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ASCI 691 Graduate Capstone Comprehensive Exam Project

The Impact of Training and Technology on the Future of Aviation

Jennifer Oberg

Embry-Riddle Aeronautical University

ASCI 691 Graduate Capstone Proposal

Submitted to the Worldwide Campus

in Partial Fulfillment of the Requirements of the Degree of

Master of Aeronautical Science

March 1, 2014

Abstract

The comprehensive exam proposal is intended to address the core competency requirements for the degree of Master of Aeronautical Science. In addition, the proposal will address the competency requirements for the Aviation Education Specialization. In partial fulfillment of these requirements, the proposal will examine human factors as they pertain specifically to the arena of unmanned flight, the impact computer based training and web based training advances have and will continue to have on the aviation community, the technological, social, environmental, and political aspects of the air cargo industry as they pertain to the industry's survival, the ability of Next Generation (NextGen) air traffic control technologies to navigate the advances in the aviation community and finally the ability of crew resource management to adapt and thrive in the ever advancing world of aviation technologies. The examination of these issues in aviation will be conducted utilizing a mixed-methodology. Qualitative and quantitative data will be analyzed ex-post facto for triangulation which will lead to the validity of conclusions.

Keywords: comprehensive exam, proposal, aviation education specialization

Proposal

Comprehensive Question # 1

Statement of the question. A misconception once existed in the arena of unmanned flight that unmanned meant human factors did not pertain to this industry. The term unmanned is no longer synonymous with lack of human involvement. A pilot and crew are present during flight; presented with not only the well-known human factors issues, but a litany of unique circumstances. The unmanned systems have introduced a whole new realm of human factors issues never before considered. Human factors related to flight control automation, unique control interfaces, multi-modal display technology and transfer of control (Williams, 2006) are all immerging in this industry. While this unique arena does offer the advantage of good Situational Awareness (SA) due to a great deal of on-board and off-board sensor data, disadvantages such as demanding cognitive workflow, joystick controls inconsistent with current human factors principles and sensory isolation are all leading to new ways of managing decision making, workload and crew resource management training. Many articles and reports have been written by experts like the Federal Aviation Administration (FAA) and the Remotely Piloted Aircraft (RPA) manufacturers that address this up and coming issue in great detail. Statistical analysis conducted in this industry has attributed over half of current recorded accidents to human factors issues (McCarley & Wickens, 2005). In light of this data, RPA’s are only slowly becoming part of the National Airspace System. The FAA has been tasked with developing standards and regulations for these types of systems (Elias, 2012) in preparation for the potential and eventual release. Engineers and the FAA must determine what level of hybrid, manual and automatic control will be necessary to ensure safety. The unique situational awareness issues associated with autonomous flight are hindering this progression (McCarley & Wickens, 2005).

Engineers believe the new Ground Based Sense and Avoid (GBSAA) system will alleviate the difficulties associated with the overload of data and SA which can exist with unmanned flight (Ramjug, 2012). Research and consider the human factors implications of autonomous control associated with unmanned flight in national airspace. What unique human factors issues can be mitigated? What conclusions can be drawn regarding the eventual release of unmanned aircraft to occupy national airspace? Will this technology change the way pilots approach situational awareness in unmanned flight? Draw conclusions regarding the FAA acceptance of this technology and eventual implementation.

Program Outcomes that will be addresses by this question:

Program outcome #2

The student will be able to identify and apply appropriate statistical analysis, to include techniques in data collection, review, critique, interpretation and inference in the aviation and aerospace industry.

The ***statistical analysis*** aspect will be addressed by examining data compiled by the FAA regarding incidents related to human factors occurring on unmanned aircraft across the services. This data will be utilized for the purpose of calculating the probability of four different types of unmanned aircraft, the Army Hunter, the Army Shadow, the Navy Pioneer and the Air Force Predator to have significant variance among airframes in human factors incidents. A ***One-Way ANOVA*** test will be utilized to calculate the significance (sig. < .05) of variance.

Program outcome #3

The student will be able, across all subjects, to use the fundamentals of human factors in all aspects of the aviation and aerospace industry, including unsafe acts, attitudes, errors, human behavior, and human limitations as they relate to the aviators adaption to the aviation *environment to reach conclusions.*

The ***human limitations*** aspect will be addressed by utilizing the research conducted in program outcome two for identifying what limitations exist among differing airframes which cause the differing percentages of procedural errors.

The ***unsafe acts and errors*** aspects will be addressed comparing data gathered by the FAA regarding the distribution of human error incidents among differing airframes. This data will be utilized to analyze the reason for the differing percentages among unmanned aircraft.

The ***human behavior and attitudes*** aspects will be identified through investigation of crew resource management as it applies to unmanned flight for the purpose of investigating crew adaption to this environment. Situational awareness and training will be addressed by investigating if comprehensive changes in training will address all differing procedural errors among airframes.

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***quantitative research methodology*** will be utilized by examining data compiled by the FAA regarding human factors occurring on unmanned aircraft across the services. The purpose is to draw conclusions regarding the probability of variance among human factors incidents in unmanned airframes. The ***hypothesis*** will be offered that different airframes will vary significantly $< .05$ in human factors related incidents. In addition, it will be proposed this variance will assist the Army in becoming the first to receive release into national airspace. The null hypothesis that variance will not be significant among human factors incidents in airframes will be rejected.

Comprehensive Question # 2

Statement of the question. Computer Based Training (CBT) and Web Based Training (WBT) are quickly becoming an integral part of aviation training in all aspects. New and innovative aviation organizations are offering web based simulation training and some even claim to provide everything one may need to obtain a Sport or Private Pilot Certificate (Computer-based Instruction, n.d.). In response, the Aviation Industry Computer-Based-Training Committee and the Advanced Distributed Learning Initiative is developing the next generation online learning environment called the Training & Learning Architecture, or TLA, which is thought to provide learners with a richer and more innovative learning experience (Aviation Industry Computer-Based-Training Committee, n.d.1).This shift to online learning is thought to provide an adequate transfer of knowledge from the legacy training materials and traditional classroom training. Statistical evidence provided regarding the ability of these new training platforms to provide more effective and cost efficient training than the classroom environment is widely supporting this shift. Despite this trend, it has been suggested the single greatest impediment to the success of WBT is a low completion rate (Hawkins & Sener, 2007). Some of the reasons for this are suggested to be lack of organizational support, cognitive load factors, user proficiency with technology and lack of motivation. These considerations must be addressed in curriculum development for WBT to be successful. Additionally, memory and cognition play an important role in the success or failure of WBT. To address these shortcomings, hybrid instruction, a combination of WBT and traditional classroom training is becoming increasingly popular in the aviation community by allowing for personal communication in the classroom with the flexibility of an online component (“Georgia Northwestern Technical College”, n.d.).

This new training environment has largely influenced flight simulation training. Years have been devoted to enhancing flight simulators so as to provide pilots with a training environment as close to actual flight as possible. Current advances in CBT have proven to provide a more realistic flight training experience and are thought to be revolutionary in the industry. Can these advances in CBT overcome the low completion rates and provide an adequate transfer of training? The addition of flight simulation training for unmanned aircraft pilots has also altered the way engineers approach flight simulation. Consider the unique training requirements for unmanned flight simulation. Identify the characteristics of unmanned flight which are ideal for this training environment. Draw conclusions regarding the ability of CBT to successfully overcome the unique obstacles present in unmanned flight simulation.

Program Outcomes that will be addressed by this question:

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***qualitative research methodology*** will be utilized by analyzing the ability of WBT and CBT to offer an adequate transfer of training in relation to classroom instruction. The effectiveness of WBT and CBT platforms will be investigated for application in aviation training. Hybrid training, a combination of WBT/CBT and classroom training will be researched for the potential to close gaps in current WBT/CBT techniques. The ***hypothesis*** will be offered that CBT will provide successful transfer of training in flight simulation in the arena of unmanned flight. Evidence will show that current systems in unmanned flight simulation such as the Predator Mission Aircrew Training System (PMATS) are providing adequate transfer of training.

Program outcome #6

The student will investigate, compare, contrast, analyze, and form conclusions to current aviation, aerospace, and industry related topics in education technology, including computer based instruction, simulation systems, education foundations, curriculum development, continuing education, adult teaching and learning techniques, and memory and cognition.

ASCI 614 Advanced Aviation/Aerospace Curriculum Development and ASCI 652 Continuing Educations Role in Aviation were not part of the researcher's curriculum, accordingly these aspects will not be addressed in this examination.

The ***simulation systems*** aspects will be addressed by conducting research to legitimize or disprove the assertion of the AICC that TLA will innovate pilot training and provide a richer learning environment.

The ***computer based instruction and adult teaching and learning techniques*** aspects will be addressed by analyzing WBT techniques compared to traditional classroom instruction. The contrast between the two will be identified and further compared to hybrid instruction.

The ***memory and cognition and curriculum development*** aspects will be addressed by analyzing the human abilities of memory and cognition for the role both play in WBT and the effect to which these abilities determine the development of aviation curriculum.

The ***continuing education and education foundations*** aspects will be addresses by drawing conclusions from research regarding the ability of WBT to offer an adequate transfer of training in relation to classroom instruction, the effectiveness of the WBT platforms as it pertains to aviation training and the ability of hybrid training to close any potential gaps in current WBT techniques.

