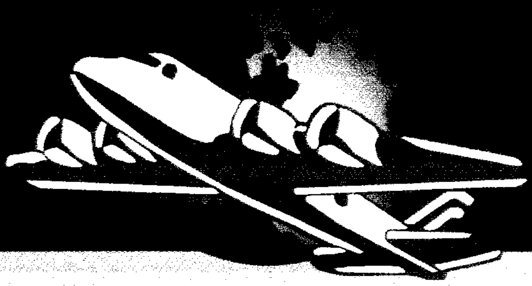
JOURNAL OF AIR TRANSPORTATION



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Brent D. Bowen, Editor

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The mission of the *Journal of Air Transportation* (JAT) is to provide the global community immediate key resource information in all areas of air transportation. The goal of the Journal is to be recognized as the preeminent scholarly journal in the aeronautical aspects of transportation. As an international and interdisciplinary journal, the JAT will provide a forum for peer-reviewed articles in all areas of aviation and space transportation research, policy, theory, case study, practice, and issues. While maintaining a broad scope, a focal point of the journal will be in the area of aviation administration and policy.

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The JAT was conceptualized to fulfill an international void of scholarly publications in this area as identified by the primary organizers. It is envisioned that aviation leaders will utilize the JAT as a key decision-making tool. Scholarly rigor and standards will be uncompromised with regular evaluation by the Editorial Board and Panel of Reviewers.

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The JAT accepts manuscripts on all topics that relate to air transportation, both technical and non-technical. The Panel of Reviewers represents the interdisciplinary nature of air transportation to ensure review by recognized experts. Broad categories of appropriate topics include, but are not limited to:

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Fall 2004

Dear JAT Subscriber:

We hope you enjoy the new issue of the *Journal of Air Transportation*, volume 9, number 3. The interesting mix of articles should make for some insightful reading.

In response to subscriber demand, subsequent volumes will be published on CD-Rom. In special circumstances, our hard copy editions will be provided solely to library subscribers. However, individual hard copy editions may also be purchased by special order. This change is necessary to keep our subscription prices low for the individual subscribers and to respond to the *JAT* subscribers' changing needs.

In case you missed the letter that accompanied volume 9, number 1 and 2, please note that number 2 was only available on CD-Rom. This was a special issue created in conjunction with the Air Transport Research Society. Due to the nature of the project, the second issue is not available in hard copy. All subscribers received the standard two hard copy editions for 2004

We appreciate your continued support and look forward to continuing this relationship.

Sincerely,
Brent D. Bowen
Executive Editor
Journal of Air Transportation

The Editors

Brent D. Bowen

Dr. Brent Bowen is Director and Distinguished Professor, Aviation Institute, School of Public Administration, University of Nebraska at Omaha, and the University's Director of Aviation and Transportation Policy and Research. Bowen attained his doctorate in Higher Education and Aviation from Oklahoma State University and a Master of Business Administration degree from Oklahoma City University. His Federal Aviation Administration certifications include Airline Transport Pilot, Certified Flight Instructor (Gold Seal), Advanced Instrument Ground Instructor, Aviation Safety Counselor, and Aerospace Education Counselor. Dr. Bowen's research on the development of the national Airline Quality Rating is regularly featured in numerous national and international media, as well as refereed academic publications. Dr. Bowen has in excess of 300 publications, papers, and program appearances to his credit. His research interests focus on aviation applications of public productivity enhancement and marketing in the areas of service quality evaluation, forecasting, and student recruitment/retention in collegiate aviation programs. He is also well published in areas related to effective teaching and has pioneered new pedagogical techniques. Dr. Bowen has been recognized with awards of achievement and commendation from the American Marketing Association, American Institute of Aeronautics and Astronautics, Federal Aviation Administration, Embry-Riddle Aeronautical University, W. Frank Barton School of Business, Travel and Transportation Research Association, World Aerospace Education Association, and others.

Igor Kabashkin

Dr. Igor Kabashkin is Vice Rector of the Transport and Telecommunications Institute, Latvia, and a Professor in the Aviation Maintenance Department and member of the Technical Committee on Transport of the European Commission for Cooperation in the Field of Scientific and Technical Research. Kabashkin received his Doctor Degree in Aviation from Moscow Civil Engineering Institute, a High Doctor Degree in Aviation from Moscow Aviation Institute, and a Doctor Habilitus Degree in Engineering from Riga Aviation University and Latvian Academy of Science. His research interests include analysis and modeling of complex technical systems, information technology applications, reliability of technical systems, radio and telecommunication systems, and information and quality control systems. Dr. Kabashkin has published over 274 scientific papers, 19 scientific and teaching books, and holds 67 patents and certificates of invention.

Sorenson Best Paper Award

The Journal of Air Transportation is proud to present the Sorenson Best Paper Award, named in honor of Dr. Frank E. Sorenson. This award gives recognition to the author(s) with the best literary and scholarly contributions to the field of air transportation. The Editor, on the basis of reviewer rankings during the review process, grants the Sorenson Award. The manuscript with the highest overall score is awarded the Sorenson Best Paper Award. This is considered a high recognition in the aviation community.

Dr. Frank E. Sorenson was a pioneer in the field of aviation education since its early beginnings in the 1940s. A renowned educator and prolific writer, Sorenson contributed not only educational texts to the field, but also served as a consultant and innovator throughout the expanding realm of aviation education and research.

Dr. Sorenson's aviation impact and potential were recognized early on by the National Aeronautics Association when he received the Frank G. Brewer Trophy in 1946 for the most outstanding contribution to the development of youth in the field of education and training. In 1958, the University Aviation Association honored him with the William A. Wheatley Award in recognition of outstanding contributions to aviation education. These were the first of many awards and citations he would earn on a local and national level as he continued his active involvement in the field of aerospace education up until his death in 1977.

Through his involvement with the University of Nebraska–Lincoln Teachers College, Dr. Sorenson generated some of the earliest teaching materials for aviation education and textbooks for military aviators during World War II. Throughout the course of his career, he contributed over forty articles and publications related to the field of aviation education. His efforts guided the way for extensive aerospace research and scholarship from the grassroots to the global level through his participation in Civil Aeronautics Association, the World Congress on Air Age Education, and UNESCO. He

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has served as chairman of the Air Force Associations Aerospace Council, the Aerospace Education Forum at the First World Congress of Flight, the U.S. Air Force Air Training Command, the Men in Space book series, and NASA's Aerospace Education Advisory Committee. As a result of his visionary involvement and development of the Link Foundation, the organization has gone on to provide grants now totaling over a half million dollars a year to support and advance aerospace education and training in aeronautics.

Dr. Sorenson's continuous involvement in aviation education and research laid the groundwork for many of the advancements currently taking place in the industry. His ceaseless research and educational outreach demonstrated how one person can make a difference not just today but well into the future.

Currently, several awards exist that are representative of his achievement in aerospace education and research. These include the Frank E. Sorenson Award for Excellence in Aviation Scholarship, representing the highest scholarly honor in aviation education, presented annually by the University Aviation Association; the Frank E. Sorenson Pioneers in Nebraska Aviation Education Award presented annually by the University of Nebraska at Omaha Aviation Institute, as well as a memorial lecture fund and scholarship fund. A maximum of two award plaques will be given per article to the two lead authors in order of submission.

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SORENSON BEST PAPER AWARD

2000 Faiba Alamdari and Julian Burrell, *Marketing to Female Business Travelers*, Volume 5, Number 2.

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Sorenson Best Paper Award Recipient

ADVANCED AVIATION AND AEROSPACE GIS: COURSE DEVELOPMENT AND CURRICULUM EXPANSION

Richard K. Snow
and
Mary M. Snow
Applied Aviation Sciences
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ABSTRACT

Embry-Riddle Aeronautical University recently began offering the highly successful Introduction to Geographic Information Systems course to its students, and subsequent geographic information system (GIS) courses are being developed. The objectives of additional GIS coursework include the integration of high-technology computer techniques and laboratory exercises, providing collaborative learning opportunities to improve pedagogy, and implementing model practices and materials. As an effective instrument for visualizing tabular data, recognizing emergent patterns, and graphically depicting results, GIS enhances student learning by adding a hands-on component while supplementing existing research methods. This paper examines GIS course development and curriculum expansion within the realm of aviation and aerospace.

Dr. Rich Snow earned his Bachelor of Science in Geography and his Master of Science in Geoscience from Western Kentucky University prior to taking his Doctorate of Philosophy in Physical Geography from Indiana State University. He teaches Meteorology I, Meteorology II, Applied Climatology, Introduction to GIS, and Advanced GIS in the Department of Applied Aviation Sciences on the Daytona Beach, Florida, campus of Embry-Riddle Aeronautical University.

Dr. Mary Snow earned her Bachelor of Arts with a double major in Philosophy and Geography and her Master of Science in Geoscience from Western Kentucky University. Mary took her Doctorate of Philosophy in Physical Geography from Indiana State University. She teaches Meteorology I, Meteorology II, and Weathering and Landforms in the Department of Applied Aviation Sciences as well as Research Methods and Statistics for the Graduate School on the Daytona Beach, Florida, campus of Embry-Riddle Aeronautical University.

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INTRODUCTION

The term geographic information system (GIS) refers to and can be characterized as technology with the capacity to record, store, and analyze information about spatial features. In a benchmark definition, Burrough (1986) describes GIS as "a powerful set of tools for storing and retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes" (p. 6). Likewise, Clarke (1995) defines GIS as an "automated system for the capture, storage, retrieval, analysis, and display of spatial data" (p. 13). Originally a tool of geography departments, GIS rapidly has evolved into the interdisciplinary field of Geographic Information Science, based on the notion that the use of GIS requires one to make scientific inquiries regarding the methods and results obtained through a GIS-based analysis (Foresman, 1998, Goodchild, Parks, & Steyaert, 1993Star & Estes, 1990). Roach (2001) notes that a wide variety of multi-disciplinary GIS applications have been incorporated into higher education as more universities develop curricula surveying GIS theory and introduce students to the organization, planning, and techniques involved in spatial database administration systems.

The Department of Applied Aviation Sciences (AAS) is a recent academic addition to the Daytona Beach campus of Embry-Riddle Aeronautical University (ERAU) with degree programs in Safety Science, Air Traffic Management, and Applied Meteorology. Students in each of these disciplines require the capability to conduct spatial analyses, defined as the examination of the locations and shapes of geographic features and their relationships (Bailey & Gatrell, 1995; Fotheringham, Brunsdon, & Charlton, 2000). O'Sullivan and Unwin (2003) state that spatial analysis is an invaluable approach for assessing suitability and potential, for approximating and calculating, and for interpreting and comprehending problems associated with the location of facilities and objects, such as airports and aircraft. The visual nature of GIS gives students the chance to interact with and manipulate spatial data sets in countless ways, which is essential for aviation and aerospace studies that occur across time and space. As Friedrich and Blystone (1998) point out, the difference between viewing data on a spreadsheet and seeing it presented graphically on a map is incalculable as humans excel at pattern recognition with proper training. In short, the mode through which one observes data has a profound effect on making connections and drawing conclusions allowing the user to answer the questions of what, where, and why.

There are few aviation and aerospace endeavors that do not involve a spatial component, from the planning of an airport at a particular location and the management of daily operations to routing a flight based on traffic, topography, and weather. Although GIS is widely used by the aviation and aerospace industry, most of the education regarding the use of GIS occurs after graduation in the form of professional training. At the present, there are no known GIS courses developed specifically for aviation and aerospace undergraduates. As an effective instrument for visualizing tabular data, recognizing emergent patterns, and effectively depicting results, GIS both enhances pedagogy by adding a hands-on component to the process and provides an invaluable contribution to collaborative research among faculty and students of varying aviation and aerospace disciplines. GIS links scientific inquiry with practical applications while solving the "ancient problem of combining scientific knowledge with specific information" (Longley, Goodchild, Maguire, & Rhind, 2001, p. 9) to give practical value to both. This paper addresses the need to expand the GIS curriculum at ERAU and other aviation institutions by developing and implementing courses designed to meet the unique requirements of aviation and aerospace students.

THE COMPULSION FOR AVIATION AND AEROSPACE GIS COURSES

Lemberg and Stoltman (1999) assert that technology has revolutionized geography as a profession and has had a significant impact on the teaching of the subject in K-12 and higher education. This is reflected in the fact that the growth of GIS in government, business, research, and education has created a demand for individuals who are proficient in the principles and procedures of GIS. In addition to traditional undergraduates, Kennedy (2002) reports that working professionals upgrading their skills or retraining in technology represent a substantial number of the students enrolled in GIS programs.

There are negative teaching issues involved in the use of multimedia technologies in the classroom, such as those required for GIS instruction. These include the tendency to substitute slide shows for substance and hardware constraints that compel lecturers to stay close to the podium (Deadman, Hall, Bain, Elliot, & Dudycha, 2000). However, positive benefits such as working directly with the computer within the realm of a hands-on, tactile learning environment often preferred by pilots appear to outweigh the disadvantages. As a result, Baker and Case (2000) maintain that GIS is emerging as a pedagogical tool for advancing contextually productive student education.

Realizing that access to technology and the appropriate hardware is critical to the success of GIS (Meyer, Butterick, Olkin, & Zack, 1999) and understanding the need to prepare students for the opportunities GIS offers, AAS licensed a popular off-the-shelf GIS software for its two 30-seat computer classrooms. Equipped with the appropriate technological tools an experimental course, Introduction to Global Information Systems, was developed for aviation and aerospace students with lectures articulating the fundamental principles of GIS and computer-based laboratory exercises emphasizing training.

The course begins with a scenario in which students are employed by an aviation history foundation that is researching the last flight of Amelia Earhart. The foundation believes Earhart and Noonan crashed on the island of Nikumaroro and is mounting an expedition to search for the wreckage. Students are tasked with managing a GIS project that will help organize data and acquaint potential sponsors with the plan. The course closes with teams of students developing a GIS based on data they have obtained from external sources such as the FAA or other governmental agencies. Past projects range from topics such as lost aircraft in the Bermuda Triangle to Homeland Defense resources. Since its inception in the Fall 2002 semester, the class has been full each semester, upgraded from experimental to permanent status in the ERAU curriculum, and students from aviation disciplines across campus are requesting additional GIS courses.

The success of Introduction to Global Information Systems helped contribute to the establishment of a GIS Applications Lab (GIS Lab) at ERAU. Among the initial activities of the lab was the creation of a three-dimensional airspace GIS designed to benefit Aeronautical Science (AS) and Air Traffic Management (ATM) students. One of the most difficult tasks for ATM students involves looking at a two-dimensional display and having to translate that image into three dimensions. In this project, aeronautical charts and other data are incorporated into a GIS displaying different airspace classes as three-dimensional images depicting their correct dimensions and structures. The software enables the scene to be zoomed and rotated for optimal viewing. As a result, situational awareness is likely to be greatly enhanced enabling student pilots and future air traffic controllers to better comprehend the complexities of airspace.

Approach charts can be added to the GIS, which prove to be an exceptional aid when debriefing pilots during Instrument Flight Rules training. Global Positioning System (GPS) data also can be integrated allowing a flight to be tracked and later plotted in a virtual three-dimensional environment. Thus, flights can be analyzed for precision of maneuvers helping student pilots and their instructors review and analyze each flight from taxi to landing.

Another aviation application under investigation by the GIS Lab involves the integration of flight routes and corridors into a GIS along with real-time weather information. Using the spatial accuracy of GIS, it is possible to develop individual forecasts for each flight, allowing pilots, air traffic controllers, and meteorologists to work together making course corrections to produce the safest and most efficient flight path. Such a system would save fuel, time, money, and, most importantly, lives, as flying into inclement weather remains a major cause of general aviation accidents.

Among the most demanding tasks associated with aviation Safety Science are the retrieval of debris and the reconstruction of an aircraft or spacecraft after a disaster. The GIS Lab can provide the tools for data acquisition and analysis as Safety Science student search teams sift through simulated wreckage. Using hand-held GPS units, students are able to accurately log the exact locations along with descriptions of the debris. Afterward, students can return to the GIS Lab where the data are uploaded into a GIS, maps of the debris field are produced, and a database is created that ultimately could help determine the cause of the simulated accident.

The three-dimensional airspace project and other aviation applications have created a growing interest in GIS within AAS and across the Embry-Riddle campus as more faculty members become aware of the potential of GIS in research and pedagogy. Acting on this enthusiasm along with the call from students for additional aviation GIS courses, the authors seek to attain the following objectives:

1. Integrate GIS-related laboratory exercises with fieldwork to encourage students to examine scientific concepts related to aviation and aerospace including describing and summarizing spatial data, making generalizations concerning complex spatial patterns, estimating the probability of an outcome, making inferences about a population from a sample, and determining differences in phenomena at various locations;
2. Enhance teaching and learning through the use of GIS high-technology computer techniques and applications such as spatial analysis and three-dimensional visualization;
3. Provide collaborative learning opportunities based on GIS theory and applications to improve pedagogy among the faculty and students within the diverse aviation and aerospace disciplines;
4. Conduct evaluations on the effectiveness of the aviation GIS coursework in enhancing student knowledge, which will determine the future direction of the GIS curriculum;
5. Ensure participating faculty are well-trained in the latest GIS software applications through workshops, seminars, and on-line coursework; and
6. Expand the impact of the GIS curriculum beyond AAS to enhance the diverse aviation and aerospace disciplines at Embry-Riddle and the larger aviation community.

THE PROPOSED AVIATION AND AEROSPACE GIS COURSES

The authors plan to develop and implement two new courses designed specifically for aviation and aerospace undergraduates, with the expectation that following the proposed approach to curriculum development will multiply the dissemination of new GIS methods across the Embry-Riddle campus and eventually spread to other aviation and aerospace institutions.

Advanced Geographic Information Systems

The first course, Advanced Geographic Information Systems, is being offered as an experimental course during the Spring 2004 semester and consists of three modules to address the needs of ATM, Safety Science, Applied Meteorology, and other aviation/aerospace students.

Module One: Understanding and Displaying Information.

This module begins with an overview on the nature of geographic data including explanations of GPS, surveys, aerial digital photography, and satellite remote sensing before turning to maps, layers, and databases within an aviation framework to yield advanced techniques for cartographic presentation. Goals include gaining skill in data acquisition and management, creating custom aviation symbols, displaying tabular point data, and producing high quality graphs and maps.

Module Two: Raster Data.

The second module involves working with rasters and will enable aviation/aerospace students to add digital imagery and thematic rasters to their GIS projects. For students of all aviation and aerospace disciplines, incorporating digital imagery allows visualization of the specific terrain, which is essential for understanding the effects of the natural and built landscape on aviation. For example, air traffic controllers presently use this GIS technique to determine the best approach and departure paths in order to minimize noise levels over residential areas. Safety scientists working to recover debris from the space shuttle Columbia were aided in their efforts by a GIS with images of local topography. Applied meteorologists can visualize aspects of the landscape that could impact wind speeds, create wind shear or turbulence, and other variables that might influence aircraft operations. After completing the module, students will understand how rasters represent geographic features within cells, be able to interpret rasters, and display raster properties.

