots should not have to pass through security and why airport security remains flawed, Aircrew Security: A Practical Guide delivers what it promises.