Comprehensive Question # 3

Statement of the question. Many companies in the air cargo industry have alluded to the fact that survival depends on getting the basics right (Schaecher, 2011). Basics such as technology and communication, managing globalization of trade and adapting to environmental policies are shaping the industry. This poses many challenges because air cargo is largely reliant on the globalization of trade, political instability is a consistent threat and environmental catastrophes will always exist. All of these considerations provide the potential for a modal shift to sea. Additionally, the ever increasing homeland security concerns have led the air cargo industry to re-evaluate the way business is conducted (Department of Homeland Security, 2012). In response, many technological advances have been made available to the industry for use in overcoming global transport. New technologies such as Radio Frequency Identification (RFID) are proving successful for tracking purposes. Security concerns are paving the way for an advance screening strategic plan which is thought to enhance risk-based targeting and streamline customs entry requirements. Globalization and airline regulation have driven not only technological but environmental changes to the air cargo industry (Schaecher, 2011). Legislation on carbon is becoming a market restriction and a cost factor. This is driving the industry to find innovative ways to reduce carbon emissions to remain in compliance. Current Revenue Ton Miles (RTMs) combined with predicted decreases in jet fuel costs is one way this stress is being alleviated. Yet another consideration in regards to globalization is the air cargo industry role as a key player in the world economy. Air cargo is responsible for carrying approximately 40 percent of world trade (Coyne, n.d.). Because it is growing more rapidly than the passenger business, the world economy will need air cargo to prosper. This will present challenges to develop programs which provide more efficiency. One response is the trend toward just-in-time logistics intended to reduce the need to store excessive levels of material in a warehouse. These changes in inventory management practices and production line innovations are predicted to provide more efficient, cost effective and customer responsive effects on new time-sensitive products in the global market. Examine the impact these changes toward production flexibility will have on air cargo operations. Identify the political and social implications of globalization on the air cargo industry? Draw conclusions regarding the financial impact of logistic changes on the industry as a whole. Investigate the extent to which regulation will restrict air cargo profitability. Can the air cargo industry overcome the impacts of globalization and regulation?

Program Outcomes that will be addressed by this question:

Program outcome #1

Students will be able to apply the fundamentals of air transportation as part of a global, multimodal transportation system, including the technological, social, environmental, and political aspects of the system to examine, compare, analyze, and recommend conclusion.

The ***technological*** aspect will be addressed by exploring advances in technology specifically in the air cargo industry. Opportunities to adopt technology for tracking shipments such as Radio Frequency Identification (RFID), how this technology could potentially improve security and the potential for this ability to win over regulators (Schaecher, 2011).

The ***social*** aspect will be addressed by researching the importance and reliance on air cargo in regards to the production and procurement of goods. The effects and strategic impact of the possibility for more local procurement of goods versus air cargo utilization will be explored. The potential for economies opting for a modal shift in market procurement will be analyzed (Schaecher, 2011).

The ***environmental*** aspect will be addressed by researching the impact of legislation on carbon in the air cargo industry as it becomes more restrictive and cost of complying becomes an ever increasing factor. Conclusions will be drawn regarding the ability of the industry to adapt to changing legislation and more restrictive regulation (Schaecher, 2011).

The ***political*** aspect will be addressed by conducting research to analyze the effects political instability consistently imposes on the success of the globalized air cargo industry. In addition, the ever changing price of fuel in the global economy will be explored to show the impact this fluctuation can place on the air cargo industry and how this can impact oil production (Schaecher, 2011).

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***qualitative research methodology*** will be conducted to identify the effect globalization has on both political and social aspects of the air cargo industry. The impact political instability will place on the success or failure of cargo transport will be analyzed. Additionally, the ability of the air cargo industry to comply and adapt to current and future regulation and the lasting effect it will have on the globalization of air cargo will be compared. The ***hypothesis*** will be offered in which the economic future of the air cargo industry based on regulatory compliance, predicted fuel prices, technological changes and environmental adaptation will be favorable.

Comprehensive Question # 4

Statement of the question. It is widely believed in the aviation industry that NextGen technology will make the skies safer and less congested (“NextGen Technology,” n.d.). National economic success and air traffic growth are purported to hinge upon the success or failure of

NextGen incorporation. This new immerging technology is intended to enhance safety and efficiency by utilizing satellite communication technology versus the current ground based radar. Current air traffic control technology has been determined to be antiquated for increasing air traffic control demands and imposes significant cost to the airline industry and society in general. The forecasted increase in operations over the next decade cannot be sustained by the system in place. NextGen technology is believed to address this as well as many additional concerns. A few of the acknowledged benefits are improved operational efficiency, reduced fuel consumption, lower emissions and operating costs. NextGen has the potential to increase capacity by more precisely spacing aircraft and increase productivity by flying more direct routes which will directly impact fuel consumption. The overall benefits of implementing NextGen technology are intended to outweigh the suggested financial impact on global organizations (Schank, 2013). In addition to gains in efficiency, NextGen has environmental benefits to consider. Fuel efficiencies introduced by direct routes can contribute to a reduction in greenhouse gas emissions. Lastly, and perhaps most significant, the technology will improve safety. NextGen will allow pilots to enjoy better situational awareness by providing a more enhanced picture of where they are in the airspace with respect to other aircraft. The system is already being successfully utilized in many locations, including here in the United States by United Parcel Service (NextGen, n.d.). This will lead to social impacts regarding multimodal intercity planning and national policy. One such impact is the implementation of Ground-Based Sense and Avoid (GBSAA) technology being researched by the military for use with unmanned aircraft. Research and determine the overall impact of NextGen technology in terms of safety, environmental benefits and financial gains. What affect will the release of NextGen have on GBSAA implementation? Examine the potential effect NextGen will have on the certification process and new training requirements imposed on pilots. Determine the social impact it may impose on the number of regional air traffic control centers and the local politicians fighting for the centers to remain.

Program Outcomes that will be addressed by this question:

Program outcome #1

Students will be able to apply the fundamentals of air transportation as part of a global, multimodal transportation system, including the technological, social, environmental, and political aspects of the system to examine, compare, analyze, and recommend conclusion.

The ***technological*** aspect will be addressed by examining and comparing NextGen technology to the current air traffic control technology. A determination will be made regarding the ability of NextGen technology to successfully replace current technology by examining locations where NextGen is already in use.

The ***social*** aspect will be addressed by examining NextGen technology for its potential impact on the global economy. The affects upgrades can have on global oil consumption and the feasibility of upgrade costs versus benefits will be analyzed and weighed.

The ***environmental*** aspect will be addressed by researching the impact NextGen technology can have on greenhouse gas emissions compared to current levels based on existing data. Current airlines and regions utilizing NextGen technology will be examined for environmental impact in those regions and conclusions will be drawn regarding environmental impact on a global scale.

The ***political*** aspect will be addressed by analyzing the potential reduction in current regional air traffic control centers for impact on facility closures and job loss. Current congressional push back regarding these potential closures will be examined and conclusions will be drawn regarding future congressional actions.

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***qualitative research methodology*** will be utilized to evaluate the ability of NextGen technology to reduce congestion in the skies, potential environmental impact on a global scale, and future congressional actions regarding possible closure of regional air traffic control centers and job loss. The impact of the technology in regions currently utilizing NextGen will be investigated and problems with implementation on a global scale will be identified. The ***hypothesis*** will be offered in which NextGen technology will significantly reduce delays and environmental impact.

Comprehensive Question # 5

Statement of the question. Recent accident and incident reports, news stories, and results of investigation and audits have raised concern that Crew Resource Management (CRM) has been eroded as a cornerstone of Flight Safety in the current environment (“Human Factors”, n.d.). Current human factors incidents in the aviation industry would seem to solidify the perceived deterioration of CRM. Poor pilot training and pilot error are reported to be the leading cause of almost 80 percent of commercial airline accidents (Federal Aviation Administration, 2013a). These accidents are attributed to a wide variety of human error related incidents such as self-imposed stress, skill-based errors, misperception errors, and judgement and decision-making errors. For this reason, CRM encompasses many training areas including communication, workload management, decision-making, conflict resolution, leadership, team management and stress management (Jensen, 1995).CRM training has long been targeted on controlling these aspects in the cockpit but the goal of current training is to understand that CRM starts and ends with the entire crew, both inside and outside the aircraft. The training has now evolved to include aircraft dispatchers, flight attendants, maintenance personnel and air traffic controllers. The last decade has interjected a whole new arena of awareness into aircrew training which must deal with the consistent threat of terrorism. This has added another element to training referred to as threat management. Another element imposed on situational awareness and training is the advancements in unmanned flight operations and the unique human factors associated with this area of flight operations. Additional considerations affecting current training are advances such as NextGen technology, which will alter the approach to CRM and associated training requirements. The introduction of NextGen, which demands enhanced situational awareness, will make CRM skills even more crucial. As NextGen continues to drive operational changes, it will become even more important for CRM training to focus on interactions with crew members outside the cockpit. Hypothesize the ability of NextGen technology to impact currently perceived CRM shortfalls in the industry. Research the extent to which NextGen technology can have an impact on Air Traffic Control (ATC) situational awareness and determine what potential impact CRM changes in this environment can have on the program.