Module Three: Three-dimensional Analysis.

The final module procures cohesion of the various course elements by providing training in the use of three-dimensional GIS software, which will be an important contribution to the three disciplines in AAS. While some GIS programs are cumbersome and difficult to use requiring the input of typed commands and knowledge of a specific computer language, three-dimensional GIS software is especially user-friendly with drop-down windows used to perform functions, rather than command lines (Karnavou & Mikelis, 1994; Lively & Czapar, 2002). Safety scientists can include topographic representations of crash sites, air traffic control students can better view complex airspace, and applied meteorologists will be able to extract data from two-dimensional weather charts to better interpret atmospheric parameters. The goals of the three-dimensional module are to understand the structure of three-dimensional data types, explore three-dimensional analysis, set three-dimensional viewing properties for two-dimensional data, and create three-dimensional surface features.

Aviation Geographic Information Systems Analysis

The second course to be developed, Aviation Geographic Information Systems Analysis, consists of two modules that contain mathematical and statistical elements, incorporate the scientific method, and allow students to apply spatial analyses within their respective aviation and aerospace disciplines.

Module One: Spatial Analysis.

The first module examines topics related to the visualization, measurement, transformation, and optimization of spatial data. Students will be introduced to cell-based modeling, map algebra, and other mathematical functions that are relevant to their disciplines. Module components include assessing the nature of spatial data, identifying how to best represent spatial data, and techniques of autocorrelation, sampling, and interpolation. Students also will query and measure spatial data, produce statistical summaries of spatial data, and understand the rationale and methods for spatial hypothesis testing.

Module Two: Aviation Applications.

The second section of the course puts into practice the lessons learned from the first module. Topics include mapping floods, hurricanes, and other natural hazards, identification of at-risk population centers, understanding geographic features and their associated impacts, analyses of atmospheric and oceanic processes, performing hypothetical scenarios of aircraft incidents and hazardous weather, and discovering ways to reduce accident risks. Students will develop a final research project applying spatial analysis techniques, which should serve to help students recognize that GIS is a toolbox to be applied to solving problems and not a series of fragmented entities.

AVIATION AND AEROSPACE GIS COURSE EVALUATION

To provide the authors with the necessary data to improve lesson plans and exercises while guiding and motivating students to participate in and direct their education, a formative assessment of the courses will be implemented. A classroom assessment technique will be selected that best provides information about what is being learned, the extent to which the courses are achieving their goals, and that enables students to analyze their understanding of the material. Realizing that evaluation directs and drives curriculum development, the chosen assessment instrument will be capable of appraising the students' command of course content while providing the student feedback that is required to govern the educational process.

The two new courses have knowledge-based goals encouraging students to learn GIS facts and concepts, skills-based goals requiring students to use the software, and goals affecting their future interest in GIS. The classroom assessment technique will be aligned with the formalized and stated goals of both courses, which include comprehension of the scientific method, mastery of research methods and writing, increasing computer skills, and the fostering of a sustained interest in GIS. The classroom assessment technique also will assist the authors in evaluating how well students are performing by affording beneficial information for improving lectures, lab exercises, and other instructional methods to better attain the stated course goals.

Assessment of the new courses will be addressed through qualitative surveys and quantitative tests. Combining these methods should enhance data collection and yield a broader understanding of the results. Additionally, as a result of serving students from more than 100 countries, ERAU is sensitive to the needs of diverse population groups. Thus, to more accurately reflect the complexity of the cultural contexts in which the data were gathered, a review panel of representatives from various student groups will examine the findings and offer suggestions for enhancing pedagogy. The results of the evaluations will be published, as they become available.

IMPLEMENTING AVIATION AND AEROSPACE GIS COURSES

To implement aviation GIS courses, an institution needs facilities, trained instructors, a dynamic curriculum, and funding. Fortunately, a number of external sources are available. The United States government offers GIS grants through the National Science Foundation (NSF, n.d.), the National Aeronautics and Space Administration (NASA, n.d.), and the U.S. Geological Survey (USGS, n.d.). Environmental Systems Research Institute provides start-up monies and financial incentives for institutions seeking to establish GIS programs (ESRI, n.d.). Additionally, numerous state, private foundation, partnership, and industry grants are available. A key component of GIS education and research is access to affordable and reliable data. Real-time and archived data from a number of Internet sources are compatible with most GIS software. Among these is the Geography Network which provides free data and maps with a range of aviation-related themes including business, economics, and transportation (Geography Network, n.d.). A variety of governmental sites also are available, such as the National Oceanic and Atmospheric Administration (NOAA, n.d.), that include wind, humidity, temperature, and precipitation data from locations around the world. Numerous off-the-shelf GIS software programs are available. In addition to seeking products that are user-friendly, affordable, and compatible with the existing infrastructure, the software should provide data visualization, query, analysis, and integration capabilities along with the ability to create and edit geographic data. Other features should include a catalog for browsing and managing data, on-the-fly coordinate and datum projection, metadata creation, editing and cartographic tools, and the capacity to directly access Internet data.

Due to its interdisciplinary nature, establishing a GIS program presents the potential for turf wars between departments, which best can be overcome through multidiscipline coordination. Questions also might arise concerning where GIS fits into the established curricula; whether it should be treated as vocational, academic or extended education; and whether it should be taught at the lower division, upper division, or graduate level. Without well-trained instructors and standards concerning course or curriculum content, there could be problems with accreditation, and inadequate planning or a lack of funding to upgrade hardware and software could seriously inhibit growth. Despite the possible perils, the prospect of developing, implementing, and maintaining a successful aviation GIS curriculum is highly favorable. Approximately 3,000 colleges and universities in the U.S. and 4,000 worldwide already have integrated GIS into more than 70 disciplines.

CONCLUSION

Currently, the prevailing paradigm for education is evolving. As many universities are administered like businesses, businesses are offering, or even requiring, advanced education of their workforce (Hills, 1999). In a society that is increasingly adept in the use of technology, graduates today must be equipped with the skills necessary to compete. Undergraduates enrolled in aviation institutions expect and deserve to acquire the most sophisticated education available in science, math, engineering, and technology. Adapting, developing, and implementing courses in advanced aviation GIS will better prepare students to contribute to society's growing technological demands.

While GIS is a highly marketable skill that can broaden opportunities during those times when the aviation industry is in a downturn, emphasis must be placed on context. Without a comprehensive cognition of technology and science there can be no meaningful depiction of data. Success with GIS arises only through a broad-based education because "expertise in one area is not enough" (Longley et al., 2001, p. viii). Competency comes through understanding the complex interactions between people, their environments, and technologies. As an interdisciplinary instrument focused on the universal language of maps, GIS offer a means to a more comprehensive understanding of the whole.

The expertise acquired in GIS courses is being applied in government, industry, and academia to advance the analysis of spatial data and to enhance decision-making capabilities at all levels. Airport planners employ GIS to analyze the best locations for new runways and other structures, the proper placement of radar units and wind-shear detectors, and to determine how nearby buildings might interfere with aircraft operations. Likewise, airport managers use GIS for a multitude of applications from assessing the condition of pavement to determining optimal flight paths for reducing aircraft noise levels over highly populated areas (Lang, 1999).

Through the facilitation of data collection and analysis, GIS allows students and teachers to cooperate in the pedagogical process as students seek direction from faculty regarding how best to investigate research interests, collect and analyze data, and make new discoveries. Students who are familiar with advanced cartographic principles and have well-developed GIS laboratory skills are empowered to collaborate in research as they are able to map any aspect of the spatial world.

ERAU has a large number of international students and many of these have explicitly expressed a desire to return and contribute to their local communities. Equipped with the ability to visualize data formerly confined to tables or graphs, students will be placed in a significantly superior position to help modernize the workplace and enhance the global research infrastructure. Together with their cohorts in the United States, they will serve as the seeds of dissemination for widespread applications of GIS. Within the industry itself, graduates who are proficient in GIS will have the ability to manage large databases for government agencies or the private sector, improve air traffic control systems, mitigate noise levels, reduce aircraft accidents, and enhance airport design, management, and security. In short, developing courses and expanding aviation and aerospace GIS curricula at ERAU and similar institutions will have impacts that are both far-reaching and imminently practical.

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SWISSAIR 111 HUMAN FACTORS: CHECKLISTS AND COCKPIT COMMUNICATION

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ABSTRACT

On March 27, 2003, the Transportation Safety Board of Canada released the final Swissair Flight 111 Air Investigation Report. This paper analyzes the human factors of the accident involving the captain's and first officer's use of checklists and their cockpit communication. A dearth of research exists on the use of checklists in emergency situations. A case study is presented that analyzes the use of checklists on Swissair 111 and their use in the aviation industry at that time. After reviewing and discussing past research on cockpit communication, publicly available information from the Swissair 111 cockpit voice recorder (CVR) is analyzed. The flight crew's communication is placed into some broad categories of linguistically-oriented aviation communication research. For public safety reasons, the author recommends the Swissair 111 CVR transcript be released to leaders in the field of aviation psycholinguistics for further research.

INTRODUCTION

On March 27, 2003, the Transportation Safety Board of Canada (TSB) released the final Swissair Flight 111 Air Investigation Report titled In-Flight Fire Leading to Collision with Water: Swissair Transport Limited McDonnell Douglas MD-11 HB-IWF Peggy's Cove, Nova Scotia 5 nm SW 2 September 1998 (TSB, 2003a). This article examines two human factors aspects of the Swissair 111 accident. First, it examines the use of checklists in emergency situations such as the onboard fire experienced by Swissair 111. Second, it examines the captain's and first officer's (FO) communication during the in flight emergency.

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While some research has focused on the design of checklists and their use under normal circumstances, scant research is available on their use during non-normal situations. A comparison will be made between the industry and regulatory customs for use of specific checklists and the Swissair 111 flight crew's use of checklists. Also discussed will be problems with the MD-11 checklist uncovered during the TSB's investigation of the Swissair 111 accident.

Past research indicates that FOs may have difficulty communicating with captains and that this difficulty increases during times of high stress. Two famous examples of the phenomenon are the March 27, 1977, Pan-Am 747 and KLM 747 collision in Tenerife, Canary Islands and the January 13, 1982 Air Florida 737 collision with the 14th Street Bridge near Washington National Airport (hereafter referred to as the Tenerife collision and Air Florida 737 collision, respectively). Within human factors research there is a set of research concerning cockpit communication. Within that set there is a smaller subset concerning the communication between the authority figure of the captain and the other members of the flight crew. What is publicly known of the conversation between the Swissair 111 FO and captain will be related to prior research and prior accident investigations. Their communication will be placed into some broad categories of linguistically-oriented aviation communication research. Specifically, the ideas of negative politeness/mitigation will be used to analyze if there was a disagreement about certain actions between the FO and the captain and if the FO was hindered in his communication effectiveness by using polite/mitigated communication. While the public record of their communication is incomplete, the TSB's preliminary summary of the Swissair 111 cockpit voice recording (CVR) was leaked to the Wall Street Journal (WSJ; Carley, 1999), and paraphrased excerpts of the CVR were included in the TSB's final Air Investigation Report (2003a).

The TSB's Human Performance Division developed an integrated investigation process after a 1992 TSB study indicated the need to search for human factors systematically in the course of an investigation. The study also indicated a need for a single tool to guide investigators through that search (Hill, 1992). The integrated investigation process involved seven steps. First, collect occurrence data. Second, determine the occurrence sequence. Third, fourth, and fifth, identify unsafe acts/decisions, conditions, and failure modes. Sixth, identify behavioral antecedents that are factors in the work system (e.g., physical, physiological, psychological) that may have facilitated a failure and its original unsafe act or decision. Seventh, identify potential safety problems. The TSB utilized this integrated human factors investigation process for the Swissair 111 investigation. (Nottrodt, Hill, & McCullough, 1997).

A CVR Audition Group was established by the TSB to transcribe Swissair 111's CVR. Members of the group were selected based on their expertise in one or more of the following areas: (a) MD-11 aircraft or flight systems engineering; (b) MD-11 aircraft operations; (c) CVR expertise; (d) familiarity with the voices of the flight crew members; and (e) fluency in English and Swiss-German (TSB, 2003b, sec. CVR Audition Group). Under Canadian Law, CVRs cannot be released publicly with rare exceptions, such as when necessary to understand a specific aspect of an accident or to improve future safety. Because of this protection, only a few people were given access to the recording. It is not known how far this group progressed in their work before the summary preliminary transcript was leaked to the WSJ.

The TSB conducted an in-depth analysis of flight crew communication from the CVR and air traffic control (ATC) recordings to assess, as objectively as possible, crew interaction including crew coordination, workload, and problem solving in handling the emergency. A speech micro-coding protocol—developed from theory, research, and experience—was refined to classify verbal communication segments in order to discover and analyze relevant data. The recordings were matched with aircraft actions recorded on the flight data recorder (FDR; TSB, 2003c, sec. Speech Micro-coding Analysis). The detailed analysis was reflected in the TSB's final report, but not in the WSJ's article based on the TSB's CVR preliminary summary transcript (Carley, 1999). Because the WSJ's article appeared just four months after the accident, it appears the preliminary summary transcript was from an early stage of analysis.

The Swissair fire was insidious, giving off a faint odor and a hint of smoke that appeared, quickly disappeared, and then re-appeared 2 minutes later. Based on fire damage, various electrical tests, and innovative computer fire modeling, one scenario did emerge that was at least a single factor in the fire's ignition (Hamer, 2003; TSB, 2003a, pp. 153-154, 233-235, 248). Evidence of an arcing or spark from the wiring for the in-flight entertainment network was found that set nearby flammable metallized polythylene terephthalate (MPET) covered thermal acoustic insulation on fire. "Without the presence of this and other flammable material," stated Vic Gerden, TSB Investigator-In-Charge, "this accident would not have happened" (TSB, 2003d).

Starting in the attic of the cockpit, between the ceiling and aircraft skin, and behind the pilots and to the right, the fire initially was a small creeping flame with a little smoke and an increasingly strong odor (TSB, 2003a, p. 253).

It was the FO who first mentioned an unusual smell in the cockpit. Twenty seconds later, the captain said "Look." Later, he said, "It's definitely smoke which came out." The FO stood up and took a look. By the time he reached the back of the cockpit, he said there was nothing more "up there" (TSB, 2003a, p. 184). The visible smoke came through openings in a panel near an air conditioning outlet (the right overhead diffuser outlet), and appeared to the pilots to be coming from the air conditioning outlet itself (TSB, 2003a, p. 231, 234). It ceased within thirty seconds of first being noticed (TSB, 2003a, p. 184).

The captain had the first class flight attendant come take a look. She said she could smell the odor in the cockpit, but had not noticed anything in the cabin. She did not mention any smoke. The captain commented, "Air conditioning is it?" The FO answered yes (TSB, 2003a, p. 184).

Airflow was carrying the smoke away from the pilots, into the avionics compartment where it was filtered and exhausted overboard, and into the attic area over the cabin (TSB, 2003a, p. 247). No smoke, however, was ever reported in the cabin.

The FO was re-assigned the flying duties, and the captain ordered him to begin descending immediately. The FO did so at an initial rate of 2,000 feet per minute. Based on the pilots' few cues, the TSB considered this a timely and proper decision by the pilots. Even so, according to the TSB, the problem was already too far advanced for the aircraft to land safely:

> Theoretical calculations confirm that from any point along the actual flight path after the aircraft started to descend, it would not have been possible for the pilots to continue maintaining control of the aircraft for the amount of time necessary to reach the airport and complete a landing (TSB, 2003a, p. 248).

CHECKLISTS – LITERATURE REVIEW

There is a dearth of research on the use of checklists. As the one major research report on checklists published in 1990 states up front, "Although the aircraft checklist has long been regarded as the foundation of pilot standardization and cockpit safety, it has escaped the scrutiny of the human factors profession" (Degani & Weiner, 1990, p.1). As of 2004, checklists have largely remained free of this scrutiny.

Degani and Wiener's 1990 research focused on normal checklists such as take-off procedures. They analyzed the normal checklist's functions, format, design, length, and usage. To illustrate the influences on checklist design and use they discussed the development of the checklist from the design and initial delivery of an aircraft to its use over time by various airlines. Their research did not cover non-normal checklists like those used by the Swissair 111 flight crew during the in-flight fire. Also, their research discussed issues surrounding the use of normal checklists, such as phraseology and design, but did not discuss when or if checklists should be used under specific circumstances.

In 1996 an investigation of non-normal checklist procedures was carried out by Foernsler. She studied the possibility of integrating multiple checklists for non-normal procedures into one single checklist. The aviation industry was interested in this possibility as automation in glass cockpit aircraft such as the MD-11 (the aircraft involved in Swissair 111) reduced the number of checklist items required for various crew procedures. However, the automation was also complex which increased crew workload if the automation confused the flight crew. The investigation concluded that multiple failures were extremely improbable considering the highly automated and redundant systems found in modern transport aircraft. Conflicts between multiple checklists were exceedingly unlikely considering the low probability of a multiple failure and the low number of checklist items with conflicting commands. Foernsler concluded that multiple non-normal checklists could be combined into a single checklist with relative ease.

CHECKLISTS – SWISSAIR 111

When the Captain alerted the maitre de cabin (M/C) that there was smoke in the cockpit and that the cabin crew should begin preparing for landing, the pilot stated that he was about to start a checklist. Three minutes later, the FO asked the Captain if he was in the emergency checklist for air conditioning smoke, "(Du bisch i dr) emergency checklist (fr) air conditioning smoke" (Aviation Safety Network, n.d.).[1] The captain said that he was. However, no items from the Air Conditioning Smoke checklist were ever completed (TSB, 2003a, pp. 231-232).

The captain was an instructor pilot on the MD-11 as well as a line pilot. Not only did he take the six-week pilot training course for transitioning to the MD-11 in June 1997, he also instructed other pilots during in-flight simulator lessons including those lessons that practiced smoke in the cockpit

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[1] Words in parentheses are questionable text. Communication between the pilots was carried out primarily in Swiss-German. Communication between pilots and ATCs was in English. The communication "(Du bisch i dr) emergency checklist..." was intended for the captain, but was accidentally radioed to the ATC. A transcript of the communication between ATC and Swissair 111 was released on September 8, 1998, but then was removed from the Internet. The following message was put in its place: "...the TSB's interpretation of Canadian laws governing the release or protection of such information was called into question. Pending resolution of the matter, the TSB has removed the transcript from its Web site" (TBS, 1998). The TSB has not placed the transcript on the Internet again, and has also removed the note concerning the transcript. In this article, the transcript available from the Aviation Safety Network (n.d.) Web site was used for Swissair 111-ATC quotations. The author checked the quotes against other published reports of the transcript to insure accuracy.

scenarios. He gave detailed briefings to his students before, during, and after their sessions. On his own initiative, he questioned technical specialists in the maintenance department about the aircraft and its systems to learn as much as possible about the MD-11. The FO completed the six-week MD-11 officer training in May 1998. In the MD-11 training, crews were taught to evaluate emergency situations before starting any checklists. Commencing an emergency descent was considered a flight crew judgment based on their perception of the threat (TSB, 2003a, pp. 6-7, 160).

One of the criticisms of the pilots and Swissair culture was an over-reliance on checklists. Captain John Nance, pilot, author, attorney, and ABC Television Network safety analyst, believed that Swissair's culture emphasized the checklist causing the pilots to spend precious time going through a logic tree rather than preparing to land (Carley, 1998). This argument was strengthened by one of the Swissair Captain's apparent comments recorded on the CVR later in the flight. The FO asked him a question, and the captain replied that he was in the midst of a checklist and "didn't want to be interrupted" so often (Carley, 1999). However, the pilots did not initiate the Air Conditioning Smoke Checklist immediately (TSB, 2003a, pp. 231-232). While they did perform at least one action to troubleshoot an air conditioning smoke situation, when smoke again became clearly visible to the pilots, they immediately began discussing a diversion to a nearby airport and the need to bring navigation charts forward from the plane's library.

Almost two years to the day before the Swissair 111 MD-11 crash, on September 5, 1996, a DC-10, Federal Express Flight 1406, caught fire and was forced to land in Newburgh, New York. Like Swissair 111, the DC-10 was flying at 33,000 feet at night when a problem was noticed. Smoke alarms started going off in the cockpit, and the captain said, "What the hell's that" (NTSB, 1998, p. 84). Within 20 seconds, the flight crew knew definitively it was the number nine smoke detector in the cargo compartment. Even with the quick reaction and smoke detectors, almost 4 minutes passed before the captain said, "We've definitely got smoke guys...We need to get down right now, let's go" (NTSB, 1998, p. 89). The plane landed 18 minutes after the alarm first sounded.

The U.S. National Transportation Safety Board (NTSB) report on the Federal Express 1406 crash was released on July 22, 1998. The report did not state that the captain correctly decided on an emergency descent rather than trouble-shooting the problem. It did, however, criticize him for not initiating any checklists (his flight engineer initiated two of them), for not properly managing his crew's completion of the checklists, and for using his memory rather than the emergency descent checklist (NTSB, 1998, pp. 58-59). NTSB member John Goglia said, "I don't know how long it's going to take to drill into people's heads to follow the checklist" (Systemic Safety

Shortcomings, 1998). There is no way of determining if the Swissair captain read any news about the NTSB report, but it is an indication of the aviation's industry's thoughts on the emergency descent versus completing checklists debate during the summer of 1998.

The MD-11 had three flight crew checklists for identifying and working with smoke or fumes: Air Conditioning Smoke; Smoke/Fumes of Unknown Origin; and Smoke/Fumes Removal. The aircraft manufacturer, McDonnell-Douglas, recommended that the Air Conditioning Smoke checklist only be used when the crew was sure that the source of the smoke was the air conditioning system. McDonnell-Douglas removed the Air Conditioning Smoke checklist from the Flight Crew Operating Manual in 1993 because the same steps were included in the Smoke/Fumes of Unknown Origin Checklist (McDonnell-Douglas, 1993b). These same steps could potentially isolate the source of the smoke regardless of the type of that source. The FAA-approved Airplane Flight Manual retained the two separate checklists, as did Swissair (McDonnell-Douglas, 1993a; Swissair, 1998). Swissair believed that if a flight crew could determine with 100% certainty that the air conditioning system was the source of the smoke, then the Air Conditioning Smoke checklist was the safest list. The Smoke/Fumes of Unknown Origin called for turning off electrical power and pneumatics that make the aircraft more difficult to fly. The TSB concluded that the two checklists did not create a problem for Swissair 111 since the crew did not feel the threat was serious enough to complete the Air Conditioning Smoke checklist. It was unlikely that the pilots would have performed a single checklist any earlier. The TSB did use the two types of checklists, however, as examples of the misconception in the industry that the human sense of smell can always accurately evaluate the source of smoke (TSB, 2003a, pp. 164-165, 216-217).

More troublesome for the TSB was the location of landing preparations on the checklists. Neither the Swissair nor the McDonnell-Douglas Smoke of Unknown Origin Checklist stated that preparations for an emergency landing should be considered immediately. In fact, landing was the last item on the checklist. With Swissair 111, the TSB found that even if landing had been first on the list, the aircraft would not have had enough time to land safely at Halifax. Also, as noted above, the pilots did begin preparations for landing before initiating any checklists. While inconsequential for Swissair 111, however, placement on the checklist could endanger future flights (TSB, 2003a, p. 217).

The Smoke of Unknown Origin Checklist could take more than 30 minutes to complete. In the Conclusions – Findings as to Risk section of its report, the TBS warned that for ongoing in-flight fires 30 minutes may be too long (TSB, 2003a, p. 255). In the Federal Express 1406 crash, two related checklists concerning fire and smoke were completed. First, the Fire and Smoke Checklist was completed. This checklist then instructed the flight engineer to move through the Cabin Cargo Smoke Light Illuminated Checklist. The last item on the second checklist—land at nearest suitable airport—was reached at 05:48. This was 8 minutes after the pilot said, "We need to get down right now, let's go" (NTSB, 1998).

In 1997, McDonnell-Douglas merged with Boeing and that company became responsible for the MD-11 type aircraft. After Swissair 111, Boeing reviewed MD-11 smoke/fire procedures and sent out a Flight Operations Bulletin based on this review (1999). Boeing mentioned at the beginning of the Bulletin that the MD-11 checklists and the smoke switch used in the procedure were all developed to replace the multiple steps a flight engineer carried out for many years on the DC-10. While it is true that the procedures and the development of a single switch in some respects simplified smoke troubleshooting, it also placed the workload previously handled by three crew members onto the shoulders of only two crew members. The important role of the flight engineer in the Federal Express 1406 crash illustrates this point. It was he who initiated and performed the checklists.

Boeing advised that, in future, "...anytime smoke has been detected and the source cannot be POSITIVELY [capitalization in original] identified and eliminated, the aircraft should be landed as soon as possible" (Boeing, 1999). In their December 2000 Interim Air Safety Recommendations, the TSB recommended that regulators ensure industry standards incorporate the idea that when smoke from an unknown source appears in the aircraft, preparations should be made to land the aircraft expeditiously (TSB, 2000). The TSB was still concerned about checklists when they published the final report. In the Safety Action – Safety Concern section of the report, the TSB noted concern for the lack of industry standards for checklist modification and approval. Without these standards, airlines may unknowingly introduce unsafe conditions particularly in emergency checklists (TSB, 2003a, pp. 296-297).

There is one final note on checklists. Checklists and simulator training tended to reinforce the idea that actions taken by pilots would result in the smoke quickly dissipating. The premise was that isolating the source could kill potential ignition sources (TSB, 2003a, p. 215). In the case of Swissair 111, the fire was fully realized by the time the smoke appeared in the cockpit. The insulation was already on fire, and eliminating the initial ignition source would have been inconsequential. Starting a checklist immediately would have had no effect. The possibility of an ongoing fire was not emphasized in the checklists.

COMMUNICATION – LITERATURE REVIEW

Communication research in aviation has been classified into two categories by Silberstein and Dietrich (2003). One category researches the social dimension of communication and the psychological categories behind language use. Called the psychologically-oriented approach, it investigates communication patterns to shed light on social behavior, performance (both as a team and as an individual), and teamwork. A second category, called the linguistically-oriented approach, researches the structural properties of language that might lead to misunderstandings or other problems. Both approaches, they say, have been productive and have achieved results. The communication literature review and communication sections of this article focus on research using the linguistically-oriented approach (pp. 10-11) and are most interested in research relating to communication difficulties encountered between captains and FOs.

Brown, an anthropologist, and Levinson, a linguist, defined different types of politeness based on the assumption that politeness was simply an attempt to avoid face threatening action (1988). Face is a person's public self-image, and the term derives partially from the English folk term and its idea of losing face. There is negative face–the desire of every adult for his or her actions to be unimpeded by other adults—and there is positive face–the desire of every adult for his or her wants to be desired by other adults. From these flow two types of politeness. Negative politeness is a type of communication where person X uses self-effacement, deference, avoidance, or other techniques to save the face of person Y. Positive politeness is where person X uses some assurance to indicate that X wants, at least partly, what person Y wants and thereby saves the face of person Y (pp. 61-62, 70).

These definitions were applied to cockpit communications by Linde (1988). She used the term mitigation for negative politeness and argued that examples of positive politeness were generally regarded in the aviation community as direct communication rather than polite communication. In a study involving both aircraft accident CVR transcripts and flight simulator cockpit communication, she found that the more indirect and tentative the suggestion to the captain, the less likely the captain was to use the suggestion during problem situations. She could not find an association between these suggestions—which she termed draft order statements—with poor safety performance. However, her study did find an association between a high rate of topic failure and poor safety performance. A mitigated topic introduction tended to fail more than a direct topic introduction. She defined topic failures as speech acts expressing a new topic not followed by a speech act from another speaker having the same topic. Overall she found that comments to the captain tended to be more mitigated than comments from the captain to the flight crew.

Foushee and Manos (1981) applied small-group theory to the cockpit. They wrote that subordinate crewmembers can be conditioned to limit their speech after encountering insensitive or intimidating captains. A behavioral normative pattern they termed appropriate copilot behavior existed and occurred even in situations where there was no impediment to free communication. They also used the terms sheepish and intimidated when relating examples from NTSB aircraft accident reports. By analyzing flight simulator CVRs with a technique from Bales's (1950) interaction process analysis, Foushee and Manos found that crews who communicated less also tended to perform less well. More importantly, increased communications about flight status correlated with decreased aircraft systems operations errors.

An increase in commands was associated with a lower incidence of flying errors, but they also found that overuse of commands could lead to negative results. In their analysis, Foushee and Manos (1981) found that crews with more errors tended to show higher rates of response uncertainty, frustration or anger, embarrassment, and lower rates of agreement (Bales, 1950).

An NTSB study provided further evidence that it can be difficult for an FO to communicate with a captain. In 1994 the NTSB studied major accidents of U.S. air carriers between 1978 and 1990 in which the NSTB cited the flight crew as one cause of the accident. Failure to monitor or challenge another crewmember's error (monitoring/challenging error) occurred in 31 of 37 of the accidents. The most frequently unchallenged error was a captain's failure to perform some activity. In 17 of the 37 accidents the captain made an error (a tactical decision error) and the FO failed to challenge the captain's decision. The report pointed out that FOs have a difficult time both deciding the captain has made an incorrect decision and choosing the correct time to question that decision. An FO may be concerned, the NTSB concluded, that the correction will be interpreted as a challenge to the captain's authority (NTSB, 1994, pp. v-vi, 59, 75).

Tarnow (2000) found that many of the factors leading to human errors in the cockpit were similar to four findings in the Milgram (1974) obedience studies. First, Milgram found evidence in his studies of excessive obedience. Verbal orders from an authority figure could cause most people to inflict pain on, seriously injure, or even kill other people. Second, Milgram found evidence of hesitant communications. Objections to giving electrical shocks to others were frequently hesitant and could be overruled by the authority figure's replies. Third, Milgram found evidence that people tended to accept the authority's definition of the situation. Fourth, Milgram found evidence of the closeness effect. The closer the authority figure was in his tests, the stronger their authority. This last can be especially relevant in aircraft cockpits where the captain is seated closely to the FO. Tarnow then illustrated these four elements, including excessive obedience and hesitant communications, using an aircraft accident CVR transcript. Finally, Tarnow made calculations based on the 1994 NTSB study figures and concluded that excessive obedience may cause as many as 25% of all airplane accidents.

Problem solving communications were defined by Sexton and Helmreich (2003) as "...task related communications regarding the management of threats and errors during a flight" (p. 69). Examples of this type of communication include the following:

1. And if we execute a missed approach, we have two procedures we could follow.
2. Okay, what do we have for gas?
3. I don't want to dump any fuel, in case we might need it.

After studying flight simulator CVRs they found that captains—with what they classified outstanding performance—used problem solving communications seven to eight times more than poor performing captains.

In 1992, Orasanu and Fischer (1992) studied flight crews during simulated in-flight emergencies. Effective captains in their study explicitly stated plans and explicitly allocated tasks among the flight crew. However, if the captain did not have charge of the situation, the FO was more likely to suggest plans and strategies.

Building on this research, they gave questionnaires to captains and FOs concerning aviation incidents and asked what they would say to their fellow flight crew member to solve a stated goal. The intent was to study how pilots would challenge the actions of a colleague. Captains, they found, either gave direct commands or made suggestions of the collegial "Let's do this" variety. Linde would place this second type in the positive politeness category and would consider these statements direct communication rather than polite communication (1988). Fischer and Orasanu in this study found that FOs, regardless of gender, were less direct than captains. They divided the FOs' responses into three strategies. The first and most common strategy is alerting the captain to a specific problem or a specific goal. With this type of strategy no action was directly requested of the captain, merely agreement with the FO's assessment of the situation. In the second strategy, using permission-seeking questions, the FO volunteered to take an action but left the final decision to the captain. The third strategy of using confirmation seeking questions involved the FO asking or confirming whether or not the captain wanted some action (Fischer, 1997). While these final two strategies were more direct than the first, Linde would classify all three as polite communication (1998).

Again using the questionnaire methodology, Fischer and Orasanu (1997) found that the most frequent strategy by FOs for making a request, as in their 1997 study, was using hints (alerting the captain to a specific problem or a specific goal) such as "That return at 25 miles looks mean." Fifty-seven percent of FO speaker-centered communications were permission-seeking questions that assured the captain agreed with their planned action, such as "Do you want me to ask ATC if they still want us on this heading." Both captains and FOs gave direct commands the lowest effectiveness ratings, but captains used direct commands extensively in their responses. Thus there was a disjoint between members of the cockpit's ideal type of communication and their actual type of communication (Fischer, 1999).

Captains thought FOs' hints were a highly effective strategy for requesting action from them in another questionnaire-based Fischer and Orasanu study (2000). However, aircraft accident research had suggested that FOs' hints were ineffective in changing captains' behaviors. To makes sense of this discrepancy, Orasanu and Fischer developed the idea that there were actually weak hints and strong hints (2000). Weak hints do not define a problem, they just insinuated a problem. The listener is required to infer that there was a problem. These weak hints contributed to the plan continuation errors observed in aircraft accident research. As defined by Fischer and Orasanu (2000), plan continuation errors occurred when a crew continued with a plan of action when cues suggested that the plan should be reconsidered. What captains actually liked in the study were strong hints which both defined the problem and minimally challenged the captain's status since the decision on how best to respond was left to the captain. Examples of strong hints were, "Clearance was to 9000!" and "I show us 15 knots slow."

The two most famous examples of aircraft accidents involving flight crew difficulty in communicating warnings to captains are the Tenerife collision and the Air Florida 737 collision.

A Spanish commission assisted by Dutch and American commissions investigated the Tenerife collision. The Spanish commission felt one of the causes of the accident was the social dynamic between the captain and the FO in the KLM 747. In their report on the accident under the heading socio-psychological causes they wrote:

> Although nothing abnormal can be deduced from the CVR, the fact exists that a copilot not very experienced with 747s was flying with one of the pilots of greatest prestige in the company who was, moreover, KLM's chief flying instructor and who had certified him fit to be a crewmember for this type of airplane. In case of doubt these circumstances could have induced the copilot not to ask any questions, assuming that this captain was always right. (Spanish Ministry of Transportation and Communications, 1978)

The Dutch commission strongly objected to the conclusions of the Spanish commission including their conclusions concerning the KLM's captain and FO. While the Dutch had a vested interest in the outcome of the investigation, KLM is a Dutch company, their rebuttal to the Spanish commission is important to note:

> It must be considered a normal situation in a cockpit that the captain, being the chief instructor on this type of aircraft, had a certain prestige in relation to the first officer. If a condition like this is not accepted as a perfectly normal situation in flight operations, the composition of a cockpit crew would be practically impossible. The first officer was a very experienced pilot....Considering the extensive flying experience of the first officer, there certainly existed no such relationship of authority between the captain and the first officer that would have withheld the latter from taking the correct action in case of essential shortcomings of the captain. (Netherlands Ministry of Transport and Public Works, 1979, October 15)

An Air Line Pilots Association (ALPA, 1979) study group investigated the Tenerife collision and determined that the young and inexperienced KLM FO made two comments in an attempt to influence the captain's decision to takeoff. The first was direct and occurred when the captain first began accelerating the aircraft down the runway: "Wait a minute, we do not have an ATC clearance." The captain did not admit an oversight but said, "No, I know that, go ahead ask." After the ATC clearance read back—which did not contain a clearance for takeoff—the captain again accelerated the aircraft. This time, the FO's statement was indirect and ambiguous: "We are, uh, taking off?" or "We are at takeoff." This was stated over the radio, and the study group felt it indicated surprise that the captain was beginning his takeoff and was a warning to everyone on the radio. The KLM engineer also suspected the aircraft had not been cleared for takeoff but said nothing. The Pan Am 747 remained in their path on the runway and the two aircraft collided. The captain was the Head of the KLM Flight Training Department, and the study group noted there is a subtle tension when upper management captains fly line trips. In addition, this same captain had just given the FO his qualification check on the 747 two months earlier. The ALPA determined there was a lack of communication between the captain and flight crew that restricted their use of the crew concept and led them to miss the opportunity to avoid the takeoff (pp. 17-19, 26).

A system approach was used by Weick (1991) to analyze the Tenerife collision. He investigated four specific processes, the interruption of important routines, the regression to familiar or habituated ways of responding, the breakdown of coordinated action, and, of most interest to this article, misunderstandings in what he calls speech-exchange systems. He found that stress actually increased the sense of hierarchies and formal authority in an organization, and that this was followed by centralization.

This centralization leads to constrained speech. In other words, even when a flight crew may truly communicate easily both up and down the chain of command, they will revert to a hierarchical flow of information from top to bottom as the stress of a situation increases. McReary, Pollard, Stevenson, and Wilson (1998) also reviewed this centralization hypothesis and matched the KLM communication patterns to organizational behavior studies on crisis decision making. They determined that, in addition to the communication becoming highly centralized, groupthink set in and criticism and dissent were postponed until the end of the crisis. Inexperienced participants in both observational behavior studies and the Tenerife collision were shut out of the centralized decision-making process (pp. 26-27).