Program Outcomes that will be addressed by this question:

Program outcome #3

The student will be able, across all subjects, to use the fundamentals of human factors in all aspects of the aviation and aerospace industry, including unsafe acts, attitudes, errors, human behavior, and human limitations as they relate to the aviators adaption to the aviation environment to reach conclusions.

The ***human behavior*** aspect will be addressed by comparing recent incidents where human error and CRM training were directly related. The behavior of the flight crew in the incident will be examined for attributes of the CRM training program and a determination made regarding the success of the incident due solely to training experience.

The ***unsafe acts and errors*** aspect will be addressed by examining current research on aircraft accidents and incidents where human error is identified as causal. The percentage of human error related accidents prior to the requirement for CRM training and current percentages will be evaluated for the ability of CRM training to alleviate incidents.

The ***attitudes and human limitations*** aspects will be addressed by investigating CRM as it applies to currently perceived shortfalls in existing programs. Human limitations will be examined regarding the increased situational awareness new technologies will impose on flight crews.

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

An ***ex-post facto research methodology*** will be utilized by examining human error identified in previous aircraft accidents and incidents. The facts and circumstances will show crews are in need of updated and reinforced training taking into consideration new technologies. The ***hypothesis*** will be offered in which CRM training must adapt to new technology to remain valid. Additionally, research will show new technology such as NextGen will solidify the transition to a more robust flight deck system.

Comprehensive Exam Project

Comprehensive Exam Question # 1

Statement of the question

A misconception once existed in the arena of unmanned flight that unmanned meant human factors did not pertain to this industry. The term unmanned is no longer synonymous with lack of human involvement. A pilot and crew are present during flight; presented with not only the well-known human factors issues, but a litany of unique circumstances. The unmanned systems have introduced a whole new realm of human factors issues never before considered. Human factors related to flight control automation, unique control interfaces, multi-modal display technology and transfer of control (Williams, 2006) are all immerging in this industry. While this unique arena does offer the advantage of good Situational Awareness (SA) due to a great deal of on-board and off-board sensor data, disadvantages such as demanding cognitive workflow, joystick controls inconsistent with current human factors principles and sensory isolation are all leading to new ways of managing decision making, workload and crew resource management training. Many articles and reports have been written by experts like the Federal Aviation Administration (FAA) and the Remotely Piloted Aircraft (RPA) manufacturers that address this up and coming issue in great detail. Statistical analysis conducted in this industry has attributed over half of current recorded accidents to human factors issues (McCarley & Wickens, 2005). In light of this data, RPA’s are only slowly becoming part of the National Airspace System. The FAA has been tasked with developing standards and regulations for these types of systems (Elias, 2012) in preparation for the potential and eventual release. Engineers and the FAA must determine what level of hybrid, manual and automatic control will be necessary to ensure safety. The unique situational awareness issues associated with autonomous flight are hindering this progression (McCarley & Wickens, 2005). Engineers believe the new Ground Based Sense and Avoid (GBSAA) system will alleviate the difficulties associated with the overload of data and SA which can exist with unmanned flight (Ramjug, 2012). Research and consider the human factors implications of autonomous control associated with unmanned flight in national airspace. What unique human factors issues can be mitigated? What conclusions can be drawn regarding the eventual release of unmanned aircraft to occupy national airspace? Will this technology change the way pilots approach situational awareness in unmanned flight? Draw conclusions regarding the FAA acceptance of this technology and eventual implementation.

Program Outcomes that will be addresses by this question:

Program outcome #2

The student will be able to identify and apply appropriate statistical analysis, to include techniques in data collection, review, critique, interpretation and inference in the aviation and aerospace industry.

The ***statistical analysis*** aspect will be addressed by examining data compiled by the FAA regarding incidents related to human factors occurring on unmanned aircraft across the services. This data will be utilized for the purpose of calculating the probability of four different types of unmanned aircraft, the Army Hunter, the Army Shadow, the Navy Pioneer and the Air Force Predator to have significant variance among airframes in human factors incidents. A ***One-Way ANOVA*** test will be utilized to calculate the significance (sig. < .05) of variance.

Program outcome #3

The student will be able, across all subjects, to use the fundamentals of human factors in all aspects of the aviation and aerospace industry, including unsafe acts, attitudes, errors, human behavior, and human limitations as they relate to the aviators adaption to the aviation *environment to reach conclusions.*

The ***human limitations*** aspect will be addressed by utilizing the research conducted in program outcome two for identifying what limitations exist among differing airframes which cause the differing percentages of procedural errors.

The ***unsafe acts and errors*** aspects will be addressed comparing data gathered by the FAA regarding the distribution of human error incidents among differing airframes. This data will be utilized to analyze the reason for the differing percentages among unmanned aircraft.

The ***human behavior and attitudes*** aspects will be identified through investigation of crew resource management as it applies to unmanned flight for the purpose of investigating crew adaption to this environment. Situational awareness and training will be addressed by investigating if comprehensive changes in training will address all differing procedural errors among airframes.

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***quantitative research methodology*** will be utilized by examining data compiled by the FAA regarding human factors occurring on unmanned aircraft across the services. The purpose is to draw conclusions regarding the probability of variance among human factors incidents in unmanned airframes. The ***hypothesis*** will be offered that different airframes will vary significantly $< .05$ in human factors related incidents. In addition, it will be proposed this variance will assist the Army in becoming the first to receive release into national airspace. The null hypothesis that variance will not be significant among human factors incidents in airframes will be rejected.

Human Factors in Unmanned Aerial Flight

Introduction

"The alleviation of human error, whether design or intrinsically human, continues to be the most important problem facing aerospace safety" (Lederer, n.d., para 1). The trend toward unmanned flight was thought to significantly alleviate issues related to design and human interaction. Unfortunately, data collected in the field does not lend itself to this conclusion. Statistics have shown the unmanned mishap rate is 100 times higher than manned aircraft (Bertapelle, King & Moses, 2005). The absence of a pilot and crew onboard presents not only well-known human factors issues, but a myriad of unique circumstances. The unmanned systems have introduced human factors issues never before conceived. Factors such as flight control automation, unique control interfaces, multi-modal display technology and transfer of control have added an increased need for situational awareness. The pilot and crew of these airframes are faced with disadvantages such as demanding cognitive workflow, joystick controls inconsistent with current human factors principles and sensory isolation. In addition, these unique human factors characteristics do not appear to remain consistent among unmanned airframes themselves. All of these factors will affect the ability of these airframes to eventually occupy national airspace. New technologies are currently being developed which are thought to mitigate many of these concerns. One such technology, Ground Based Sense and Avoid (GBSAA) is being tested on the Army Hunter. Should this testing prove successful, coupled with Army Hunter human factor incident statistics may be the winning combination for release.

Statement of the Problem

All recorded statistics identify human error as the leading cause of most aircraft accidents. The development of the Unmanned Aerial Vehicle (UAV) was though to offer significant advantages over manned aircraft in terms of human error. The assumption was the limited involvement with the human would reduce human error. The issue remains that current statistics regarding UAV mishap rates attributed to human error is reportedly 100,000 times higher than manned aircraft (Bertapelle et al, 2005).

Purpose

The purpose of the research is to understand why the UAV mishap rate is significantly higher than manned aircraft. It is necessary to investigate what unique human factors issues are contributing to these statistics to understand how they may be alleviated. Additionally, if UAV's are ever to be released into national airspace, it will be crucial to recognize why new technologies being tested may permit FAA acceptance.

Review and Discussion of Relevant Literature

Human limitations. Throughout history manned flight has challenged human limitations with high altitudes and high speed flight. The unmanned aircraft alleviated stressors on the human body associated with these two extremes but added a few more challenges to human limitations of the mind. Understanding this new realm of human limitations requires understand how these aircraft operate.

Army Hunter. The Army Hunter is operated utilizing both an external and an internal pilot (Williams, n.d.). The Hunter will be launched by the external pilot with visual contact using a controller comparable to a store both radio controlled aircraft. Once the aircraft is airborne, control will be transferred to the internal pilot. Unlike the direct visual contact the external pilot utilizes, the internal pilot operates from a Ground Control Station (GCS). The controls in the GCS are more automated and can be adjusted by knobs which control altitude, heading and airspeed. Landing of the aircraft is accomplished by transferring control back to the external pilot who lands the aircraft by snagging a hook under the belly of the aircraft on a set of arresting cables on the runway.

Army Shadow. The Army Shadow, in contrast to the Hunter, does not utilize an external pilot (Williams, n.d.). Launch of this aircraft is achieved by a mechanical launching mechanism. In flight, the Shadow is also controlled by a pilot using a GCS. Much like the Hunter, altitude, heading and airspeed can all be adjusted by the GCS but the Shadow uses a computer menu instead of relying on knobs. Landing the aircraft is accomplished by a system called the Tactical Automated Landing System (TALS) (Williams, n.d.). This automated landing system does not allow for the crew to have visual contact or sensor input while on approach or landing. The aircraft must also snag a cable system much like that of the Hunter to stop. Engine cutoff will be initiated from the GCS once an outside observer advises the pilot the aircraft has safely landed.

Navy Pioneer. The Navy Pioneer also utilized and external pilot for takeoff and landing (Williams, n.d.). In addition, like the Hunter, control will be transferred to the GCS one airborne. Unlike the previous aircraft, the GCS can control the Pioneer in three distinct modes. The first mode is completely autonomous and uses a global positioning system. The aircraft will fly from preprogrammed waypoint to preprogrammed waypoint based on set coordinates. The second mode is much like the Hunter in that the internal pilot can set by knobs which control altitude, heading and airspeed. The third mode allows the internal pilot to fly the aircraft by use of a joystick control. The Pioneer can also be landed much like the Hunter and Shadow by use of a cable system to snag the aircraft on a runway. Where the Pioneer differs is that it can be launched and landed on a ship. Landing the Pioneer on board a ship is accomplished by flying the aircraft into a net which literally captures the UAV.

Air Force Predator. The Air Force Predator is flown solely by an internal pilot inside a GCS. (Williams, n.d.). The pilot control console has a joystick, throttle assembly, foot pedal assembly and keyboard and mouse control (GA-ASI, 2010). The pilot Heads-Up Displays (HUD's) consist of two 18 inch LCD screens. These screens give the pilot the ability to view maps, flight plans and video from the aircraft. The pilot has the ability to view either nose camera video with a 30 degree field of view or Electro Optical/Infrared (EO/IR) video from a camera mounted under the belly of the aircraft. The nose camera video is used for launch and recovery operations while the EO/IR video is typically used during flight. Two smaller Heads-Down Displays (HDD's) allow the pilot to view telemetry from the aircraft. Takeoff and landing are accomplished from the pilot console using one of two communications links with the aircraft. The first data link, C-Band frequency or line-of-sight (LOS), allows the UAV to be controlled up to 150 nautical miles. The second communication link, Ku Band frequency or beyond-line-of-sight (BLOS) satellite communication (SATCOM), allows the UAV to be controlled globally.

Unsafe acts and errors. The unsafe acts and errors observed in this research were summarized utilizing a modified version of the Human Factors Analysis and Classification System (HFACS) where accidents were classified into categories of human factors, maintenance, aircraft and unknown (Williams, n.d.).

Army Hunter. Data collected in this research showed 47% of Hunter accidents can be attributed to human factors issues (Williams, n.d). Among the accidents identified categorically as human factors related, 7% were pilot-in-command errors, 13% were errors due to alerts or alarms, 7% were display design issues, 47% were external pilot landing error, 20% were external pilot takeoff error and 20% were procedural error. The greatest human factor related issue facing the Army Hunter would appear to be issues experienced by the external pilot during landings. It has been suggested these issues are experienced due to the control inputs on approach being opposite of that during takeoff.

Army Shadow. Data collected in this research showed 21% of Shadow accidents can be attributed to human factors issues (Williams, n.d). Among the accidents identified categorically as human factors related, 40% were pilot-in-command errors, 40% were errors due to alerts and alarms, 40% were display design issues and 40% were due to procedural error. These percentages will not equal 100% as some errors were dually categorized. The human factors related issues facing the Army Shadow would seem to be evenly distributed. One issue which stood out as a particular plague for this aircraft was failure of the engine kill function which must be initiated within the GCS and acknowledged by an outside observer.

Navy Pioneer. Data collected in this research showed 28% of Pioneer accidents can be attributed to human factors issues (Williams, n.d). Among the accidents identified categorically as human factors related, 13% were aircrew coordination errors, 68% were landing errors and 10% were takeoff errors. A few errors were attributed to weather but there were not enough details to classify these as human errors. The greatest human factor related issue facing the Navy Pioneer clearly stands out as landing errors. This aircraft is also the only UAV airframe which must rely upon the operator to fly the aircraft into a net to be captured safely.

Air Force Predator. Data collected in this research showed 67% of Pioneer accidents can be attributed to human factors issues (Williams, n.d). Among the accidents identified categorically as human factors related, 13% were due to errors with alerts and alarms, 25% were due to display design errors, 1% were landing errors and 75% were procedural errors. The greatest human factor related issue facing the Air Force Predator is clearly procedural error. Many of these procedural errors can be attributed to the transfer of control process during aircraft handoff from one GCS to another. Often times this is due to missed or overlooked checklist items and accomplishing steps out of sequence. Another high volume procedural item is related to inadvertent or unintended commands being executed.

H**uman behavior and attitudes.** Crew Resource Management (CRM) was also known as Cockpit Resource Management (Hawkins et al, 2007). This was due in part to the attitudes of those developing the training which focused primarily on the actions within the flight deck. The program had to evolve as it became rapidly apparent that successful flight operations required the coordination of more than pilots. A new training program had to be established which considered dispatchers, flight attendants, maintenance personnel and air traffic controllers. CRM has become more relevant as it was discovered properly trained crews perform complex tasks better collectively than any one single individual can on a team (“Crew resource management”, 2007). CRM training focuses on the error chain. The concept being that if one weak link should break, the entire chain fails. CRM training is designed to enhance situational awareness, manage toxic attitudes, assist crews in understanding barriers to communication, steps to take when reaching task saturation and crew coordination. Loss of situational awareness can be cause by complacency, distraction, confusion and a litany of factors. Recognition of loss of awareness and reestablishing a stable environment are key. Many barriers to communication must be managed such as noise, wording or lack of rapport. Task saturation must be addressed by understanding workload and becoming aware of limitations. Lastly, crew coordination is vital on all levels from understanding assignments and communicating them appropriately to asking appropriate questions to further define a task if not understood. One of the most important lessons in successful crew management is to understand any member of the crew has the ability to call a time out if a detrimental situation occurs.

Crew resource management failures. Many of the unsafe acts and errors recorded in the military UAV's can be attributed to CRM failures. When considering the Army Hunter, the greatest human factor percentage related to landings. This was attributed to control inputs being opposite of takeoff controls. This can easily be contributed to loss of situational awareness. The external pilot lost awareness, however briefly, of the correct functionality of the controls. When considering the Army Shadow, unsafe acts and errors were evenly distributed, however it was proposed the engine kill switch being inappropriately engaged was a large contributing factor to several incidents. Due to the fact an outside observer is necessary to coordinate this engine kill function; crew coordination is a clear failure in the CRM chain. When considering the Navy Pioneer, the greatest human factor percentage also related to landings. This was attributed to the necessity of landing the aircraft in a net on board a ship. In this particular study it was cited that many accidents could be categorized in one or more areas. The second largest percentage was aircrew coordination. Landing an aircraft in a relatively small net on a moving vessel requires many levels of CRM including high situational awareness and exemplary crew coordination. This unique human factors situation encompasses so many levels of CRM; it is not hard to imagine why the error rate is approximately 5 times higher than the next highest statistic among airframes. Lastly are the unsafe acts attributed to the Air Force Predator. The greatest number of human factor incidents was attributed to procedural error. Many of the procedural errors focused on missed or overlooked checklist items and accomplishing steps out of sequence. Perhaps most significant was the high volume of procedural items noted which related to inadvertent or unintended commands being executed. In terms of CRM, the Predator crew would appear to have reached task saturation. In terms of current CRM training, it does not appear that unmanned aircraft human factors are outside the scope of established CRM training goals. It does appear the

UAV community may need to re-evaluate how it approaches each tenant of CRM training to tailor goals to unique high failure items.

Ground based sense and avoid. The Army is working to alleviate some UAV high percentage human factor errors with Ground Based Sense and Avoid (GBSAA) technology. “The Army is the lead service for GBSAA within a Department of Defense UAS task force” (Carey, 2012, para 7). GBSAA utilizes three-dimensional radar and sensor inputs, data fusion and software algorithms to provide for collision avoidance (Carey, 2012). This technology is being developed to comply with the FAA Part 91.113 aircraft right-of-way rules. The intention of Department of Defense is to employ this technology as a solution for all services to eventually occupy national airspace. GBSAA was successfully tested by the Army in June of 2012 (Bledsoe, 2012). At this time, the Army is testing GBSAA with a new unmanned aircraft, the Gray Eagle, which used in conjunction with GBSAA is thought to be the answer to many human factors issues. The Gray Eagle hails unprecedented reliability with triple-redundant avionics, flight controls and flight control surfaces (“Gray Eagle”, 2014). Additionally, in response to recorded human factors issues, the aircraft will have automatic takeoff and landing intended to reduce pilot workload.

Method

Methodology

Research Design. A quantitative research methodology will be utilized by examining data compiled by the FAA regarding human factors occurring on unmanned aircraft across the services. The purpose is to draw conclusions regarding the probability of variance among human factors incidents in unmanned airframes. A One-Way ANOVA test will be utilized to calculate the significance (sig. $< .05$) of variance.

Hypothesis. *Different airframes will vary significantly < .05 in human factors related incidents. In addition, it will be proposed this variance will assist the Army in becoming the first to receive release into national airspace.*

The results were identified to accept or reject the hypothesis that different unmanned airframes will vary significantly < .05 in human factors related incidents.

Limitations. Due to the relatively short duration of unmanned flight in relation to manned aircraft, a wealth of statistics has not been amassed. The data currently utilized has been collected from approximately 1986 to 2005. Time spans of data collected will differ per airframe.

Assumptions. The amount of data collected will be appropriate to prove the hypothesis as the time frame of the data is not significant to the research question. The data collected has been analyzed for the purpose of showing diversity among number of various incidents and not number of incidents in general.