The Air Florida 737 collision followed a conversation by the flight crew in which the FO three times indirectly tried to express his concern over the icy conditions. One example, "Boy...this is a losing battle here on trying to de-ice those things, it (gives) you a false feeling of security that's all that does (NTSB, 1982, p. 4)." Then on takeoff he indirectly tried to express his concern over an engine reading:

> FO: ...look at that thing, that don't seem right, does it?
> FO: ...that's not right...
> Captain: Yes, it is, there's 80.
> FO: Naw, I don't think that's right.
> FO: [Nine seconds later] ...maybe it is.
> FO: [Two seconds later] I don't know. (NTSB, 1982, p.5)

The plane stayed aloft only a short time before crashing into the Potomac River due to excessive snow and ice on the airplane and a frozen indicator which provided an incorrect engine power reading. The NTSB determined that the FO's comments were not assertive. In their words, "Had he been more assertive in stating his opinion that the takeoff should be rejected, the captain might have been prompted to take positive action" (NTSB, 1982, p. 68). In the report they cited their June 1979 Safety Recommendation A-79-47 which recommends the FAA to urge the aviation industry to provide participative management training for captains and assertiveness training for FOs and flight engineers (NTSB, 1979). This safety recommendation itself had been promulgated after two accidents involving poor cockpit communication in the 1970s. The NTSB warned that as of 1982 cockpit resource management was still not being used in training by most air carriers (NTSB, 1982, pp. 67-68; Kanki & Palmer, 1993, pp. 101-102).

Fischer and Orasanu (1997) proposed that one possible reason the Air Florida 737 collision FO's communications were unsuccessful was because he used indirect speech (p.624). They labeled his communication failures as monitoring/challenging errors as defined by the 1994 NTSB study, and further explained that these monitoring/challenging errors appeared to lead to plan continuation errors (Fischer & Orasanu, 2000).

COMMUNICATION – PILOTS' BACKGROUNDS

Swissair 111's captain began flying for recreation in 1966 at the age of 18. He joined the Swiss Air Force the following year and eventually became a fighter pilot. His career with Swissair started in July 1971 as a FO. He was promoted to captain in 1983. In June 1997, he completed his transition training on the MD-11 and also became an instructor pilot on the MD-11. The TSB's investigation found that the captain created a friendly and professional atmosphere in the cockpit and other pilots reported no tension in the cockpit when flying with him.

The FO was described as a partner in the cockpit. He had a quiet and calm demeanor, but was assertive when appropriate. The FO started flying in 1979, and, like the captain, became a Swiss Air Force pilot in 1982. He joined Swissair as an FO in 1991 and completed his MD-11 transition training in May 1998. The FO was also an MD-11 instructor. Both captain and FO had received the two-day, biennial human factors (crew resource management) training from Swissair (TSB, 2003a, pp. 6-7, 163.).

COMMUNICATION - DUMPING FUEL

William Carley, writing in the WSJ, believed there was a disagreement in the cockpit concerning the proper rate of descent: "While the cockpit-recording summary doesn't provide any evidence of an acrimonious argument, it does show the Swissair co-pilot repeatedly suggesting steps aimed at a quick landing, and the captain rejecting or ignoring those proposals" (Carley, 1999, p. B1). The evidence for his conclusion came from a preliminary summary of the CVR prepared by TSB investigators and leaked to the WSJ (hereafter referred to as WSJ/TSB Preliminary). Carley's belief was partially based on the FO's suggestion to dump fuel early so the aircraft would not be too heavy to land. Carley's belief was also based on an indication in the WSJ/TSB Preliminary that the co-pilot discussed heading directly to the airport rather than turning out sea to dump fuel. Finally, Carley's belief relied heavily on the captain's responses to the FO's suggestions and comments. The following two sections compare and contrast the WSJ/TSB Preliminary with the TSB's final report (NTSB, 2003a; hereafter referred to as TSB Final). These sections also place the Swissair 111 cockpit communication into some broad categories of linguistically-oriented aviation communication research

One of the most controversial moments in the flight came when the aircraft changed course away from Halifax and out to sea to dump fuel. The

TSB emphasized in the TSB Final that the pilots did not know, and could not have known, how far the problem had already developed.

The FO mentioned dumping fuel and asked the captain about his preference for when and where to do it. His statement/question fell into Brown and Levinson's (1998) negative politeness and Linde's (1998) mitigated and indirect communication. In Fischer and Orasanu's (2000) classification, this apparently was a strong hint followed by a permission request. While it appears the captain replied in the affirmative, it is unclear how the captain responded because stretching for an item, possibly a checklist or an approach chart, interrupted his response. It is clear he did not give any command such as "dump now" or "dump when we get closer to the airport" (TSB, 2003a, p. 187). Sexton and Helmreich (2003) concluded that higher performing captains use problem solving communication seven to eight times more than low performing captains. The captain here missed an opportunity to provide a problem solving communication, and in fact his response would fall into Foushee and Manos's (1981) category of response uncertainty which is more common for crews with higher errors.

The FO radioed to the ATC, "We must...dump some fuel. May we do that in this area during descent?" The ATC replied, "Are you able to take a turn back to the south or do you want to stay closer to the airport" (Aviation Safety Network, n.d.). It was the ATC's suggestion to turn back to sea, and it was appropriate based on regulations and his understanding of the situation in the aircraft. For ATCs, Swissair, and the aviation industry in general, the first choice for dumping is a designated area where potential damage to property or to people will be minimal. In the case of an emergency, fuel dumping can occur anytime and anywhere.

The WSJ/TSB Preliminary stated that when the FO asked the captain whether to turn south for dumping or to land the plane, the captain did not give any definite verbal answer (Carley, 1999). If this was the case, it would appear that the captain did not give a definite problem solving communication and instead gave an uncertain response. This was his second uncertain response. The TSB Final gave a different account, stating that the pilots decided turning south for fuel dumping would be appropriate given the current situation of their aircraft (TSB, 2003a, p. 187). The TSB Final indicated information sharing among the flight crew leading to a mutual decision. These are actually signs of a high performing crew. Unfortunately, the two differing accounts make it unclear whether the captain and FO actually disagreed on the proper course of action.

The FO radioed to the ATC, "Okay we are able for a left or right turn towards the south to dump." The ATC instructed him to turn to the left (Aviation Safety Network, n.d.). If the TSB Final was correct, and they both agreed on this course of action, at this point they had no greater understanding of the condition of their aircraft than when they first smelled an odor. Smoke may have been heavier in the cockpit. There was no smoke in the cabin. No systems had failed to this point. Landing heavy, to them at that moment in time, posed more of a threat to the passengers than the smoke that was appearing in their cockpit (TSB, 2003a, p. 232). The TSB, writing in the TSB Final, felt they acted appropriately if the aircraft had been facing an uncertain air conditioning problem. "Actions by the flight crew in preparing the aircraft for landing, including their decisions to have the passenger cabin readied for landing and to dump fuel, were consistent with being unaware that an on-board fire was propagating" (TSB, 2003a, p. 258).

COMMUNICATION – RATE OF DESCENT

There are three specific moments in the WSJ/TSB Preliminary dealing with the Swissair pilots' communication and the rate of descent. The first moment came at 10:16 when the ATC cleared the aircraft to 10,000 feet. When the FO told the captain they would descend to 10,000, the captain ordered the FO not to go too fast. Carley (1999) reported he apparently meant do not descend too fast. The second moment occurred at 10:20 after the ATC informed them that they were 30 nautical miles to the runway's threshold. The FO reduced the descent from 4,000 to 3,100 feet per minute, and Carley, based on his reading of the TSB Preliminary, thought the FO may have been heeding the captain's admonition not to descend too fast. The FO then told the captain he wanted to descend as fast as possible so they could land if the smoke became too dense. The third moment occurred around 10:22. At this time (10:21 according to the TSB Final), the FO informed the ATC of their decision to turn toward the south and away from the airport to dump fuel. The FO then told the captain that he would reduce speed if the captain agreed. He was apparently worried that the jet would get too far from the airport. It was here the captain told the FO that he was in the midst of a checklist and did not want to be interrupted so often. He told the FO to do what was appropriate (Carley, 1999).

The TSB Final provides some context to the first moment that suggests the captain had a different meaning than that reported in the WSJ/TSB Preliminary. Based on flight data recorder (FDR) data, the airspeed was changed from 292 knots to 310 knots between 10:17:16 and 10:18:20. At 10:17:38 (note the difference in time from Carley's account), the captain indicated to the FO that he should not descend too fast–an example of a problem solving communication. Based on the FDR data, the TSB Final interpreted this as referring to the airspeed being selected rather than to the aircraft's rate of descent. It is possible that a higher speed was momentarily selected and then adjusted to 310 knots (TSB, 2003a, p. 186).

Around the second moment, the rate of descent did reach 4,000 feet per minute and then was reduced to 3,500 by 10:19:28. However, the TSB Final does not mention that this was due to the captain's admonition. The TSB Final characterizes the exchange between the pilots at 10:20 as an agreement that a quick descent was warranted in case the smoke thickened (TSB, 2003a, p. 187). Notice the difference between the WSJ/TSB Preliminary and the TSB Final. The WSJ author, Carley, wrote that the FO stated he wanted to descend as fast as possible, presumably immediately, so they could land if the smoke became too dense. An FO stating this does not sound sheepish or intimidated to use Foushee's terms (Foushee, 1984). Fischer and Orasanu (2000) would consider this a very strong hint. If the captain continued in spite of the FO's comment, then the captain was committing a plan continuation error. He was sticking with the original plan instead of responding to information indicating a change was necessary. The TSB Final, on the other hand, reported they both agreed that a quick descent was appropriate in case the smoke thickened. Here again there are two conflicting versions. The TSB Final version indicates communication and agreement which are signs of a high performing crew.

As to the third moment, the TSB Final again provided context that changed the apparent intent of the speaker from that given in the WSJ/TSB Preliminary, in this case that of the FO. At 10:22, the plane was descending through 12,550 on its way to leveling off at 10,000 feet to dump fuel. At 10:22:37, the FDR recorded that the selected airspeed was changed from 320 to 249 knots. Regulations required reducing airspeed to a maximum of 250 knots when aircraft were at or below 10,000 feet. It was when the airspeed was decreasing through 306 knots at 10:23 that the FO asked the captain for his agreement to reduce the speed only slightly. The FO's question is an example of a confirmation seeking question (Fischer & Orasanu, 1997). He may have been concerned about flying too far away from the airport, but this is speculation without any other evidence. It is definitely known, as shown by data from the FDR, that he was reducing speed to comply with regulations. The TSB Final version of the captain's response was that he was proceeding with the checklist and that the FO could fly the plane as he thought best (TSB, 2003a, pp.187-188).

The captain's response at this moment could have intimidated the FO from providing further input or suggestions for the proper course of action. Depending on the captain's tone, demeanor, and words, his comments could have led to excessively obedient behavior on the part of the FO (Tarnow, 2000). In this case it is apparent that the captain's response was problematic no matter the version. If the WSJ/TSB Preliminary was accurate, then the captain was showing signs of anger or frustration (Foushee & Manos, 1981). If the TSB Final was accurate, then the earlier two-way communication, information sharing, and mutual agreement was giving way to hierarchies, formal authority, and centralization. All this leads to restricted speech which is not unexpected in stressful situations but is not conducive to problem solving (Weick, 1991). One minute later the autopilot failed due to the fire, multiple systems began to fail, and the situation deteriorated rapidly.

Reading the WSJ/TSB Preliminary and TSB Final versions of the three moments leads to different conclusions. The FDR data indicates different speaker intent for the first and third moments than that reported in the WSJ/TSB Preliminary. While a difference of opinion may have played a role in these two moments, there is no clear evidence to suggest this. There is evidence the moments were related to two specific aircraft actions: Increased airspeed in the first, and decreased airspeed as mandated by regulations in the third. The discussion between the pilots in the second moment is interpreted by the two sources in totally different ways. Carley, in the WSJ/TSB Preliminary, suggested that the FO told the captain he wanted to descend, presumably immediately, as fast as possible in case the smoke became too dense. The TSB Final reported the two agreed they should descend quickly in case the smoke thickened.

To begin deciding how to resolve these disparate versions, we can review yet a fourth moment in the flight mentioned in both the WSJ/TSB Preliminary and the TSB Final. At 10:18:17, between the first and second moments described above, the FO was given radio duties in addition to flying duties. The ATC cleared them to 3,000 feet, but the FO advised they would prefer descending to 8,000 feet while the cabin was prepared for landing (TSB, 2003a, p. 186). Neither the WSJ/TSB Preliminary nor the TSB Final mentions any disagreement between the captain and FO on this decision. Since this was in the midst of the other moments, one would reasonably expect the FO to hint or suggest to the pilot that a faster rate of descent might be in order.

Since research has found that FOs rarely use direct statements, even if the FO never said "we need to descend faster" this may have been on his mind. Carley was correct in pointing out that his references to the rate of descent—that is, his hints,—may have been an indication of his concern. However, the nature of suggestive statements also leaves them open to interpretation. If the WSJ/TSB Preliminary was correct, then this series of hints were similar to those given by the Air Florida 737 collision FO with one major exception. The WSJ/TSB Preliminary indicated that the FO told the captain he wanted to descend as fast as possible so they could land if the smoke became too dense. If he did this (the TSB Final does not mention this statement), then the FO made an extremely strong hint bordering on a direct communication and command-like statement that neither the Air Florida 737 collision nor the KLM 747 collision FOs attempted with their captains.

CONCLUSION

Foernsler (1996) was right. Multiple failures are extremely improbable considering the highly automated and redundant systems found in modern passenger aircraft. They do happen, however, as illustrated by Swissair 111. While the checklists did not play a role in the outcome of Swissair 111, conflicts did arise between two of the checklists. This, along with the placement of emergency descent considerations on the checklists, indicates why it is in the aviation industry's best interest to standardize and rationalize checklists and checklist procedures. As Foernsler concluded, combining and rationalizing checklists is inexpensive and easy. The cost/benefit analysis weighs heavily in favor of this process for both normal and non-normal checklists.

No matter the CVR version, some conclusions can be drawn concerning the captain's and FO's communication. While the FO was not sheepish or intimidated, his comments did fall into the negative politeness/mitigated/indirect category and he used hints, permission requests, and confirmation seeking questions which research has shown is common for FOs when addressing captains. If he did disagree with the captain, his best tool was strong hints which defined the problem or stated a specific goal for the captain. The captain was at his best when he used problem solving communication. He did give uncertain responses at critical moments. As stress increased at the very end of the flight so did the hierarchies, formal authority, and centralization. Centralization led to restricted speech which has the potential to cripple the crew concept and crew problem solving. It did not impact this flight since it happened so close to the end. The flight crew may have shown signs of anger and frustration at the end as well.

For public policy and public safety reasons I recommend the TSB release the Swissair 111 CVR and CVR transcript for psycholinguistic analysis by one or more of the aviation communication experts cited in this article. It should be done in a way to preserve the privacy of the pilots, but it should be done. Perhaps portions of the CVR could be released to the researchers with the understanding that the researcher's conclusions alone will become publicly available and not the CVR or CVR transcript. The TSB preliminary summary of the CVR transcript was paraphrased and formed the basis of a WSJ article, and the conclusions of the article were published in newspapers and magazines around the world. The TSB's Swissair 111 final aviation accident report from the TSB received much less press attention. There are major discrepancies between the two versions of the Swissair 111 cockpit communication. While simulator study is important, the Swissair CVR and CVR transcript provides a modern test bed for study of real-time aircraft emergency cockpit communication. Past cockpit communication research resulted in NTSB and FAA safety recommendations and improved pilot training. There is knowledge to be gained from the Swissair 111 CVR and CVR transcript. These should be placed in the hands of the experts to allow the extraction of this knowledge from the words and sentences that formed the final communications between the Swissair 111 captain and FO.

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PERCEPTION OF SAFETY, SAFETY VIOLATION AND IMPROVEMENT OF SAFETY IN AVIATION: FINDINGS OF A PILOT STUDY

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ABSTRACT

This pilot study explores perception of safety, reasons of safety violation, and improvement of safety in a defined population of a flight training facility. Employees took part in a facilitated focus group discussion and a mailed survey. They argued that considering the nature of aviation operations, safety could only be forecasted, not guaranteed. The findings indicate that safety is being violated for a variety of reasons including personal and financial gain. The study reported that accident and incident reporting structure, human resource management, organisational processes, and the role of the Civil Aviation Authority of New Zealand are some of the areas that require urgent attention to improve safety in the aviation industry.

INTRODUCTION

These days the term safety is used frequently in aviation. More importantly organisations in the aviation industry are gaining strategic advantage by creating a favourable image in the minds of the public that portrays them as genuinely caring about the safety of their employees and customers. This is done with the idea of safety at a reasonable cost and without a standardised definition of safety in the aviation setting. In many aspects the aviation industry resembles other high technology, high-risk industries such as the nuclear, oil and gas, and petrochemical industries, and

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therefore has similar concerns about safety. This similarity has influenced perception of safety in the aviation context.

The aviation system is composed of various levels, each differing in their perception of safety (Curtis, 2000; Swedavia & McGregor, 1988). This would mean that the definition of safety perceived at one level, might not be the same at another level. Lowrance (1976) tackled the confusion about the nature of safety by defining it "as a judgement of the acceptability of risk, and risk, in turn, as a measure of the probability and severity of harm to human health" (p. 8). In other words, anything is safe if its risks are judged to be acceptable. With this in mind and the premise that no man-made system can be absolutely safe, we can only talk about relative safety, and the understanding that simply because a flight is completed without an accident it does not mean that the flight was risk free and, therefore, safe (Profit, 1995, p. 16). Despite the unclear nature of the term, some concrete definitions are offered such as "freedom from risk or danger" (McAllister, 2001, p. 88) and "the act of keeping safe" (Profit, 1995, p. 16). Helmreich and Merritt (2001) think about safety as an abstract concept rather than a binary condition defined by safe and unsafe conditions. They suggested that it is a continuum that covers an array of conditions, practices and resources that are likely to vary from one place to another. Every organization attempts to operate as safely as resources and conditions permit. Further, it is speculated that the very definition of safety is culturally determined (Merritt, 1998). With this in mind, it is hypothesised that the perception of safety in the aviation environment in New Zealand would be unique.

Violation of safety in the aviation context is not uncommon. There are deliberate deviations from regulated codes or procedures (Reason, 1993). According to Reason, violations take place due to psychological precursors of unsafe acts, organisational deficiencies (line management decisions), corporate actions (senior management decisions), and inadequate defenses. There is a motivational basis for these that needs to be understood within the context of an organisation (Reason). Maurino, Reason, Johnston and Lee (1995) provide a framework to understand violations and define these as deviations, deliberate or erroneous, from safe operating practices, procedures, standards, or rules and classify them as skill-based level, rule-based level, and knowledge-based level. They describe that violations at the skill-based level form part of a person's repertoire of skilled actions and that such actions often involve corner cutting and are carried out routinely in an unresponsive environment. Violations at the rule-based level tend to be deliberate acts carried out in the belief that they will not result in bad consequences and that such violations are the outcome of cost-benefit trade-offs—with the benefits exceeding the costs. Finally, violations at the knowledge-based level occur as a result of actions taken to tackle an unexpected occurrence of a rare but trained-for situation, or an unlikely combination of individually familiar situation (pp. 16-21).