Research Instrument

A database was constructed using Statistical Package for the Social Sciences (SPSS) (SPSS Inc., Chicago, IL) where each airframe was assigned an identification number and human factors incidents were entered into a table per airframe and incident type. The data set was partitioned to show incident frequency by type and airframe. A One-Way ANOVA was utilized to calculate the significance (sig. < .05) of variance among incident occurrences per airframe.

Results

Data Analysis

Data utilized was based on data collected for a report by Kevin W. Williams, PhD. entitled A Summary of Unmanned Aircraft/Incident Data: Human Factors Implications (Williams, n.d.). This data has been utilized industry wide in several reports for the purpose of comparing unmanned aircraft human factors incidents and is the most recent compilation of statistics suitable for this study. The purpose of utilizing this particular data was to compare variations among unmanned airframes for frequencies of similar human factors incidents. For this reason the factor of weather has been omitted from the data as an outlier as only one airframe has this category and data could be skewed. The data has been summarized in Table 1.

Table 1. SBSS Data

Airframe	Incident Type	IncidentFreq
1	1	1
1	2	2
1	3	1
1	4	7
1	5	3
1	6	3
2	1	2
2	2	2
2	3	2
2	6	2
3	4	46
3	5	7
3	7	9
4	2	1
4	3	2
4	4	1
4	6	6

Statistical Analysis Result. The frequency of human factors incidents was compared by airframe to yield significance in variation of .046. The criterion for statistical significance was (sig. <.05), therefore the research hypothesis has been confirmed and the null hypothesis rejected. It can be concluded there is significant difference among airframes in human factors incidents. Additionally, when data is entered into a graphical representation below, the difference in the Navy Pioneer airframe can be clearly seen and will be further analyzed for significance in the discussion. The analysis results are summarized in Table 2 and Table 3 below.

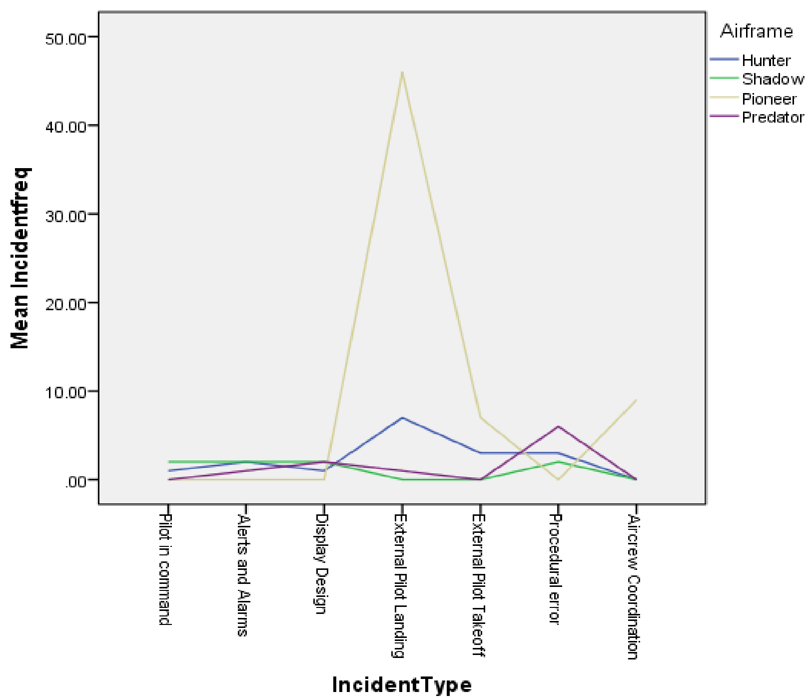
Table 2. Descriptives

Descriptives								
Incidentfreq								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Hunter	6	2.8333	2.22860	.90982	.4946	5.1721	1.00	7.00
Shadow	4	2.0000	.00000	.00000	2.0000	2.0000	2.00	2.00
Pioneer	3	20.6667	21.96209	12.67982	-33.8902	75.2235	7.00	46.00
Predator	4	2.5000	2.38048	1.19024	-1.2879	6.2879	1.00	6.00
Total	17	5.7059	10.67570	2.58924	.2169	11.1948	1.00	46.00

Table 3. ANOVA Results

ANOVA					
Incidentfreq					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	817.029	3	272.343	3.518	.046
Within Groups	1006.500	13	77.423		
Total	1823.529	16			

Figure 1. Incident Type per Airframe



Discussion

“One of the most dangerous forms of human error is forgetting what one is trying to achieve” (Nitze, n.d.). It was thought unmanned flight would resolve many human factors errors associated with manned flight. While perhaps some issues were resolved in regards to physical stressors brought on by the presence of a human being in the aircraft, many new human factors issues were introduced. A variety of unmanned airframes are being utilized by the different military services. In addition to unique human factors associated with unmanned flight in general, each airframe experiences a unique probability of certain human factors errors. This statistical variance among airframe errors is likely to drive the FAA to allow particular airframes into national airspace before others. The success the Army has experience with GBSAA and the Gray Eagle has this airframe poised as the first to receive such an allowance. In an article by Todd Lopez with the Army News Service, it was stated, “By March 2014, the MQ-1C Gray Eagle, an Army unmanned aerial system, or UAS, will be able to train in the same airspace as the Boeing 747, with the help of the Army-developed Ground Based Sense and Avoid system” (Lopez, 2012, para 1). While this has always been the ultimate goal of unmanned flight and it seems this achievement is on the horizon, it would be dangerous indeed to overlook the continued need for managing human error despite the environment.

Comprehensive Exam Question #2

Statement of the question

Computer Based Training (CBT) and Web Based Training (WBT) are quickly becoming an integral part of aviation training in all aspects. New and innovative aviation organizations are offering web based simulation training and some even claim to provide everything one may need to obtain a Sport or Private Pilot Certificate (Computer-based Instruction, n.d.). In response, the Aviation Industry Computer-Based-Training Committee and the Advanced Distributed Learning Initiative is developing the next generation online learning environment called the Training & Learning Architecture, or TLA, which is thought to provide learners with a richer and more innovative learning experience (Aviation Industry Computer-Based-Training Committee, n.d.1).This shift to online learning is thought to provide an adequate transfer of knowledge from the legacy training materials and traditional classroom training. Statistical evidence provided regarding the ability of these new training platforms to provide more effective and cost efficient training than the classroom environment is widely supporting this shift. Despite this trend, it has been suggested the single greatest impediment to the success of WBT is a low completion rate (Hawkins & Sener, 2007). Some of the reasons for this are suggested to be lack of organizational support, cognitive load factors, user proficiency with technology and lack of motivation. These considerations must be addressed in curriculum development for WBT to be successful. Additionally, memory and cognition play an important role in the success or failure of WBT. To address these shortcomings, hybrid instruction, a combination of WBT and traditional classroom training is becoming increasingly popular in the aviation community by allowing for personal communication in the classroom with the flexibility of an online component ("Georgia Northwestern Technical College", n.d.). This new training environment has largely influenced flight simulation training. Years have been devoted to enhancing flight simulators so as to provide pilots with a training environment as close to actual flight as possible. Current advances in CBT have proven to provide a more realistic flight training experience and are thought to be revolutionary in the industry. Can these advances in CBT overcome the low completion rates and provide an adequate transfer of training? The addition of flight simulation training for unmanned aircraft pilots has also altered the way engineers approach flight simulation. Consider the unique training requirements for unmanned flight simulation. Identify the characteristics of unmanned flight which are ideal for this training environment. Draw conclusions regarding the ability of CBT to successfully overcome the unique obstacles present in unmanned flight simulation.

Program Outcomes that will be addressed by this question:

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***qualitative research methodology*** will be utilized by analyzing the ability of WBT and CBT to offer an adequate transfer of training in relation to classroom instruction. The effectiveness of WBT and CBT platforms will be investigated for application in aviation training. Hybrid training, a combination of WBT/CBT and classroom training will be researched for the potential to close gaps in current WBT/CBT techniques. The ***hypothesis*** will be offered that CBT will provide successful transfer of training in flight simulation in the arena of unmanned flight. Evidence will show that current systems in unmanned flight simulation such as the Predator Mission Aircrew Training System (PMATS) are providing adequate transfer of training.

Program outcome #6

The student will investigate, compare, contrast, analyze, and form conclusions to current aviation, aerospace, and industry related topics in education technology, including computer based instruction, simulation systems, education foundations, curriculum development, continuing education, adult teaching and learning techniques, and memory and cognition.

ASCI 614 Advanced Aviation/Aerospace Curriculum Development and ASCI 652 Continuing Educations Role in Aviation were not part of the researcher's curriculum, accordingly these aspects will not be addressed in this examination.

The ***simulation systems*** aspects will be addressed by conducting research to legitimize or disprove the assertion of the AICC that TLA will innovate pilot training and provide a richer learning environment.

The ***computer based instruction and adult teaching and learning techniques*** aspects will be addressed by analyzing WBT techniques compared to traditional classroom instruction. The contrast between the two will be identified and further compared to hybrid instruction.

The ***memory and cognition and curriculum development*** aspects will be addressed by analyzing the human abilities of memory and cognition for the role both play in WBT and the effect to which these abilities determine the development of aviation curriculum.

The ***continuing education and education foundations*** aspects will be addressed by drawing conclusions from research regarding the ability of WBT to offer an adequate transfer of training in relation to classroom instruction, the effectiveness of the WBT platforms as it pertains to aviation training and the ability of hybrid training to close any potential gaps in current WBT techniques.

Computer Based and Web Based Training in Aviation

Introduction

Computer Based Training (CBT) and Web Based Training (WBT) can be used to teach almost any conceivable subject. One such subject where this technology has found innovative application is aviation education. CBT permits potential pilots to utilize flight simulation in ways never before conceived. This unique training environment offers a safe, cost effective and realistic way to train aviators. For years aviation educators have struggled to deliver a flight simulation training platform as close to actual flight as possible. CBT techniques have proven to provide a realistic flight training experience which enables an adequate transfer of training to the real world environment. Regardless of these advances, some concern still exists that CBT alone cannot alleviate the need for classroom instruction. For this reason, hybrid training, a combination of WBT/CBT and classroom training has been introduced to achieve a complete and adequate transfer of training. To ensure this is accomplished, organizations such as the Aviation Industry CBT Committee (AICC), have been established to "bring together aviation trainers, courseware developers, software vendors, simulator designers and airframe manufacturers to develop standards, technology recommendations and analyse best practices" (Aviation Industry Computer-Based-Training Committee, n.d.2, para 1). One such best practice has produced the Training & Learning Architecture (TLA), which has been hailed as the next generation learning environment (Aviation Industry Computer-Based-Training Committee, n.d.1). In addition to a next generation learning environment, CBT must advance with next generation aircraft. CBT and WBT, once only concerned with achieving realistic manned flight simulation, must now consider the ability to provide an adequate transfer of training in unmanned flight simulation techniques. This new arena of flight training has introduced unique training requirements not previously considered for standard flight simulation. One company, L-3 Communications, believes they have achieved the necessary transfer of training required for this type of flight simulation with the Predator Mission Aircrew Training System (PMATS).

Purpose

The purpose of the research is to identify the ability of aviation related CBT and WBT to provide an adequate transfer of training when compared to traditional classroom instruction. Additionally, the capability of hybrid training to close any potential gaps in the transfer of training will be ascertained. Current technology in the realm of unmanned flight simulation will be reviewed and evaluated for the capacity to surpass existing manned flight simulation to provide training as close to actual flight as possible.

Method

Methodology

A qualitative research methodology will be utilized by analyzing the ability of WBT and CBT to offer an adequate transfer of training in relation to classroom instruction. The effectiveness of WBT and CBT platforms will be investigated for application in aviation training. Hybrid training, a combination of WBT/CBT and classroom training will be researched for the potential to close gaps in current WBT/CBT techniques. Research will be conducted utilizing all available electronic means including web engine searches and ERAU Library Database. A thorough review of relevant literature will be performed and a conclusion included. The findings will be examined and a recommendation offered utilizing a critical thinking approach.

Review of Relevant Literature

Computer based instruction and adult teaching and learning techniques. One of the key principles of progressive education is that of new education methodology (Elias & Merriam, 2005). The need for new educational methodology can arise from a simple formative assessment of existing training techniques. The success or failure of any instructional design lies in the ability of the designer to translate knowledge to a student in a style most appropriate for absorption. This style will not and should not remain constant as training evolves. One such evolution has taken place in regards to adult education. A thorough understanding of adult learning motivators is necessary if training is to adapt for a diverse generation of adult learners. Adults possess a wide variety of characteristics not necessarily suited for traditional classroom instruction. The Rochester Institute of Technology has outlined many of these characteristics. Perhaps one of the most important in this case is that adult learners tend to seek educational opportunities that directly apply to their personal needs or job specialty (Rochester Institute of Technology, n.d.). Additionally, adults tend to be more self-guided in the learning process and appreciate a more hands-on approach. Lastly, adults have significantly less time available to spend in traditional classroom training due to busy schedules and full time employment.

One response to this assessment of adult learning characteristics has been the advent of CBT and WBT. This training venue has many advantages over traditional classroom training. First, CBT is self-paced and learners can progress at their own speed and repeat course content as many times as necessary for absorption (Teach, 2011). CBT can be delivered via the internet and accessed at home. Lastly, CBT can be designed for the workplace in direct relation to a specific position or career in general. All of these advantages make this educational setting appealing to adult learners. While this setting may certainly be advantageous to the adult learner, it is also very appealing to business. CBT and WBT can be very cost effective for an organization as instructional materials can be developed once and utilized to train large numbers of employees in a standardized way (Teach, 2011). This particular benefit is not only evident in the civilian corporate market but the military as well. The military is increasingly utilizing CBT to satisfy training needs. The U.S. army Research Institute stated, "the Army seeks to take advantage of the benefits offered by distributed learning, such as reduced travel costs, increased accessibility and improvements in learning (Wisher & Olsen, 2004, p. 1). Dr. Terrell Perry, a CBT developer and senior instructional systems designer with W R Systems, has developed over 246 CBT and WBT courses (Perry, 2000). Dr. Perry draws comparisons between CBT and classroom training in Table 1 below.

Table 1. Comparison of Multimedia versus Classroom Training

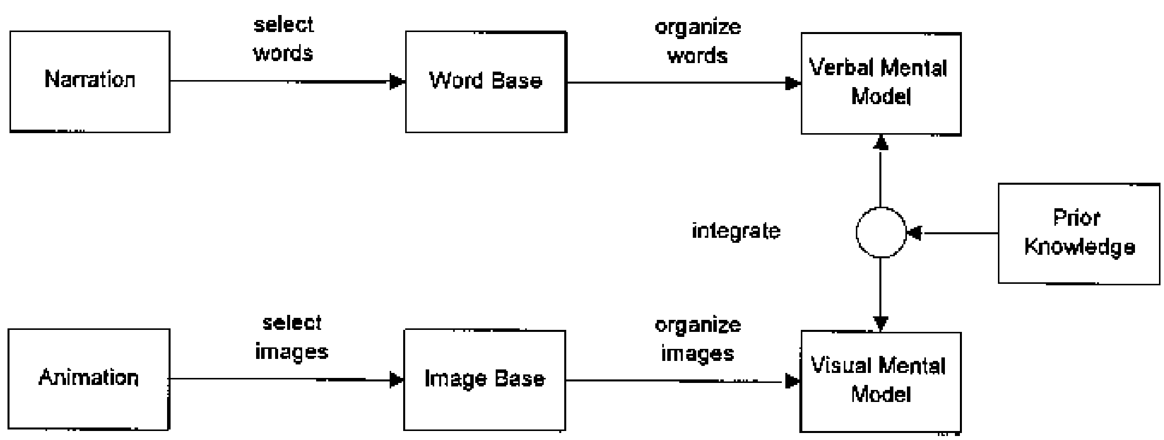
RATED FACTORS	CLASSROOM	MULTIMEDIA (INCLUDES CBT, CD-ROM, INTERNET/WBT)
Cost		
Cost Per Student	Initially lower at startup, but increases over time. Cost remains constant for each student, each time course is taught.	Has higher development cost, which declines as the number of students increases.
Cost of Training Resources	Equipment simulators and the associated classroom instruction have higher life cycle cost.	Multimedia simulations have comparable development cost, but much lower life-cycle cost.
Safety/Accident Prevention	Use of costly, dangerous, or scarce equipment in actual environment increases cost and number of accidents.	Use of computer simulations reduces accidents and reaches training goal through successive approximations to actual equipment and conditions.
Instruction		
Application of Instruction	Learning scheduled in discrete blocks, applied at later time after instruction.	Learning takes place in context, at the moment knowledge is required.
Consistency of Content and Instruction (Delivery Variance)	Depends largely on instructor's skill.	Consistently high, no variability in content or way course is taught.
Instruction/ Assessment of Higher Order Cognitive Skills	Better accomplished by classroom instructors.	Difficult to create applicable interactive methods on computer.

(Perry, 2000, pg. 1)

Despite all of these advantages, there are still issues that plague CBT. In some instances, training may require a security level regarding sensitive information that CBT cannot facilitate (Teach, 2011.). Additionally, there are some mechanical skills where it is necessary for the student to interact directly with a subject matter expert for demonstration and feedback. For these reasons, a blended learning or hybrid solution which incorporates the best of CBT and the face to face contact of classroom instruction is becoming popular. Graham Spanier, former President of Penn State University stated, “hybrid instruction is the single greatest unrecognized trend in higher education” (Gould, n.d., para 1). Hybrid instruction makes use of CBT for a significant amount of learning activities related to lecture (Gould, n.d.). Shifting this type of instruction from the traditional classroom environment to CBT allows the student to access the same instruction numerous times for reference and at their own pace. Additionally with enrollment growth, shrinking classroom space and budget constraints, institutions can maximize instruction in this way. The traditional classroom portion of instruction can be focused primarily on critical physical skills which require face to face contact, demonstration and hands-on training. By combining the strengths of both CBT and classroom instruction, organizations can design highly effective training.