In Aviation safety report (CAA NZ, 2002) a violation is defined as "an unintentional but not necessarily malevolent behaviour that may or may not lead to a bad outcome." Some examples from the safety report are as follows:

1. The relatively inexperienced pilot did not perceive that the flock of seagulls posed a threat to his light aircraft and flew through them during the approach, rather than completing a go-around from 200 feet.
2. The check pilot signed off the first officer for an approach into an airfield after completion of only 5 of the 6 approaches required under their company regulations.
3. The visual flight rules (VFR)-only pilot frequently flew aircraft in instrument meteorological conditions (IMC) weather conditions knowing that company management was aware of and did not overtly object to this kind of behaviour.
4. The engineer adopted practices, which he considered normal and safe, but which provided evidence of a poor safety culture. The engineer placed unserviceable part on a shelf next to serviceable parts.
5. With the knowledge at hand that violations occur, due to a variety of reasons, the present study endeavours to find the motivational factors behind such behaviour in the aviation industry in New Zealand.

The aviation system incorporates various sub-systems such as aircraft maintenance, airports, aircraft manufacturers, and airspace management for safety. In addition, human factors and organisational factors are paramount in making the system safe and efficient. Invariably, accidents occur when pre-existing and long-standing hidden failures within managerial and organisational sectors are combined with local triggering conditions on the flight deck, in air traffic control centres and in maintenance facilities that penetrate or bypass the aviation system's multiple defenses (Reason, 1990). The International Civil Aviation Organisation (ICAO) at the global level and civil aviation authorities at state levels are finding innovative ways to improve safety in the industry in an on-going manner. For example, the United Kingdom Civil Aviation Authority (UK CAA) recognises the value of safety management systems to achieve high levels of safety performance (2002). Similarly, the Civil Aviation Authority of New Zealand (CAA NZ) has taken steps to enhance safety culture in the industry by identifying safety issues impacting the industry through safety forums (2003).

These forums identified 18 problematic areas in need of urgent attention to improve safety culture in the aviation industry in New Zealand. It is anticipated that although the issues raised in this study would be more relevant to a flight training facility, they also could guide further research in aviation safety overall. This pilot study was set in New Zealand. Given New Zealand's population size (about 4 million), its geographic isolation and terrain, available resources, and the fact that very little research has been carried out in this area, it was imperative to start with the basics. In other words, it was considered necessary to establish how those who work within the aviation industry perceive safety. Similarly, it was important to know why some employees violate safety and others do not. Finally, employees' knowledge was examined to explore strategies to improve safety in the industry.

The specific objectives of this pilot study are as follows:

1. To construct a definition of safety;
2. To establish reasons for safety violation and non-violation; and
3. To explore how safety in the aviation industry can be improved.

METHOD

Participants

A defined population within a flight-training organisation in New Zealand volunteered to take part in the study. All 36 staff, both management (managers/supervisors/examiners) and other staff (flight instructors, safety standards staff, maintenance staff, operations staff, and aviation specialist teaching staff) were sent the survey questionnaire. A total of 18 staff (50 percent) took part in the study by returning the completed questionnaire. Out of these, 4 respondents identified themselves as management staff and the remaining 14 as other staff. The background characteristics of participants are presented in Table 1, and the questions used to gather this information is presented in Appendix A.

All participants were invited to take part in a voluntary focus group. Eight staff—two management staff and six other staff—took part. It should be noted that all focus group participants were male and no other background characteristics were obtained from the focus group participants.

Materials and procedure

Data were collected in two phases: a focus group discussion and an anonymous survey. The author-led focus group discussion followed the tunnel approach (Morgan, 1997, p.65) where the discussion moved from general aspects of aviation safety to specific questions: a) how the term safety was conceptualised in the aviation environment and b) what factors contributes towards ensuring safety in aviation operations. The focus group discussion took place at the participating flight training centre, as it was not logistically possible to accommodate all of the participants at another location. Data were generated through group interaction while the author maintained the focus of the discussion (Morgan, 1997, p. 6).

Table 1. Background characteristics of respondents

	Number	*Percentage*
Role in Organization		
Manager/Senior Flight Instructors/Examiners	4	22
CATS A, B and C	9	50
Safety Standards Issues Staff	0	0
Maintenance Staff	2	11
Operations Staff	2	11
Other	1	6
Total	*18*	*100*
Age		
25 years or less	2	11
Between 26 and 35	6	33
Between 36 and 45	2	11
Between 46 and 55 years	5	28
56 years or more	3	17
Total	*18*	*100*
Gender		
Male	17	94
Female	1	6
Total	*18*	*100*
Formal Education		
Primary	0	0
Secondary	5	28
Technical/Trade	5	28
University Degree/Diploma (undergraduate)	6	33
Masters/PhD (postgraduate)	2	11
Total	*18*	*100*
Work experience in aviation industry		
Up to 5 years	4	22
Between 6 and 10 years	5	28
Between 11 and 15 years	1	6
Between 16 and 20 years	0	0
21 years and more	8	44
Total	*18*	*100*
Hours of work in organization		
Up to 35 hours/wee	0	0
Between 36 and 40 hours/week	7	39
Between 41 and 45 hours/wee	8	44
46 hours and more/week	3	17
Total	*18*	*100*
Type of Employment		
Permanent	15	83
Part time	2	11
Casual	1	6
Total	*18*	*100*

Although the most effective way of capturing group interaction is to audiotape the discussion (Morgan, 1997, p. 55), this was not an option due to aircraft noise in the background. Instead, the author, with the help of a volunteer and a whiteboard, made notes of the focus group discussion.

The second phase of data collection occurred through an anonymous survey. The survey questions, prompted by safety reports of the CAA NZ, endeavoured to determine reasons behind safety violation and seek suggestions for improvement of safety. These questions, not previously examined, were expected to generate information on probable causes of safety violation, and provide suggestions for improving safety. The questions are listed in Appendix B. Unfortunately due to the limited size of the sample, advanced level of statistical analysis could not be carried out to validate the questions. However, some cross-examination of responses was carried out to ascertain the validity of the survey questions. This aspect will be elaborated in the discussion section of the paper.

The notes from focus group discussion and responses to open-ended questions in the survey were organised into thematic categories.

RESULTS

Definition of safety

Focus group participants indicated that in the aviation environment safety could not be guaranteed, it can only be forecasted. Its assurance comes only when the operation is completed safely. Forecasted safety depends on the perceived capability of the safety delivery system in which operations are conducted safely. A safety delivery system incorporates all stakeholders who are responsible, directly and/or indirectly, for the safe completion of an operation. With this in mind, participants defined forecasted safety as a situation dependent upon the safety delivery system for a safe outcome.

For this to happen, certain vital conditions and organisational processes need to be present in the safety delivery system. Some examples of these are as follows:

1. Existence of a safety plan incorporating an effective and efficient safety management system;
2. Allocation of resources to effectively implement the plan;
3. Senior management to take interest in safety, own the safety plan and lead by example;
4. Active participation of staff in the safety plan both in principal and in the doing;
5. An effective reporting structure to deal with emerging safety issues;

6. Active participation of the regulator, the CAA NZ, in the industry to provide guidance and monitor safety;
7. Competent and safety-conscious staff; and
8. Safety-conscious culture in the organisation.

In sum, favourable organisational dynamics would enhance safety. In other words, if management is committed to safety and puts in place a well-resourced safety plan, implements the plan effectively, motivates staff, and upholds safety norms through leading by example, then the organisation is likely to achieve the forecasted safety. Furthermore, participants perceived forecasted safety as the outcome of a partnership—based predominantly on commitment to safety—between the various stakeholders such as employer and employees, suppliers and customers, and the regulatory authority.

Reasons for violation and non-violation of safety

In order to understand why some employees violate safety, it is important to know why others do not engage in this behaviour. Table 2 presents reasons for violation and non-violation of safety. Findings show an interesting comparison between motivational factors leading to violation and non-violation of safety. Violations appear to be due to deficiencies in training, skills, knowledge, experience, and organisational processes. These are also attitudinal.

Table 2. Reasons for violation and non-violation of safety

Some employees violate safety because...
Lack of knowledge and/or experience
Lack of knowledge of complexity of issues in the industry
Lack of flying experience
Lack of training and awareness
Lack of communication of verbal and written materials
Lack of safety courses and briefings
Poor management and supervision
Poor safety structure
Poor auditing
Anti-authoritarian attitude
Financial gains
"Gotta get there" attitude
Some employees do not violate safety because...
Inherent self-preservation
Responsible individuals
Professionalism
Fear of an accident, of "getting caught"
Professional, conscientious and dedicated to work at the highest possible standards
Personal pride and professionalism
Being safety conscious
CAA/FAA rules and regulations
Audits by CAA
Proper procedures for accountability of checks

It is interesting to note that individuals are perceived to violate safety for personal and/or financial gains as well. On the other hand, participants agreed that safety is not violated because of dedication and professionalism, auditing, monitoring, individual accountability, and the instinct for self-preservation. The findings are in-line with the motivational factors suggested by Reason (1993). Some violations may be skill-based or rule-based (Maurino et al., 1995). However, violation for personal and financial gain is a new finding.

Improvement of safety in aviation

Participants provided ample ideas to improve safety in aviation. These are presented in thematic categories.

Effective accident/incident reporting system.

A speedy, non-judgemental and non-punitive approach is required for reporting incidents and safety issues. This would cut down the lapsed time between occurrences and feedback, and encourage honest reporting. An anonymous reporting system would encourage everyone to report safety concerns without fear. For the reporting system to be effective, everyone needs to have the confidence that the reported concerns would be addressed.

Human resource management.

Job continuity and security is essential to developing a safe and viable general aviation industry. Management needs to take a keen interest in human resource issues in order to address constraints and limitations experienced by staff. For example, poor pay and a lack of career opportunities for general aviation flight instructors often create a situation wherein an instructor cannot afford to stay in the instructor's role after reaching an experience level acceptable to airlines. Consequently, the best instructors are lost. There is a need to praise and reward staff and provide opportunities for career development to improve motivation and morale and to lift achievement level. The airline industry needs to put something back in the general aviation sector to support the training of pilots. Thus, by producing better quality flying instructors—with more category B pilots with higher experience—this sector would be strengthened. Compulsory safety training for all certificate holders on a regular basis, and more training courses for flight safety officers are needed. Training in the safety culture throughout New Zealand, by the CAA NZ, would significantly enhance safety in the industry.

Effective organisational processes.

Management needs to communicate, in a non-threatening manner, to all staff all incidents and accidents and their outcomes. For example, having a summary of all incidents and accidents available in written form for the crew to review would keep everyone in the safety loop. Senior staff members needs to meet regularly to practice their skills to maintain currency without threat of reprisal or failure of test.

Role of CAA NZ.

The CAA NZ needs to arrange and/or sponsor industry seminars for instructor courses and make attendance compulsory at these events for renewal of ratings. For example, a team of instructors could be set-up to run such workshops around the country. The CAA NZ should carry out audits more frequently, but needs to keep its safety investigation reports separate from its infringement investigation reports. This is essential to remove the culture of fear currently operating in the industry. The cost of government charges for publications and tests is extremely high; this leads to operators having to use outdated publications and materials. Finally, the CAA NZ needs to be forceful and actively enforce standards and rules.

DISCUSSION

The findings of this study support the notion that safety is somewhat subjective and therefore difficult to conceptualise, as it varies in different environments (Helmreich & Merritt, 2001). The concept of forecasted safety depicts reliance on the capability of the safety delivery system for a safe outcome. This shows that safety is to be conceptualised within this framework. In other words, safety is not perceived to be an absolute phenomenon, but rather a calculated prediction based on one's confidence in the ability of the safety delivery system to ensure safety from beginning-to-end. It is therefore expected to vary across systems and organisations. The hypothesis that the perception of safety in the aviation industry in New Zealand would be unique appears to be confirmed. However, considering the size of the focus group, this definition needs to be further explored with a bigger sample within the New Zealand aviation industry.

Findings on violation of safety are somewhat similar to those indicated in the literature (Maurino et al., 1995; Reason, 1993). However, violation of safety due to poor attitude toward safety, and for personal and financial gains is new and somewhat of a concern. This may be the psychological precursors of unsafe acts (Reason, 1993). This aspect needs to be further explored as it may indicate intent of malaise. The intent may be attitudinal and quite often innocent, but could have serious implications for safety, as the aviation system works because of compliance of standards and regulatory procedures. This is not to say that some legitimate deviations are not allowed.

Participants' suggestions about improving safety in the industry have highlighted a number of deficiencies in the aviation system. Interestingly, these deficiencies have also been mentioned as reasons for violation of safety (see Table 2). Specifically these are organisational deficiencies such as poor communication, inadequate management and supervision, and poor safety culture. Furthermore, participants have highlighted some local triggering conditions such as lack of knowledge of complexity of issues in the industry and deficiency in flying training and experience among industry professionals. These may be the pre-existing conditions and long-standing failures in organisations waiting to penetrate or bypass the defense system (Reason, 1990). The issues raised by participants are also in-line with the problems identified in safety forums by CAA NZ (2003).

By cross-examining the responses to reasons of violation and non-violation and ways to improve safety, the survey questions can be validated against each other, and against reasons of safety violation established in the literature (Maurino et al., 1995) and those identified in the Safety Reports of the CAA NZ (2002). Unfortunately in this pilot study it was not possible to collect information on respondents' own reasons of violations and non-violations to make comparison with those identified in the study. While this step in the validation processes remains to be carried out, the survey questions have shown strength for identifying causes of safety violation and non-violation.

The findings of this study have indicated the need for further research in a number of areas. The subjective notion of forecasted safety is interesting. Violation of safety due to poor attitude toward safety and personal and financial gain is of concern. Strategies identified to improve safety in the aviation system appear to be valid and worthy of consideration. Finally, the questions asked in this preliminary study have received some intriguing responses. These require further exploration in order to validate the concerns raised.

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APPENDIX A

Questions used to gather background information of the participant

1.1 Role in organisation

- Managers/Senior Flight Instructors/Examiners ☐
- CAT A or B ☐
- CAT C ☐
- Safety Standards Issues Staff ☐
- Maintenance Staff ☐
- Operations Staff ☐
- Other ☐
- If other, please state ________________________________

1.2. Age

- 25 years or less ☐
- Between 26 and 35 years ☐
- Between 36 and 45 years ☐
- Between 46 years 55 years ☐
- 56 years or more ☐

1.3. Gender

- Male ☐
- Female ☐

1.4. Formal education details

- Primary ☐
- Secondary ☐
- Technical/Trade ☐
- University Degree/Diploma (undergraduate) ☐
- Masters/PhD (Postgraduate) ☐
- Other ☐
- If other, please state ________________________________

1.5. Work experience in aviation industry

- Up to 5 years ☐
- Between 6 and 10 year ☐
- Between 11 and 15 years ☐
- Between 16 and 20 years ☐
- 21 years and more ☐

1.6. Hours of work in organisation

- Up to 35 hours/week ☐
- Between 36 and 40 hours/week ☐
- Between 41 and 45 hours/week ☐
- 46 hours and more/week ☐

1.7. Type of employment

- Permanent ☐
- Part time ☐
- Casual ☐

APPENDIX B

Safety Culture Assessment Tool Questions

1. In your view violation of safety in aviation organisations takes place because:
2. In your view violation of safety in aviation organisations does not take place because:
3. It would help if you could describe the ways in which safety can be improved in aviation in New Zealand:
    3.1. In your own organisation:
    3.2. In general in New Zealand:
4. PLEASE NOTE: If you think I have missed some important points to assess safety culture in your organisation please add by using the space below.

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MEASURING THE IMPORTANCE OF RECENT AIRPORT SECURITY INTERVENTIONS

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ABSTRACT

Given the economic impact of airport delays, in particular the impact on business travelers and potential revenue from this source, it is imperative that authorities and regulators consider the outcomes and effectiveness of implementing security measures, such as armed pilots, secured cockpits, baggage matching, electronic scanning, passenger searches, and sniffer devices. Significant changes in security measures have been ongoing at major airports in the United States over the past year. Some of these changes represent knee-jerk reactions to 9/11. Other changes had long been planned for implementation as technology has advanced. This study queried flight crews and cabin crews to determine their perceptions about the relative importance of security measures. A survey was developed through a focus group of crew members whose work enabled them to observe and interact with security measures on a daily or regular basis. Results of the nearly 100 responses indicate some significant concerns about the importance of several security devices and measures.

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INTRODUCTION

In the late 1960s, attacks on commercial aviation increased significantly (Merari, 1999). In an effort to thwart these acts, a variety of security measures were instituted, including bomb detection and passenger screening. Merari argues that the best method to evaluate the effectiveness of these measures is to analyze the rate at which attacks are foiled. Over the past three decades, he found that the worldwide foil rate of terrorist hijackings has been less than 25%, suggesting limited success of the security measures that have been employed to date.

In the wake of the terrorist attacks on September 11, 2001, (9/11) considerable expenses and efforts have been expended to avert further attacks. Prior to 9/11, the response to an aircraft hijacking was to negotiate with the hijackers. It is now evident that this strategy is no longer feasible and that new measures must be adopted. Consequently, the United States Congress has become seriously involved in developing legislation to increase and support security at airports across the nation.

The problem concerns the consequences of security measures, namely, the extraordinary delays now impacting the efficiency of air travel and, to some extent, air cargo shipments. Significant changes in security measures have been developed at major airports. These recent measures include background checks of employees, stringent passenger screening, baggage matching and x-ray scrutiny, secure cockpits, and sky marshals.

The economic impact of these costly measures and the ensuing airport delays has resulted in significant loss of revenue for air carriers; thus it has become imperative to consider the importance of these new security measures.

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THE STUDY

The purpose of this study was to gather data about the relative importance of recent security measures. In order to ground the study, a focus group of airline pilot and cabin crew members was queried on their observations regarding the effectiveness of the security measures. Their input was deemed important since their work enables them to observe and interact with security measures and security personnel on a regular basis. From their feedback, a survey was developed. The survey used a five point Likert scale to determine subjects' perceptions concerning 16 security measures, with the addition of one open-ended item. It was distributed to a total of 120 volunteer pilot and cabin crew participants. Respondents represented three major and two regional air carriers throughout the United States. Three airline crew members assisted researchers with the distribution and collection of data, possibly accounting for the high survey return rate of 108 responses. The survey queried subjects about their perception regarding the relative importance of recent security measures.

Literature review

In the aftermath of 9/11 many new security systems and devices were proposed or implemented. While greater scrutiny is required, the question of which new methods are the most effective remains to be studied. Furthermore, enhanced airport security and implementation of the new technologies will cost billions of dollars and will drive up the cost of tickets and increase taxes (Ott, 2002; Tynan, 2002). Aviation security cost $400 million in 2001, and increased to $1.5 billion in 2002. For fiscal year 2003, Congress appropriated $4.8 billion to protect the U.S. aviation system, a 210% increase over the previous year's budget (United States Department of Transportation, n.d.). Assessing security is, therefore, of great concern.

Passenger and baggage screening

The federalization of security checkpoint personnel is now in place at airports throughout the United States (Anderson, 2002). By providing standardized training of higher paid personnel, it is believed that the quality of service will improve and weapon detection will be more consistent. Prior to entering the gate area, passengers must pass through metal detecting devices and subject their carry-on bags to examination through an x-ray machine (Anderson). Trace detection of explosives on carry-on bags can be achieved by use of a swab. Bunney (2001) states that immigration checks could be processed automatically, and that frequent fliers could expedite processing by providing detailed, personal information and their travel plans to the airline. According to Tynan (2002), this information could also be stored on an embedded chip on a Smart Card.

Biometric information is likely to be implemented in the near future to screen airline passengers (Tynan, 2002). Iris recognition and retinal scanning are the most accurate of the biometric measures. Fingerprints could be used to ensure that the person that checked in is the same person that boards the aircraft (Bunney, 2001). Finally, face recognition technology is under consideration, but the lack of accuracy could cause unacceptable delays. Currently, face recognition technology is only 80 to 90 percent accurate (Tynan).

More controversial is the notion of passenger profiling. As Karber (2002) states, profiling systems may be helpful, but there is a reluctance to implement them because of the political implications associated with singling out racial, ethnic, gender, or age groups in a free society.

Another vulnerability related to the current security system is checked baggage. The government expanded its program of matching checked baggage with the passenger manifest. This method would avert instances in which a terrorist slips an explosive device onto the airplane. It is clear, after 9/11, however, that terrorists are willing to give up their own lives for their cause. As a result, the federal government has mandated that, by the end of 2002, x-ray machines must scan all checked baggage in an effort to detect explosive devices (Ott, 2002). Trace detection equipment and bomb-sniffing dogs are also being utilized to detect explosive devices in checked bags (Ott). Among the benefits of utilizing the low-tech canine approach is the sensitivity of the dog's olfactory system, which minimizes the false positive rate associated with mechanical methods (Pups for Peace, 2002).

Facility and personnel security measures

Airport perimeter security procedures are now required at airports. These measures address concerns related to cargo, fencing, and surveillance (Anderson, 2002; Ott, 2002). The new laws mandate the implementation or enhancement of access controls to sensitive areas of the airport. Current technology in many airports requires the entry of a personal identification number for access to a secured area, but it is likely that biometrics may be installed in the near future (Anderson).

An increasing concern around the perimeters of the nation's airports is the threat posed by shoulder-mounted surface-to-air missiles. A recent attempt in Kenya failed due to a faulty weapon (U.S. Suspects Qaeda Link, 2002). Given the amount of open space around airports, and the vulnerability of airplanes during the take-off and landing phases, measures to secure these areas will likely be instituted.

New federal regulations require that all airline and airport employees undergo comprehensive background screening (Anderson, 2002). The fingerprints of all new employees will be sent to the FBI and background investigations will be conducted. In addition, workers employed prior to the implementation of this regulation are subject to the same type of background checks as new hires.

Securing the flight deck

A number of options to secure the aircraft are under consideration. Keeping passengers out of the cockpit is a primary goal and can be effected by reinforcing the cockpit door (Anderson, 2002; Karber, 2002). Karber contends that every flight should have onboard guards to protect the cockpit. Indeed, he argues that, U.S. air marshals should be on flights that originate from high-risk regions because the terrorist threat is international. He further suggests that any weapons supplied to the guards should provide limited lethality and only enough force to subdue the attackers. Recently, United Airlines and Mesa Airlines applied to the Transportation Security Administration for the authority to arm their pilots with less-than-lethal weapons (Airlines Push, 2003).

Dell (2001) contends that biometric technology can be utilized to gain access to the cockpit. Furthermore, this technology may also be used to control the airplane by working in conjunction with the autopilot. The pilot or co-pilot would be required to submit the biometric data every few minutes. Failing to do so would cause the airplane to engage the autopilot mode, which can be overridden only by a crew member's biometric input. While these technologies are not entirely fail-safe, the authors contend that biometrics technology could be used to enhance security. Finally, trial studies in iris scanning technology for aircraft access are currently underway (Bunney, 2001).

Human factors implications

Although new technologies have the potential to enhance the aviation security system, human element must not be ignored (North, 2002). Human error is inevitable, even in the best of circumstances. According to the Office of Technology Assessment (1992), the repetitive nature of security work, and the job of seeking rare events is prone to human error. Physical and/or mental errors may result in faulty judgment, decisions, communication, or perception. Furthermore, the design of the equipment could contribute to inaccuracies if they are not engineered with the human operator in mind. Consequently, the implementation of new technologies may exacerbate the incidence of security-related errors. In fact, reports of injuries to workers scanning checked baggage began shortly after the procedure was instituted (Nichols, 2003). The Transportation Security Administration has formed a committee to address the issue.

At the 33rd Session of the International Civil Aviation Organization (ICAO) General Assembly (n.d.), the International Transport Workers Association argued that security measures, following 9/11 require an approach that integrates technology and human factors. The lessons that have been learned from human factors research in transportation safety should be applied to the revised aviation security system (Francis, 2002; ICAO). Sources of stress, loss of concentration, distraction, and fatigue (Francis), and work volume and environment (ICAO), need to be addressed to improve worker performance. Finally, technical assistance, personnel licensing, improved communication skills, and whistle-blower protection could all contribute to the quality of security services (ICAO).

DATA ANALYSIS AND RESULTS

Survey responses

Survey responses produced some significant data about the importance of several security devices and measures. Responses totaled 108 airline employees, of which 57 were pilot crew and 51 cabin crew. The ratings were based on a 1-5 ordinal scale with 5 representing the most important security measure and 1 representing the least important security measure. The data was analyzed to determine the most and least important security measure for both pilot and cabin crews. Additional tests were run to determine significant response differences between flight crew members and cabin crew members.

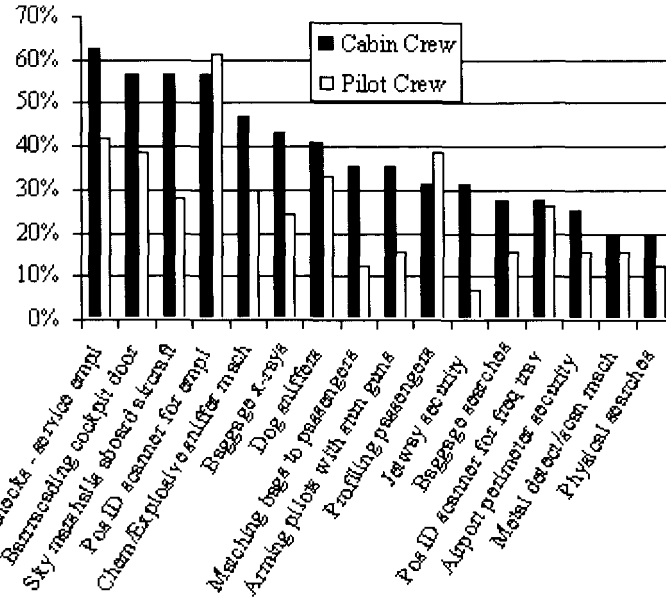
Figure 1 shows a comparison between the cabin and pilot crews of each group's perception of the importance of each security measure. Figure 2 shows the five most important security measures as rated by a combined pilot and cabin crew group.

Results of the statistical analyses indicated that the use of a "positive identification scanner for employees" received the highest combined score for importance (from both pilot and cabin crews). This result agrees with the current U.S. federal mandate.

Other items receiving high scores by pilot crews were "barricading cockpit doors and retrofitting bulkheads," "background checks of service personnel," and "profiling passengers." Cabin crews also favored "air marshals aboard aircraft" as an important security measure.

Of particular interest were those items perceived to be least important. These included "physical searches," "metal detection/scanning machinery," and "jet way security."

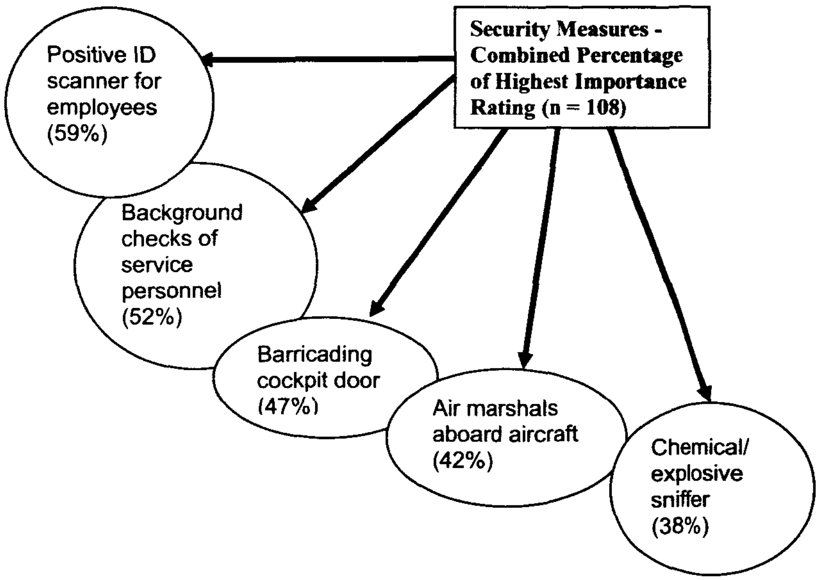
Figure 1. Percent of pilot crew and cabin crew member respondents who rated airport security measures as most important, 2002.



For the combined results in Figure 2, a frequency difference of approximately 8% between any two specific security measures results in a statistically significant difference using a two-sided t-test with unequal variances at the 5% significance level. For the purposes of this test, the data can be considered Bernoulli (responses being either "5" or not "5"). Using the same test for the pilot crew and cabin crew (see Figure 1), a frequency difference of approximately 10% between any two specific security measures results in a statistically significant difference.

Pilot crews rated "arming pilots" as another very important tool. This importance was indicated as a frequent write-in item (nearly 50% of the pilot crew respondents). As a conservative method of statistically analyzing the importance of this item, the 21 write-in responses were considered to have an importance rating of 5 and the other 36 pilot crew members were considered to have each given this item the average importance rating of all other items (3.59). Based on this method, the average importance rating for arming pilots is 4.17—thus ranking "arming pilots" second only to "positive ID scanners for employees" in importance as rated by the pilot crew members. It could easily be argued that "arming pilots" is the highest rated security measure.

Figure 2. Airport security measures rated as most important by pilot and cabin crew member respondents, 2002.



Differences in response between pilot crew members and cabin crew members

An analysis of variance was performed to determine differences in variation between the cabin crew member and pilot crew member groups. An F-test was performed at the 5% level and the only security measure having a significant difference was "profiling passengers." Based on this result, a two-sided t-test was performed on this item assuming unequal variances and a 5% significance level. The pilot crew members' average rank for "profiling passengers" was statistically higher than the cabin crew members' average rank.

All security measures other than "profiling passengers" were statistically analyzed using a two-sided t-test with equal variances. Statistically significant average importance ratings are shown on Table 1. A Wilcoxon signed rank test was also performed as a distribution-free alternative test that does not depend on an approximate normality assumption. This test produced the same statistically significant results at the 5% level.

Table 1. Differences in the average ratings of importance of security measures, for cabin crew and pilot crew member groups, 2002

	Average Rating**	
	Cabin Crew	Pilot Crew
Positive identification scanner for employees	4.27	4.32
Background checks of service personnel	4.33	4.07
Profiling passengers	**3.43***	**4.05***
Barricading cockpit door and retrofitting bulkheads	**4.39***	**4.02***
Dog sniffers	3.98	3.98
Chemical/ explosive sniffer machinery	4.08	3.91
Air marshals aboard aircraft	**4.29***	**3.70***
Positive identification scanner for frequent travelers	3.37	3.54
Baggage x-rays	**4.06***	**3.51***
Baggage searches	3.69	3.37
Matching bags to passengers	**3.90***	**3.35***
Metal detection/scanning machinery	3.63	3.32
Airport perimeter security	3.57	3.32
Physical searches	3.33	3.12
Jet way security	**3.63***	**2.82***
Arming pilots with stun guns	**3.53***	**2.81***

* = statistically significant at the 5% level
** 1 = least important security measure; 5 = most important security measure

DISCUSSION

Most important measures

The use of "positive identification scanners for employees" was considered the most important security measure by cabin and flight crews combined. Biometric technology is currently available to provide such scanners. Whether it is economically feasible to use biometrics and whether or not there are associated human factors issues remains a question.

The positive write-in response of "arming pilots" and the rejection of "arming pilots with stun guns" option concur with the recent support by pilot unions for the establishment of an Armed Pilots Program and the rejection of less-than-lethal weapons. A poll taken by the Air Line Pilots' Association indicated that 73% of its members favor authorizing pilots to carry firearms (Scott, 2002).

Another measure considered important was "barricading cockpit doors and retrofitting bulkheads." Evidence indicates that this measure has generally been accomplished by most airlines.

"Background checks of service personnel" were thought to be a relatively important security measure. Despite the huge costs associated with this effort, thousands of airport employees are being screened.

Having "air marshals aboard aircraft" has long been thought to be an important means of enhancing security and this study confirms that they continue to be perceived as important. Recently, security guards on Israel's national airline El Al overpowered a man who tried to hijack a flight from Tel Aviv to Istanbul (Attempts, 2002). Incidents such as these confirm the importance of air marshals as a security measure.

Unlike cabin crews, pilot crews strongly favored "passenger profiling." This is surprising since cabin crews interact with passengers over longer periods of time than do pilot crews.

Least important measures

Since "physical searches" and "arming pilots with stun guns" were rated the least important security measures, these measures seem to warrant further research. Multiple searches of passengers and carry-on bags causing delays both at checkpoints and again at passenger loading points, as well as, electronic scanning of all baggage has proved to be primarily responsible for the extraordinary delays that are currently impacting the efficiency of air travel.

CONCLUSION

A number of agencies in the United States, namely, the Department of Transportation, the Federal Aviation Administration and the Transportation Security Administration (TSA) are tasked with the job of meeting security challenges in a speedy and effective manner. Although these agencies have made considerable strides in meeting deadlines imposed by security legislation, our airports are still embarrassed by security lapses and failures. It is unlikely that the process of security will ever become faultless in spite of the more than 100,000 proposed employees of the TSA. All our best efforts are unlikely to produce an error-free security system. This is because security at airports is highly dependent on human behavior and the inevitability of human error. The goal then is to manage error so as to avoid adverse consequences. Aviation human factors specialists have developed powerful tools to address aviation errors. Security experts can learn from these resources. One of the lessons to be learned is to gather input from those on the scene and develop data to help address security decisions.

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COMBATING AIR TERRORISM: SOME IMPLICATIONS TO THE AVIATION INDUSTRY

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ABSTRACT

The entire world uses and relies on aviation for leisure and business travel. Aircraft are also relied on to transport millions of tons of cargo every day. Without airlines, the world would come to a grinding halt. Aviation security concerns all unlawful acts connected with civil air transport. The attacks of September 11, 2001, on the United States have caused harm in almost every imaginable area including personal lives, economy and the aviation industry. Airlines were already beginning to experience the effect of a weak economy when the tragic events of 9/11 took place. This paper provides a perspective on the current status of the aviation industry including airlines, airports and passengers. It also sheds some light on the debate of funding aviation security and its implications on the aviation industry.

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INTRODUCTION

Although there is no internationally established definition for terrorism, Dr. Charters at the University of New Brunswick suggests that "terrorism is a violent process of social change involving the premeditated use of criminal techniques by agents of a state or a clandestine political organization to achieve political ends" (Wallis, 1993, p. 1). The expression aviation security concerns all unlawful acts connected with civil air transport. The unlawful acts and the actual number of causalities are less significant than the threat that anyone who uses air transport could become a casualty. It is important to realize that air transport is not the real target of terrorism. The targets are enemy countries and their governments, upon which the terrorists want to enforce a change in their politics. The terrorist can choose the time and place for the attack. The aircraft itself may be worth several hundred million dollars. The unlawful act will become a central theme of the news of all television and radio stations of the world, and the terrorist will get the required publicity.

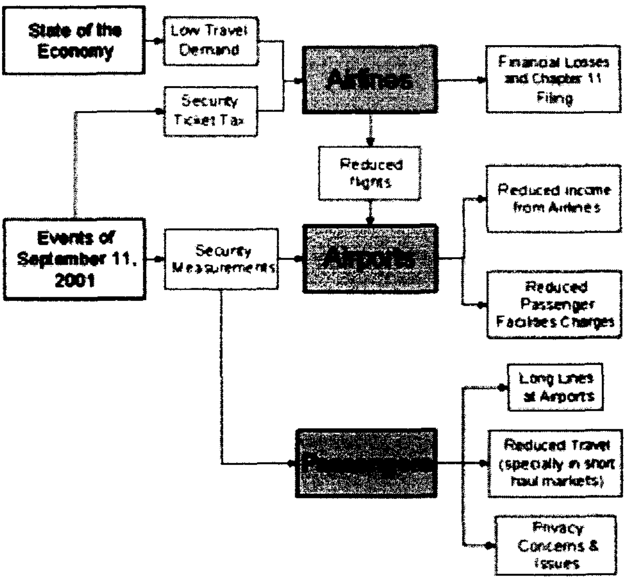
The attacks of September 11, 2001, on the United States (9/11) were intended to cause harm in several ways: fatalities and casualties among innocent, disturbance of the air transport system, and negative economic impacts. Aviation plays an important role in the economic prosperity of the U.S.: it links communities and countries together for business and leisure travelers, is a means for shipping goods, and it employs millions of Americans.

Unfortunately, the aviation industry was already in a difficult condition before 9/11. Many airlines have recently faced bankruptcy and almost all reported net losses in the billions. Layoffs have become a means to reduce the operating costs of airlines. High fuel prices, rising insurance costs, and the added costs of ensuring security have all contributed to the troubled condition of the aviation industry.

The paper provides a perspective on the current status of the aviation industry including airlines, airports and passengers. It also sheds some light on the debate of funding aviation security and its implications on the aviation industry.