Memory and cognition and curriculum development. Computer based learning environments provide a valuable venue for enhancing student understanding. Unfortunately, not all CBT is designed to promote meaningful learning. “Words and pictures are the two most common modes of representation and are central to dual-code theories of information processing” (Mayer & Moreno, 2000, pg. 2). Dual-code theory suggests that individuals use two distinct codes for mental representation of knowledge (Sternberg, 2007). These codes are imaginal (analogical) code and verbal (symbolic) code. One potential flaw that exists in regards to dual-code theory and CBT is presenting too many words or pictures at the same time can overload the student and hinder information processing. In order for meaningful learning to take place, students must be able to process relevant words and images and organize them into coherent information (Mayer et al, 2000). In contrast, if words and pictures are presented in a careful and strategic manner, the student can connect verbal and visual information which may result in superior absorption of knowledge. Figure 1 below provides a visual representation of this cognitive theory of multimedia learning.

Figure 1. Cognitive theory of multimedia learning



(Mayer et al, 2000, pg. 5)

When designing CBT it is imperative to consider this process of information absorption in relation to dual-code theory. The goal of the final product of instruction is to deliver information in such a way as to promote knowledge construction in the student (Mayer et al, 2000).

Aviation training and curriculum must also consider this cognitive theory in instructional development as verbal and visual associations are crucial in this environment. The majority of aviation instruction is sequential in nature (Quilty, 1996). Students must learn about checklists, flight theory, aircraft systems and federal regulations. This type of information is ideal for CBT as it can be taught in a repetitive nature. Dual-code theory will enter into consideration when it becomes necessary to intertwine this repetitive instruction with the visual task of flight training. Flight simulation training, another form of CBT, will encompass both verbal commands which must be enacted upon and visual processing in regards to stimuli such as altitude and horizon. Designers of CBT for this unique environment must weigh the delicate balance of crucial information processing and potential sensory overload.

Simulation systems. One group that is particularly concerned with the value of CBT designed for aviation is the The Aviation Industry Computer-Based-Training Committee (AICC). The "AICC provides and promotes information, guidelines, and standards that result in the cost-effective implementation of computer-based training (CBT) for the aviation industry and the worldwide training community" (Aviation Industry Computer-Based-Training Committee, n.d.1, para 7). AICC is currently working with a new and innovative technology called the Training & Learning Architecture (TLA). TLA is comprised of technologies that together will provide a richer learning environment (Freifeld, 2012). Most virtual training does not function appropriately with a web browser. This is particularly true when dealing with simulations in regards to aviation training. The majority of full-scale simulators do not have web browser interfaces. This makes it very difficult for instructors to track student progress, provide guidance during simulation or capture scores. TLA will change this dynamic by first focusing on capturing and recording flight simulation data which is necessary for effective training.

The ability to track progress, provide guidance during simulation and capture scores does seem to be evident in one area of simulation. The Air Force is currently utilizing a simulator for MQ-1 Predator and MQ-9 Reaper UAV's which appears to be the first step in bridging the gap that exists between simulation and the actual flight experience. The L-3 Communications

Predator Mission Aircrew Training System (PMATS), "accurately replicates mission environments Predator and Reaper aircrews experience in real world operations" (L-3 Communications, 2013, para 2). The system is pictured in Figure 2 below.

Figure 2. PMATS. Retrieved from Global Defense Media 2010.

When questioned about the ability of this system to do just that, Major Kristin Williams, a pilot instructor at the Flight Training Unit (FTU) located at March Air Reserve Base California, answered with a resounding "yes absolutely" (K. Williams, personal communication, June 10, 2011). The PMATS system utilizes an actual Ground Control Station (GCS) uploaded with L-3 Link software and a visual system database which provides for a high-fidelity environment encompassing all communications, operations, emergencies and environmental conditions experienced during flight (L-3 Communications, 2013). The system can be utilized for all stages of training from initial qualification to recurring maintenance of flight hours. The system appears to have mastered a sizeable concern TLA was incorporated to address, data sharing. The PMATS can enable aircrews to accomplish networked training encompassing a full range of mission scenarios. Additionally, the PMATS has conquered the ability to provide guidance during simulation. The system is integrated with and Instructor Operating Station (IOS) which affords the instructor the ability to “set exercise conditions, insert malfunctions, communicate with the aircrew and modify and control all aspects of the simulation” (Armed Forces International, 2010, para 6). Lastly, the PMATS has provided students the ability to view the mission they have just flown and with the assistance of the instructor, identify areas which need correction. It would appear the PMATS has functionally answered all technological questions raised by TLA and answered with a resounding yes absolutely!

Continuing education and education foundations. The principle concept underlying any form of training is the capacity of the instruction to transfer to the student and the student then having the capacity to transfer the knowledge into useable action. This process is referred to as transfer of training. If learning does not eventually equate to task performance and no transferrable skills are acquired, the training is for naught (Hahn, 2011). In aviation, flight simulation is a low-cost, low-risk environment in which to engage in this transfer of training. This type of computer based training has the ability to be quite successful in this process. In order to gauge the degree of success there must be a method for measuring the amount of training which has transferred. In regards to flight simulation there are a few viable options. One option suggested is to test student performance on a second simulator which more closely resembles the actual environment in which the trainee will fly (Hahn, 2011). While this may prove to be measurable, it still does not allow for testing complete transfer of training in the real environment. For this reason another option is to test the trainee in a mock real life situation. This may consist of training in an actual plane but in a controlled environment. A tool called the Semi-Automated Flight Evaluation System (SAFES) was designed to measure performance in this manner (Hahn, 2011). The SAFES is a device which monitors flight in the same way it would be monitored in a flight simulator. Flight exercises can be measured and compared to the students' performance previously demonstrated in the simulator. Despite use of this device, nothing is a better measure of training transfer than actual flight.

For complete transfer of training, instruction would ideally take place in the actual environment. In regards to flight simulation, the PMATS claims to offer a level of realism between simulation and real world which is transparent (L-3 Communications, 2013). By utilizing an actual GCS, students are essentially training in the real world environment in which they will eventually fly. The realistic training experienced with the PMATS offers complete transfer of training according to Major Williams (K. Williams, personal communication, June 10, 2011). This may be true but the complete process of training transfer in regards to the MQ-1 Predator UAV and the PMATS takes place in a hybrid environment. Students in Major Williams training unit receive a mixture of classroom training, simulator training and actual flight training. The total hours spent by pilots and sensor operators in each type of training can be seen in Table 2 below.

Table 2. Course Training Hours MQ-1 Predator

Type of Training	Basic		TX 1		TX 2	
	Pilot	SO	Pilot	SO	Pilot	SO
Academic Training	84.0	83.0	84.0	83.0	84.0	83.0
Device Training						
(Sessions)/Hours	(16)/40.5	(14)/36.0	(14)/35.5	(12)/31.0	(10)/26.0	(9)/23.5
Briefing/Debriefing	16.5	15.5	14.5	13.5	10.5	9.5
Flying Training						
(Missions)/Hours	(9)/20.0	(13)/26.5	(6)/13.5	(9)/18.5	(4)/9.5	(6)/12.5
Briefing/Debriefing	13.5	19.5	9.0	13.5	6.0	9.0
Total	**174.5**	**180.5**	**156.5**	**159.5**	**136.0**	**137.5**

(U.S. Department of the Air Force, 2008, p. 10)

The result of this hybrid approach upon graduation is a fully qualified pilot and sensor operator.

Conclusion

Aristotle once stated, "excellence is an art won by training and habituation. We do not act rightly because we have virtue or excellence, but we rather have those because we have acted rightly. We are what we repeatedly do. Excellence, then, is not an act but a habit" (Aristotle, n.d., para 1). If excellence is indeed won by training and habituation then the gauge for this excellence would be transfer of training. The purpose for successful transfer of training is for a task to ultimately become second nature or habit and habits are generally formed through repetition. CBT is an ideal venue for training of a habitual nature as the student has access to the same instruction numerous times. A task can be trained and repeated ad nauseam. In aviation flight training the simulator has been utilized for this purpose. One flight simulator in particular, the PMATS, which is a UAV flight simulator, has proven successful in creating training transparent to the eventual real world experience. This simulator combined with classroom instruction and actual flight training form a hybrid instruction which results in complete transfer of training and therefore, excellence!

Comprehensive Exam Question # 3

Statement of the question. Many companies in the air cargo industry have alluded to the fact that survival depends on getting the basics right (Schaecher, 2011). Basics such as technology and communication, managing globalization of trade and adapting to environmental policies are shaping the industry. This poses many challenges because air cargo is largely reliant on the globalization of trade, political instability is a consistent threat and environmental catastrophes will always exist. All of these considerations provide the potential for a modal shift to sea. Additionally, the ever increasing homeland security concerns have led the air cargo industry to re-evaluate the way business is conducted (Department of Homeland Security, 2012). In response, many technological advances have been made available to the industry for use in overcoming global transport. New technologies such as Radio Frequency Identification (RFID) are proving successful for tracking purposes. Security concerns are paving the way for an advance screening strategic plan which is thought to enhance risk-based targeting and streamline customs entry requirements. Globalization and airline regulation have driven not only technological but environmental changes to the air cargo industry (Schaecher, 2011). Legislation on carbon is becoming a market restriction and a cost factor. This is driving the industry to find innovative ways to reduce carbon emissions to remain in compliance. Current Revenue Ton Miles (RTMs) combined with predicted decreases in jet fuel costs is one way this stress is being alleviated. Yet another consideration in regards to globalization is the air cargo industry role as a key player in the world economy. Air cargo is responsible for carrying approximately 40 percent of world trade (Coyne, n.d.). Because it is growing more rapidly than the passenger business, the world economy will need air cargo to prosper. This will present challenges to develop programs which provide more efficiency. One response is the trend toward just-in-time logistics intended to reduce the need to store excessive levels of material in a warehouse. These changes in inventory management practices and production line innovations are predicted to provide more efficient, cost effective and customer responsive effects on new time-sensitive products in the global market. Examine the impact these changes toward production flexibility will have on air cargo operations. Identify the political and social implications of globalization on the air cargo industry? Draw conclusions regarding the financial impact of logistic changes on the industry as a whole. Investigate the extent to which regulation will restrict air cargo profitability. Can the air cargo industry overcome the impacts of globalization and regulation?