The approach used in this study follows a conceptual qualitative model to assess the effects of 9/11 on the aviation system. We attempt to assess these impacts on airlines in terms of reduced travel demand and the addition of security ticket taxes. Increased ticket taxes along with low travel demand due to the state of the economy and fear of travel resulted in severe losses for airlines. Airlines then had to reduce capacity at almost all airports. Reduced airline operations triggered similar effects to airports that suffered reduced income from airlines and reduced income from passengers in terms of passenger facilities charges (PFCs). Imposing security measures at airports resulted in long and unpredicted passenger queues and delays. Sharing passenger data with federal agencies has received criticism from many individuals and groups. Figure 1 depicts the flow of the impacts of 9/11 on airlines, airports and passengers.

Figure 1. A conceptual model of the effects of 9/11 on the aviation industry



THE AIRLINES

Deregulation of the aviation industry in 1978 has made significant changes in the structure and management strategies of U.S. airlines. An airline's survivability depends on the revenue generated mostly from passengers and shippers, and also on the cost structure of the airline. In addition, airline business is highly responsive to the ever-changing cycles of economy. In good times, profits can be met with ease, and during the down cycles those profits can be gobbled up at exponential rates. The aviation industry is perhaps the first to feel the negative affects of a weak economy, and could be the last to feel the positive affects of a rising economy. Airlines compete with each other in terms of the quality of services offered to passengers, while at the same time try to manage costs that are often uncontrollable.

Following 9/11, the federal government created the Transportation Security Administration (TSA). With respect to aviation, the agency would centralize aviation security and create policies to prevent future threats and attacks. This could increase passengers' confidence in air travel and reassure them that the government is in charge of aviation security on a national level. It can be argued that the downturn in air travel had started before 9/11. The added security measures and expenses have only escalated the inevitable.

A number of the major U.S. airlines have faced bankruptcy, and almost all airlines have had serious losses. Delta Air Lines has reported a loss of $466 million in the first quarter of 2002—its largest loss since the months immediately after 9/11. In addition to increased security costs, airlines attribute the losses to the fact that operations used more cash than was generated because of high fuel prices and the slump in demand leading up to the war in Iraq (Grantham, 2003).

A significant concern for airlines is the substantial increase in liability insurance since 9/11. Pre-9/11, terrorism insurance was merely included into a normal airline insurance policy for little-to-no cost. Post-9/11, the premium for insurance protection from terrorism rose from about $2 million annually to $150 million annually. These additional costs could continue to rise as concerns of subsequent attacks still loom and as the U.S. continues to fight terrorism (Brelis, 2002).

The new security tax imposed by the federal government has added a financial burden on the airlines. A tax of $2.50 per segment was initially thought to be passed onto passengers. However, the decline in demand for air travel forced airlines to reduce airfares to encourage air travel after 9/11. It seems that airlines do not have pricing power. Leo Mullin, CEO of Delta, has stated that $52 of a $200 ticket is tax, which represents a 15% increase in the past five years (Field, 2002). The amount is significant since consumers, at the present time, are conscientious when they purchase tickets. Given that the demand for travel is elastic to price, airlines and airports are concerned that the additional taxes will result in fewer trips by passengers. In this high capacity and low demand environment, airline customers do not have to accept price increases, and they do not (Delta Air Lines Website, 2002).

AirTran Airways was among the very few airlines that showed small profits in 2002 rather than huge losses. AirTran is also concerned that increases in the security fees could impact small discount-airlines. Taxes already account for a high proportion of the lower-priced tickets, sometimes up to $42 of a $100 fare (Pickel, 2002). A spokesman for Continental Airlines stated that any new fees would further jeopardize the industry along with thousands of jobs (Alexander, 2002).

Another factor that has impacted the aviation industry is the availability of purchasing tickets on the Internet. Internet ticket sales accounted for more than 20% of U.S. aviation industry revenues for the first time in the third quarter of 2002. The ability to sell tickets online through airline and third-party websites permitted airlines to shed some $3 billion in costs over a period of four years ending in 2002. However, it is argued that the pricing transparency inherent to the Internet may cost carriers more in lost average fare than it otherwise saves in distribution expenses.

Airlines are also facing higher landing fees and PFCs as they struggle to reduce their costs and attract customers through discounted airfares. Examples of airports that have significantly increased landing fees include Raleigh-Durham, North Carolina and Lehigh Valley, Pennsylvania. These airports have increased their fees by 30-40% since September 2002. Other airports in the U.S. have either raised their rates or are considering it (Field, 2002). Airlines are facing the costs of airport modifications to improve security. From the airport perspective, funds for security modifications could either be provided by the government, or by raising the fees they charge airlines, even though the aviation industry is in no state to absorb extra costs (Larson, 2002). If airports continue to delay exiting capacity expansion projects due to lack of funds, infrastructure constraints would limit the comeback of the aviation industry when conditions for air travel improve. This will particularly be apparent when airlines start bringing some relatively large aircraft back into markets where smaller and medium-size aircraft are being used (Airport modification, 2002; Larson, 2002).

Another lost source of potential revenue to airlines is federal marshals who are taking up first-class seats that could otherwise be sold at premium prices. Federal Air Marshals (FAMs) have guarded more flights in the first two months of 2003 than they did during their entire career before 9/11. The agency currently has several thousand FAMs guarding the majority of the long-haul and international flights. The agency targets approximately 6,000 of the 23,000 daily flights in the U.S. (Airport security report, 2003).

Given the general state of the economy, airlines have realized that the alternative of passing these additional costs onto consumers is not feasible. In the past, airlines could transfer additional costs onto their best customers, that is, business travelers who are time sensitive and less price elastic than leisure travelers. That business segment of the market generated 37% of the airline revenue in 1998, and by June 2002, it only constituted 20%.

While some travel experts argue that the business segment will regenerate when the threat of terrorism subsides and the economy rebounds, others argue that the business travel segment has witnessed some significant changes that are likely to last, and that airlines will need to adjust their marketing and operational strategies accordingly. For example, many business organizations have instituted new travel policies, such as encouraging employees to book travel 14 or 21 days in advance and to use low-cost carriers. Some experts believe that these patterns will continue to persist even when the general conditions of the economy improve (Wieffering, 2003).

With new threats of bankruptcies, and appeals for labor concessions and government assistance, the nation's major airlines are facing a crisis that may well spell the end for one or more carrier in the next few years, according to industry executives and experts. First is the growing competition from low-cost, low-fare carriers that is unlike any competitive threat seen by the industry before. Carriers such as Southwest Airlines, JetBlue and ATA have grown so fast and so large they have limited the ability of the network carriers to raise fares to stem losses, even with a record high percentage of seats being filled on aircraft in 2003. A second factor is the prolonged period of losses. None of the big carriers other than Continental has posted a quarterly profit since 2000. Nor are any of them expected to be profitable this year, and only half are expected to have a profitable 2005. During the recent downturn, the legacy carriers have gradually used up their financial cushion of aircraft and other assets they can borrow against, (Airline industry, 2003)

Another revenue sources for airlines that has been impacted by security considerations is the transportation of time sensitive cargo. Before 9/11, airlines were able to carry both passengers and time sensitive cargo on the same flight. This was particularly important on routes with thin passenger traffic, where the revenue from transporting cargo subsidized that from passengers. Following 9/11, the FAA enforced a measure prohibiting passenger airlines from transporting mail weighing more than 16 ounces. To comprehend the magnitude of this measure on airline revenue, we use Delta Air Lines as an example. Before implementing that security measure, mail weighing in excess of 16 ounces constituted approximately 50% of cargo revenue for Delta. Delta's 2002 Annual Report shows that its revenue from cargo operations declined by 9 percent to $458 millions (Delta Air Lines, 2003, p.15). A study by the U.S. General Accounting Office found that on the average, the hull of passenger planes is typically half-full with cargo (U.S. GAO, 2002, December).

U.S. air carriers carry billions of tons of cargo each year in both passenger and all-cargo planes. Because of the magnitude of the volume of air cargo carried, vulnerabilities in the system could potentially threaten the entire air carrier system. Tampering could occur at various handoff points where cargo leaves a shipper's place to the point that it is loaded onto aircraft, (U.S. GAO, December, 2002). The federal government, along with industry groups and security experts identified measures to improve air cargo security. Examples of these measures include checking the identity of individuals making air cargo deliveries to implementing a computerized cargo profiling system. On March 13, 2003, the Senate Committee on Commerce, Science and Transportation approved the Air Cargo Security Act (U.S. Senate, 2003). The Act would, among other things, require the TSA to develop a strategic plan to ensure that all air cargo is screened, inspected, or otherwise made secure. The TSA would also be required to develop a system for the regular inspection of air cargo shipping facilities. The Act also requires the development of a database that contains information on known shippers, and ensures that air carriers and third-party carries could have their certificates revoked if they do not adhere to security laws or regulations. In November 2003, TSA announced that it would require passenger and freight airlines to inspect air cargo randomly and that non-U.S. all-cargo carriers transporting goods into and out of the U.S would also comply with the same security procedures. But TSA will not require 100% physical screening of air cargo because it is impractical" given technological and infrastructure limitations (Airlines ordered, 2003).

Although the dark clouds that have hung over the U.S. aviation industry since the 9/11 are starting to fade, airline executives are not yet seeing sunny skies ahead. Speaking at an analyst conference in New York on June 10, 2003, several airline executives said they were still hesitant to predict that the industry, which spiraled into an unprecedented financial crisis after 9/11, has turned a corner. However, the end of the war in Iraq and abating fears about Severe Acute Respiratory Syndrome (SARS) are good signs for airlines. A number of airlines are starting to see a modest increase in traffic, except on Pacific routes where SARS is, to some extent, still denting demand.

Carriers are hoping that the start of the summer travel season will help drive revenue higher. The injection of cash from a federal government aid package to help airlines offset security costs could also help airlines financially. Declines in fuel prices would also be a factor in airlines' recovery, whose second largest expense behind labor is jet fuel. For example, Delta Air Lines reported net income of $180 million in the second quarter of 2003, substantially improved compared to a loss of $189 million a year previously. The apparent turnaround, however, was due entirely to special items including a $251 million net gain from federal security rebates and a $176 million after-tax gain from the sale of Delta's stake in the Worldspan Global Distribution System. If special items are excluded from both periods, the carrier's loss actually widened to $237 millions (Government aid, 2003). Likewise, Continental Airlines returned to profit in the second quarter, earning $79 million compared to a loss of $139 million a year previously. Continental received $176 millions in pre-tax security rebates (Continental leads, 2003).

Still, the leaders of many carriers expressed similar caution in painting a picture of their future business. US Airways Chief Executive David Siegel believes that any recovery in the next 12 to 18 months is likely to be modest, and that no meaningful recovery will take place before 2005. Continental Airlines Chief Executive Gordon Bethune highlighted his company's effort to slash costs by $500 million in 2004. Delta CEO Leo Mullin believes that, while the worst is over for the industry, it still faces another tough year. He argues that removing the national security burden from the airlines is crucial not only to the aviation industry, but to millions of people, businesses, and organizations that depend on a secure, healthy, and efficient air transportation system (Airline executives, 2003)

THE AIRPORTS

U.S. airlines are not the only segment of the aviation industry that has been impacted by the events of 9/11. In the past, airports were concerned with the pressure arising from passenger complaints and the political pressures stretching from city halls to Capital Hill. A new source of pressure has emerged in the wake of 9/11. It came in the shape of the TSA. Airports are facing additional costs they never thought they would have to deal with (Field, 2002). The Inspector General for the U.S. Department of Transportation (DOT) estimated that airports would be liable for about $2.3 billion in construction costs to accommodate the new explosive detection devices. The devices were mandated to be installed by the first of the year 2003. The costs of purchasing and installing the machines are significant, especially that older airports have limited space to accommodate the devices. These airports include the three major hub-and-spoke airports in the U.S., namely, Chicago, Atlanta, and Los Angles. Some airport analysts believe that the estimated cost of $2.3 billion is probably low. They argue that airport parking garages will need to be rebuilt, rental car facilities relocated and considerable concession spaces removed. All of these assets represent key revenue sources for airports (Field, 2002).

Although many in the aviation industry believe that funding security projects has become even more important in the aftermath of 9/11, they also recognize the need to continue funding other airport development projects, such as those designed to enhance capacity in the national airport system. During fiscal year 2002, the Federal Aviation Administration (FAA) awarded a total of $561 million, 17% of the $3.3 billion available for grants, in the Airport Improvement Program (AIP) funds to airports for security projects related to 9/11. This amount is the largest amount awarded to airports for security projects in a single year since the program began in 1982, (U.S. GAO, 2002, October).

The financial problems at airports have been compounded further as airlines eliminated flights in low-yield markets. Airports are thus receiving less user fees, and will resort to increasing fees to airlines, which in turn will impact the demand for air travel. It is estimated that airport user fees have dropped by 19% (Field, 2002).

Pre-9/11, airports were challenged to make travelers comfortable by providing spacious seating and to accommodate the needs of special populations–that is, travelers with special needs. Post-9/11, airports are also concerned with controlling the long passenger lines in the terminal as cost efficiently as possible. The TSA has been looking at some queuing management mechanisms and seeking assistance from industries dealing with crowds, such as Walt Disney, to design systems for faster processing and access to boarding gates (Field, 2002).

Despite decreases in the revenue from most airport operations, revenue from concessions at most airport has risen. This is due to passengers having to spend more time at the airport and because of food service being eliminated from most domestic airline flights.

THE PASSENGERS

The most immediate impacts of the new security measures on passengers are the increased taxes on airline tickets. Given the state of the economy, the demand for travel is weak. The problems are compounded further by increased taxes on tickets that could increase the total airfare by 25 to 40 percent. Because leisure travel is price-dependent, the demand for air travel has suffered considerably. Also, some passengers have chosen other means of travel in fear of repeated attacks similar to 9/11. Business travel also has declined given the general state of the economy and the need to find alternate means to flying large air carriers. Many business travelers have chosen to fly discounted, no-frills carriers. Others changed their travel behavior by purchasing advanced tickets. These shifts in passenger behaviors along with the low-cost structure of a few airlines, such as Southwest and AirTran, have resulted in some positive net earnings for these carriers in 2002. Other large carriers have reported massive losses in the same year.

Prior to increased security procedures, passengers could arrive at the airport approximately 30 minutes before a flight and still be able to check-in and be at the gate in time for departure. Passengers now have to allow ample time for the long lines at check-in counters and at security check points before boarding. This is sometimes referred to as the hassle factor. Increases in security could continue to cause delays and inconveniences for travelers and for airport operators. During holidays and summer periods, airports will have to reduce sophisticated electronic screening and resort to less sophisticated screening to avoid causing operational delays. The problem is a prime example of the difficulties that are faced by the TSA and airports when attempting to balance security and efficiency (Airport Security Report, 2003). On the positive side, lines are now relatively shorter as airlines have implemented kiosk machines for self-service check-in of passengers holding electronic tickets. It is still inconvenient and worrisome for passengers as to how early they should be at the airport to avoid missing their flights. It is expected that U.S. air carriers will carry 65 million passengers each month during summer 2004, a 12% increase from the year before. Federal officials will closely monitor 25 of the busiest U.S. airports in the summer of 2004 and send in extra help if security delays arise as part of a plan to minimize waits for travelers (TSA unveils, 2003)

As passengers face the possibilities of increased ticket prices, they must also prepare themselves to be searched before boarding the aircraft. Some passengers have abandoned air travel all together or have cut back on flying due to the hassle factor. Many travelers who would have normally chosen a one-hour flight over a four- or five-hour drive would now rather drive. This new pattern is impacting the demand for air travel, especially in short-haul markets.

In addition to the physical searches, air travelers must become more accustomed to extensive and sometimes intrusive searches. The new security measures have implied some privacy risk for passengers. In January 2003, the TSA (2003) published a Federal Register notice announcing the Aviation Security Screening Records (ASSR) database. The Federal Register notice described a system that would allow government access to financial and transactional data as well as virtually unlimited amounts and types of data from other proprietary and public sources. TSA also indicated that many private and public entities might gain access to the personal information used in the ASSR database. Yet the notice did not provide information about how passengers can challenge their score or otherwise seek redress for their treatment at airports if they think it is based on inaccurate information. Over 100 individuals and organizations filed comments on the ASSR database that were almost universally critical of the program (Air travel policy, 2003).

Following the announcement of ASSR, the TSA announced the deployment of the second-generation airline passenger profiling system known as CAPPS II (Computer Assisted Passenger Prescreening System). CAPPS II would attempt to assess the security risk of every single airline passenger based on commercial and government data. The program would gather four pieces of information about each passenger from the airlines: full name, home address, home phone number and date of birth. That information would then be checked against credit header information and other data held by various data aggregators—private corporations that maintain files on the commercial activities of most American citizens—in an effort to verify the traveler's identity. However, credit header information can be inaccurate, and thieves can easily sidestep the identity check by presenting a false driver's license or passport, undercutting the system's entire mission.

After attempting to verify identity, CAPPS II would conduct a check against government databases (including intelligence and law enforcement databases) to assign a risk assessment score to each passenger: green for minimal, yellow to spark heightened security procedures, and red for those judged to pose an acute danger and would be referred to law enforcement. Although TSA does not plan to retain data on individuals, CAPPS II puts the riskiest element of the program—the determination of risk and the construction of rules for conducting background checks—into the realm of the more secretive intelligence and law enforcement programs and databases. TSA plans to develop some mechanism for individuals to request a re-evaluation of their color code. However, it appears that CAPPS II is rooted in the secretive box of law enforcement and intelligence data which itself could include data mined from innocent people's commercial information (Alexander, 2003). The TSA claims that the purpose of the new security measures is to identify suspicious and high-risk travelers, while ensuring that most passengers are not inconvenienced by heightened security. The CAPPS II test project was initiated by Delta Air Lines at some selected airports, and the TSA expects that all of the nation's airlines will be using the system by 2004 (Alexander, 2003).

A study by the Reason Foundation (Poole & Passantino, 2003) calls for immediate creation and testing of a Registered Traveler Program and urges the TSA to adopt a risk-based approach to passenger and baggage screening that does not include the invasive privacy violations and data-mining used in CAPPS II. In order to improve security while also reducing the hassle factor, the Foundation's risk-based model separates passengers and their luggage into three categories: low-risk registered travelers, medium-risk travelers and high-risk travelers. Low-risk travelers would be part of a voluntary Registered Traveler program wherein passengers could choose to undergo in-depth background investigations in exchange for shorter security checkpoint lines. Registered travelers who voluntarily and successfully complete the investigation process would be issued biometric security cards to confirm their identities before proceeding to the security checkpoint. To alleviate personal privacy concerns, TSA would make the ultimate security clearance decisions but a private company interfacing with TSA and the airlines would operate the program. EDS, a U.S. company, operates a similar program at Israel's Ben Gurion Airport. The report also recommends restructuring the current baggage screening process and implementing a system similar to those found at most European airports. Checked bags would be processed through high-speed x-ray machines first, with those that cleared the system being forwarded for loading. If a bag triggered an alarm, it would be forwarded, along with all bags from high-risk passengers, to an explosive detection scanner for detailed inspection. If the explosive detection machine flagged the bag, it would be inspected manually, preferably with the owner present (Poole & Passantino, 2003).

In response to comments received from persons and groups concerned about privacy, the DOT explained how the TSA will manage information assessed by the second-generation CAPPS II. It will be a government-run system that replaces CAPPS I, which was administered by the airlines under federal guidelines. The new system, when active, will use routine information that individuals will provide when making reservations to confirm a traveler's identity and assess a risk level (DOT makes changes, 2003)

It should be noted that The European Union has agreed to share information about its airline passengers with the U. S., in a deal announced on December 16, 2003. The deal ends year-long negotiations over a new U.S. law intended to fight terrorism. International airlines will turn over data about their U.S.-bound passengers, such as a traveler's name, e-mail address, telephone number and credit card number to the U.S. Department of Homeland Security's (DHS) Customs and Border Protection unit. The U.S. agency will then screen the traveler data and use it for terrorist investigations and other international probes into crimes such as drug trafficking and money laundering (Goo, 2003, December). In January 2004, major U.S. airlines agreed to work with the Homeland Security Department on ways to protect travel privacy, as the government seeks to use passenger information to keep terrorists off planes (Airlines ordered, 2004).

Another issue that is of concern to travelers is the possibility of theft of their belongings when their bags are checked. The TSA urges passengers to leave their checked baggage unlocked to avoid the potential need to open them forcibly in case physical inspection is needed. Screening of bags can be done using the large explosive detection system (EDS) machines, and other screening methods such as explosive trace detection systems, explosives sniffing dogs, passenger-bag matching and hand searches. If a checked bag is inspected, a statement to that effect is placed in the bag to notify the owner. TSA said it is moving toward providing travelers with free padlock-like seals that screeners can snip open if a search is necessary. However, the agency is advising passengers to use cable or zip ties as an alternative to locks.

Travelers and members of Congress have expressed concern about screeners working in airport security who have criminal records. Hiring thousands of federal security workers after 9/11 was intended to inspire the confidence of travelers. As of June 2003, the TSA has yet to complete background checks on 22,000 of its screeners. The agency has fired 85 felons who had been hired. In the six months ending June 2003, the TSA has received more than 6,700 complaints, most of which concerned damaged or stolen items. The figure also included some claims of lost luggage which is usually the responsibility of airlines. The problem of luggage thefts intensified after a federal security screener in New York was arrested in March 2003 on charges of stealing thousands of dollars in cash from passengers while inspecting their belongings at an airport checkpoint. Two baggage screeners were arrested in Miami in June 2003 and were charged with stealing things from checked baggage. The TSA claims to have a zero-tolerance policy when it comes to malfeasance of anyone working for the agency. TSA also emphasizes that travelers should have confidence in the system as the agency continues to build a robust system for responding to their claims (Goo, 2003, June).

THE DEBATE ABOUT FUNDING OF AVIATION SECURITY

Prior to 9/11, airlines were responsible for supplying and paying for passenger screening. In practice, airlines contracted with the lowest bidders, who operated checkpoints with minimally trained and poorly compensated staff (Larson, 2002). Despite their concerns with security, airlines did not believe that the issue was serious enough to increase the costs associated with security. Airlines have always argued to have the federal government assume the responsibility of airport security and baggage screening. In 1996, Congress passed the Federal Aviation Reauthorization Act (1996) which contained a proposed legislation for funding airport security. The Act mandated that the FAA conducts a study to determine how to transfer the responsibilities of airport security —including costs—from the airlines to airport operators or to the federal government, (Sweet, 2002, p. 114).

Among the TSA first tasks was to federalize baggage screeners at airports. These were, however, met with many obstacles including the time constraints mandated by Congress and the lack of available funding. The TSA is responsible for hiring federal screeners, training and acquisition of security equipment. TSA employed nearly 62,000 screeners at the nation's airports. The TSA is attempting to reorganize staffing to better serve security needs at the nation's airports. In an effort to right-size its screener workforce, the TSA eliminated 3,000 jobs by May 2003, and plans to trim an additional 3,000 positions before the end of September 2003. The TSA claims that the right-sizing of its workforce, will save taxpayers an estimated $320 million by September 2004 (U.S. Transportation, 2003). The TSA claimed that, despite the elimination of 3,000 airport screener jobs before the end of May, a representative sampling of airports found average passenger wait times in April and May remained well below the goal of 10 minutes. In addition, the number of prohibited items intercepted by TSA screeners totaled nearly 460,000 in April, the fourth-highest monthly figure since the agency assumed responsibility for airport security in February 2002 (U.S. Transportation, 2003).

There has been a heated debate since the issue of aviation security federalization came to surface. The main argument for the federal government to take over airport security is that most passengers consider security at the nation's airports to be part of U.S. national security. The costs associated with security personnel and with infrastructure have, however, increased considerably since the government took control. For example, annual salaries for security screeners have increased from $10,000 without benefits to between $23,000 and $35,000 with benefits (Miller, 2002). These unexpected costs have contributed to a shortfall of $100 millions in the FAA budget for fiscal year 2002 (Thompson, 2002).

On October 8, 2002, Leo Mullin, CEO of Delta Air Lines, on behalf of the Air Transport Association gave a fundamental speech to the U.S. Chamber of Commerce. He stated that, since 9/11, the U.S. major carriers alone have trimmed costs by $14 billion in a series of difficult steps with far-reaching consequences. The six major hub-and-spoke carriers have cut operating expenses by $8.7 billion and most airlines are working through the painful process of re-negotiating labor contracts to further lower costs. They have removed $86.8 billion of available seat miles from the air system and 267 aircraft from the fleet. These cuts have resulted in unfortunate service reductions for many cities and for the elimination of service to some countries (Leo Mullin remarks, 2002). With soft demand for air travel and continued overcapacity, airlines do not have the pricing power to get fares, yields and revenues up to acceptable levels.

In the past, the U.S. government has repeatedly refused to accept accountability for aviation security in spite of making sweeping declarations regarding terrorism and the nation's airways as constituting a vital national interest (Sweet, 2002). Now that the government accepted control of airport security, the debate has been changed to one about who is responsible for footing the bill. Taxpayers are reluctant to pay for all the added expenses of airport security, unless threats are considered imminent and on a reoccurring basis. The argument roots itself to the question of whether airline security is considered part of national security or is it a function of the product that the airlines have to offer.

Congress has been embattled with differing views on how to assist the ailing aviation industry. Proposals in both the House and Senate leading to the Emergency Appropriation Bill (H.R. Resolution 1559) provided ways to offset the losses and the additional costs incurred by airlines for the war in Iraq and anti-terrorism efforts. The House plan was to relieve airlines of paying security fees until September 30, 2003, and to reimburse them for the fees paid since 9/11. These security fees include passenger security tax, which can be as much as $10 per round-trip ticket (Miller, 2003). The Senate package included reimbursing airlines for the cost of reinforcing cockpit doors and allowing airlines to keep revenue from passenger security fees from April 1 through September 30, 2003. The plan would reimburse airlines for the amount of $1.1 billion for undertaking security measures. The Senate plan also included $225 million for a 26-week extension of unemployment insurance for aviation workers and $375 million for such costs as security-related infrastructure (Miller, 2003). Although the Administration did not oppose some assistance for airlines, given the current economic conditions of the nation, the Administration believed that the levels of airline assistance recommended by both the House and Senate committees were excessive (Gillin, 2003).

On April 16, 2003, President Bush signed a near $80 billion Emergency Appropriations Bill (H.R. Resolution 1159), including $3.5 billion to assist airlines and airports. The Bill also extended unemployment benefits for airline and other employees. Under the Bill, Congress would reimburse airlines $2.3 billion for security costs. TSA distributed the funds electronically in proportion to the amount of security fees eligible carriers have paid to TSA since February 2002. Delta Air Lines received $390.2 million, the highest among the major airlines. American Airlines got $361.0 million, United Airlines $300.2 million, Southwest Airlines $271.4 million, US Airways $216.1 million, Northwest Airlines $205.0 million, Continental Airlines $173.2 million, America West $81.3 million, Alaska Airlines $67.1 million and ATA Airlines $37.2 million. TSA cautioned that the program is not simply a cash handout for airlines to restore them to economic health. In order to receive this money, Congress has required that the air carriers report how they allocated the funds to offset operating expenses (Measure providing, 2003).

Nine of the 66 airlines, including American, ATA, Continental, Delta, Northwest, United, US Airways and World Airways, were required to limit their executives' salaries under a special provision added in response to Congressional outrage over airline CEO compensations (High executive salaries, 2003). In addition, $100 million was set aside by Congress to compensate carriers for costs associated with reinforcing cockpit doors. The statute also suspended—from June 1 through September 30—the $5-per-leg security fee that has been charged to passengers since February 2002. A separate fee charged to airlines was suspended for the same period. The suspensions are expected to save the carriers an estimated $700 million (TSA begins, 2003).

Some analysts believe that the demands made by airlines were excessive in terms of assistance with security costs, federal subsidized insurance premiums, and a reduction in taxes, In fact, some politicians are feeling the criticism of other industries opposed to the preferential treatment of the aviation industry (Alexander, 2002). Unions complain that despite the grants and special funding that the airlines have been receiving, airlines are still reducing employee capacity in large numbers and making severe cuts into the pay and benefits of their employees. Some carriers have made drastic cuts that have never been seen before. For example, Delta Air Lines had a layoff of 10 to 15 percent of its personnel. It has also announced that it would offer a cash balance program for the retirement benefits of its non-contract employees. Delta estimated that the new program could reduce employee's retirement benefits by more than 6%, saving the company millions of dollars in employee retirement expenses (Delta Air Line Internal Memo, April 16, 2003).

Although it has not been widely publicized, airlines have been receiving subsidized funding. For decades, U.S. airlines have provided passenger and cargo transport services to the military in both times of wartime and peacetime (Air Transport Association, 2003). This system, known as the Civil Reserve Air Fleet (CRAF), was instituted through a series of presidential executive orders, the first was signed on December 15, 1951. Under the program, U.S. airlines commit to support the Department of Defense (DOD) when airlift needs of the DOD exceed its own military capabilities. Virtually all major domestic carriers are enrolled in the program. Approximately 927 planes from more than 30 airlines, air cargo operators and charter services are currently enrolled (Bull, 2003). The CRAF program was activated for the first time in its history on August 17, 1990, when aircraft were called-up in response to Iraq's invasion of Kuwait. The CRAF program is divided into three main segments: international, national and aero-medical evacuation. The international segment is then further divided into the long-range and short-range sections, and the national segment is divided into domestic and Alaskan sections. Finally, the aero-medical evacuation segment is designed to provide evacuation of casualties from operational theatres to hospitals in the continental U.S. The aircraft are also used to deliver medical supplies and crews to the theatre of operation. Special kits have been devised to modify civil Boeing-767 passenger aircraft into air ambulances (CRAF, 2003).

The DOD provides incentives for civil carriers to commit these aircraft to the CRAF program. The Air Mobility Command awards peacetime airlift contracts to civilian airlines that are enrolled in the CRAF program. The DOD is also considering the possibility of opening up its small package business to commercial carriers, which could generate an additional $200 to $400 millions. In addition to the opportunity to compete for peacetime contracts, air carriers are compensated for the services provided during active stages of the CRAF program. The government pays airlines predetermined fees based on the carriers' costs of flying the missions, plus a negotiated rate of return. For example, airlines were paid $1.2 billion for their services in Operations Desert Shield and Desert Storm (Bull, 2003). In 2002, the Pentagon spent $1.4 billion on charters, the majority of which were used to move troops in support of the war on terrorism. The CRAF program can be a substantial source of revenue for airlines considering that they have been parking their aircraft in the desert for temporary storage due to lower demand for air travel. The CRAF program provided supplemental revenue to the aviation industry before and during the war in Iraq as demand decreased during these periods.

Congress has begun to take a look at measures to prevent shoulder-launched missiles from posing a threat to U.S. commercial aviation. Momentum continues to build in Congress to equip U.S. commercial air carriers with technology to defeat shoulder-fired missiles. However, funding remains a great obstacle. On board defense systems include infrared jamming devices, small decoy flares and lasers that burn out the missile's targeting system (Shoulder-Fired, 2003). In August 2003, the U.S. government dispatched teams of aviation safety investigators to Iraq and to major capital cities in Europe and Asia to determine if their commercial airports can be defended against terrorists who might try to shoot down passenger planes using shoulder-fired missiles (Shenon, 2003).

Some policy makers claim that it is time for some airlines to sink or to soar. By letting the weakest players fail, the industry would recover by weeding out excess capacity. The survivors would be able to expand their market share, regaining the ability to raise ticket prices and thus, return to profitability much faster. Some analysts warn that providing more assistance to airlines would waste taxpayers' dollars by delaying the free market's role in weeding out the weakest players.

SUMMARY AND CONCLUSIONS

This paper presents a perspective on the status of the aviation industry following 9/11. The paper highlights the effects on airlines, airports and passengers. A discussion of funding issues as related to aviation security is also presented.

Although government assistance is needed for the dire situation that the aviation industry is in, all entities—the federal government, airlines, and airports—need to work together to come up with equitable and practical policies to deal with increased security costs. Key issues such as unionizing screeners, U.S. airmail contracts, and airport equipment costs will have to be addressed quickly and fairly. In the absence of continued cooperation between the above entities, the aviation industry is doomed to dwindle to a few small carriers providing sub-standard air services.

The issue of who should pay for aviation security will continue to be a hotly debated topic. Airlines and airports will continue to argue that it is a matter of national security and that they should not be forced to bear the burden alone. Passengers cannot be required to shoulder the burden or else the aviation industry will be doomed to fail. Lastly, some members of Congress feel that airlines should continue to receive more assistance, while others feel that the government has done more than its share. There is, however, no dispute that aviation security is a matter of national security. Thus, Congress will ultimately have the responsibility to ensure a proper combination of costs paid for by airlines, airports, passengers and the federal government.

It should be mentioned that the events surrounding the aviation industry are dynamic and can indeed affect the different components of the industry. Many analysts believe that the worst is over for the airlines. A number of large air carriers may, therefore, see much less losses, if not some profits, in 2003. Passengers' confidence in flying has also been increasing given the outcome of the war in Iraq and the perceived diminishing risks of other terrorist attacks. The contents of this paper ought to be updated continuously to reflect the dynamic changes and events surrounding the aviation industry.

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BOOK REVIEW

Thomas, A. R. (2003). *Aviation insecurity: The new challenges of air travel.* Amherst, NY: Prometheus Books. Pp. 263. ISBN: 1-59102-074-3. $21.00 US, paperback.

REVIEWED BY FREDERICK D. HANSEN, Ph.D., Oklahoma State University, Tulsa, Oklahoma.

Anyone who still believes the terrorist attacks on September 11, 2001, were successful simply because security screeners were lax and we needed more explosive detection machines at our airports, needs to read this book. Anyone who believes that the creation of the Transportation Security Administration and the installation of hundreds of new high-technology security machines have eliminated the terrorist threat against commercial aviation, also needs to read this book.

Aviation Insecurity provides a sobering, detailed account of the problems that plagued aviation security at the beginning of the new millennium. The author is an experienced aviation security analyst and a frequent contributor to the Fox News Channel in the United States. Although the author has not been employed in either the FAA office of Civil Aviation Security or Transportation Security Administration, he nevertheless demonstrates within the book that he has the depth of knowledge and experience to intelligently discuss the subject of aviation security.

Aviation Insecurity is divided into two sections. In the first section, Set Up to Fail, the author outlines the inherent flaws in the defenses established to defeat terrorist attacks against commercial aviation. The second section, A New Set of Eyes, explores the post 9/11 world of aviation safety with both a critical analysis of the vulnerabilities in security today and an outline for government and industry professionals to better safeguard air transportation.

Borrowing from the world of aviation safety, aviation security prior to 9/11 was riddled with both latent and active failures throughout the defenses erected to protect air transportation. Aviation safety relies on multiple layers of defenses (the Reason model or Swiss cheese model) to reduce the likelihood that a failure in any specific layer of defense will lead to a chain of events ending in a catastrophe. As with aircraft accidents, a failure in any specific layer of security defense does not necessarily mean that terrorists would be able to successfully commandeer one aircraft let alone a coordinated attack involving multiple aircraft on the same day.

Unfortunately, as Andrew Thomas points out quite vividly, the entire structure of security defenses we relied on so heavily was seriously flawed at many levels. Among these flaws were inadequate baggage screening equipment; underpaid, under trained, and unmotivated security screening personnel; items that were acceptable to take on the airplane that were effective as weapons; an underlying failure to understand the motives and dedication of the enemy; and policies that were unable to change known security deficiencies.

The most compelling argument in the first section of this book deals with the battle between providing a secure transportation system and the need for air carriers to make a profit. From the air carrier perspective, security was an expense that needed to be controlled and minimized both monetarily and in its impact on the passenger. The FAA also faced conflicting priorities with respect to security. On one hand, they regulated and provided oversight of aviation security to ensure the safety of the public. On the other, the FAA was also tasked with developing and fostering civil aviation. Aviation Insecurity clearly demonstrates the roles these conflicts within the airline industry and the FAA in the events leading up to 9/11.

The second section of the book also presents a serious critique of the efforts to improve aviation security that began with the Aviation and Transportation Security Act of 2001. In spite of the establishment of a new federal agency tasked with the direct protection of air transportation and the enormous infusion of money from Congress, Andrew Thomas clearly demonstrates that the new layers of protection currently in place are not enough to prevent future attacks. New technologies in the form of trace detection devices, explosive detection devices, and other innovations provide additional opportunities for an airport security system to detect weapons and explosives but they should never be considered as the ultimate barrier to future terrorist attacks. To quote an anonymous author, "bad security looks a lot like good security on the surface" (p.123).

In spite of the chilling realization that the security system that was in place in September 2001 was fundamentally flawed and that we still have several weaknesses in aviation security, the author suggests that security can be significantly improved through the use of risk analysis. Specifically, the author recommends a continuous process that includes "identifying potential threats; determining existing and possible vulnerabilities; and discerning measures, as necessary, that lead to risk reduction" (p 136).

Clearly, this book does not suggest that aviation security is no better than it was. The author does warn that a battle will continue to rage among airlines who need to make a profit; passengers who want security without hassle and inconvenience; taxpayers who do not want to pay for too much security; and terrorists who see air transportation as an ideal weapon. Complacency was our enemy on September 11, 2001, and remains our enemy today. "Security can only be achieved through constant change, through discarding old ideas that have outlived their usefulness, and adapting others to current facts" – William O. Douglas (p. 201).

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