Program Outcomes that will be addressed by this question:

Program outcome #1

Students will be able to apply the fundamentals of air transportation as part of a global, multimodal transportation system, including the technological, social, environmental, and political aspects of the system to examine, compare, analyze, and recommend conclusion.

The ***technological*** aspect will be addressed by exploring advances in technology specifically in the air cargo industry. Opportunities to adopt technology for tracking shipments such as Radio Frequency Identification (RFID), how this technology could potentially improve security and the potential for this ability to win over regulators (Schaecher, 2011).

The ***social*** aspect will be addressed by researching the importance and reliance on air cargo in regards to the production and procurement of goods. The effects and strategic impact of the possibility for more local procurement of goods versus air cargo utilization will be explored. The potential for economies opting for a modal shift in market procurement will be analyzed (Schaecher, 2011).

The ***environmental*** aspect will be addressed by researching the impact of legislation on carbon in the air cargo industry as it becomes more restrictive and cost of complying becomes an ever increasing factor. Conclusions will be drawn regarding the ability of the industry to adapt to changing legislation and more restrictive regulation (Schaecher, 2011).

The ***political*** aspect will be addressed by conducting research to analyze the effects political instability consistently imposes on the success of the globalized air cargo industry. In addition, the ever changing price of fuel in the global economy will be explored to show the impact this fluctuation can place on the air cargo industry and how this can impact oil production (Schaecher, 2011).

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***qualitative research methodology*** will be conducted to identify the effect globalization has on both political and social aspects of the air cargo industry. The impact political instability will place on the success or failure of cargo transport will be analyzed. Additionally, the ability of the air cargo industry to comply and adapt to current and future regulation and the lasting effect it will have on the globalization of air cargo will be compared. The ***hypothesis*** will be offered in which the economic future of the air cargo industry based on regulatory compliance, predicted fuel prices, technological changes and environmental adaptation will be favorable.

The Future of the Air Cargo Industry

Introduction

In North America, air cargo is defined as “anything other than persons or personal baggage traveling by air” (Keskinocak, Mutawaly & Popescu, n.d., p. 2). Air cargo is the most recent addition to freight shipment when compared to ship, rail or ground vehicles. Despite the late start in the freight sector, air cargo has become vital to the world’s economy. In the early stages, air cargo was largely limited to mail delivery (Keskinocak et al, n.d.). Currently, with globalization of trade, e-commerce and advanced logistics, the industry ships everything from perishable goods to medical and pharmaceutical products. Virtually any kind of product can be transported via air cargo. Boeing has predicted that due to an ever developing global economy, the air cargo industry stands to triple in the next twenty years (Keskinocak et al, n.d.). Notwithstanding this prediction, the industry also has many concerns to overcome. Air cargo was plagued with the financial crisis of 2009 which affected all sectors of the economy. The recovery from this downturn has been slow and methodical. Additionally, rising oil and fuel prices have severely cut into the industry bottom line. Ever increasing environmental concerns have placed industry like air cargo in the spotlight for more efficient use of resources. New regulations are being enforced every year which are introducing additional pressure to reorganize. Developing political uncertainty around the world has hindered growth of global trade in affected areas. Lastly, new safety and security concerns brought on by events post 9/11 are changing the way everyone does business. The air cargo industry hopes to manage and recover from these hindrances through technological advancement. Ideas such as just-in-time logistics to reduce excess storage, Radio Frequency Identification (RFID) to better track shipments and provide upgraded security, and more efficient fuel use to address the need for reduced carbon emissions, all prove to once again provide the industry with an advantage. Air cargo carriers will need to address all concerns if the industry is to remain viable in a global market which relies so heavily upon it.

Purpose

The purpose of the research is to determine how the air cargo industry has and will continue to adapt to technological, social, environmental and political changes. Transformation necessary to succeed in an ever increasing global market guided by more restrictive regulation will be identified. Predictions will be made regarding the future of the industry in response to these adaptations.

Method

Methodology

A qualitative research methodology will be conducted to identify the effect globalization has on both political and social aspects of the air cargo industry. The impact political instability will place on the success or failure of cargo transport will be analyzed. Additionally, the ability of the air cargo industry to comply and adapt to current and future regulation and the lasting effect it will have on the globalization of air cargo will be compared. Research will be conducted utilizing all available electronic means including web engine searches and ERAU Library Database. A thorough review of relevant literature will be performed and a conclusion included. The findings will be examined and a recommendation offered utilizing a critical thinking approach.

Review of Relevant Literature

Technological. In the quest to become more efficient in trying times and more secure in a post 9/11 world, the air cargo industry is moving toward RFID technology. RFID, also referred to as passive UHF RFID, is one of many available automatic identification technologies. ("Guidance on introducing", 2013). The underlying goal of RFID is speed and accuracy of data collection. The necessary equipment consists of a wireless tag which utilizes radio-frequency technology to store data which can later be read or retrieved from a reader that interrogates the chip. In the case of the passive RFID technology, the tag has no battery and requires no onboard power source allowing it to potentially last indefinitely. An example of an RFID tag can be seen in Figure 1 and a reader in Figure 2 below.

Figure 1. RFID Tag. Retrieved from siongboon.com 2012.

Figure 2. RFID Reader. Retrieved from Barcoding Inc 2014.

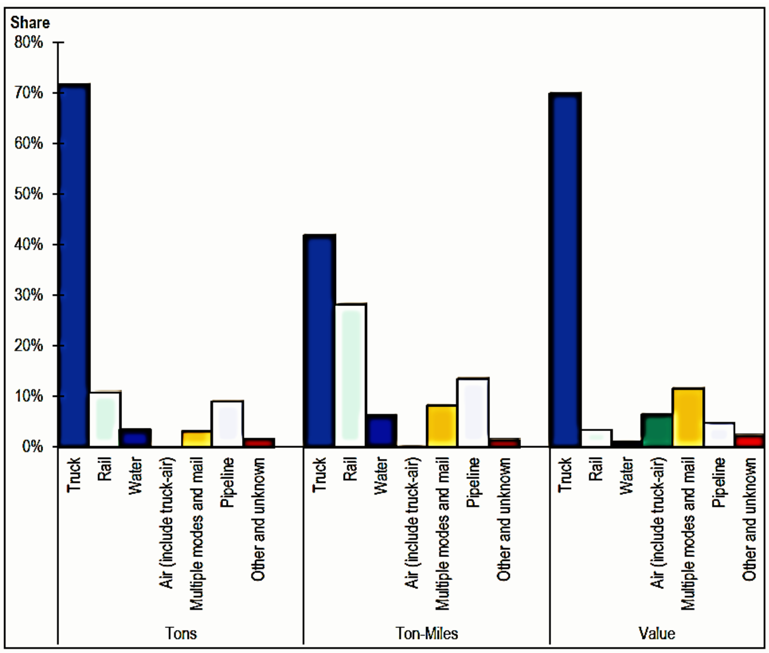
While the tag in figure 1 may appear relatively large in size, it is actually about the size of a grain of salt. Despite its small stature it is quite sophisticated. When a reader sends out a query, the tag will listen first to ensure it does not talk over other tags. Should this occur, both tags will stop response and attempt another response in a random amount of time. This allows for the reader to query hundreds of tags in one second.

This technology is providing the air cargo industry tremendous cost benefits. Cargo companies can reduce operational costs by efficient utilization of ground handling assets such as Unit Load Devices (ULDs) or pallets (Pandit, 2007). Many air cargo companies lose revenue due to poor tracking of ULDs. Utilizing RFID technology to track the ULDs provides a level of accuracy regarding location data which results in significant savings. This cradle to grave accountability leads to more rapid turnover of assets, increased utilization rates and reduced inventory. While this technology could revolutionize the industry, it will still require buy in globally to function efficiently. It would be necessary to install interrogators at all major airports around the world. In addition, there would need to be a host database from which all airlines could access ULD information. This global rollout would require a significant initial investment. Lastly, an industry standard would need to be developed which could be agreed upon by all regulatory agencies. Ultimately, RFID technology is still a better business model for tracking ULDs.

Another significant advantage RFID technology can provide is increased security in an industry which must comply with new Federal Aviation Administration (FAA) standards. Allowing security personnel the ability to identify container content at any point in the supply chain is a huge asset. One company making huge strides in the security of cargo is a company in the Netherlands called Advanced Composites Engineering Company (Hilders, n.d.). They have designed a “durable, re-useable, collapsible lightweight air cargo container that combines security and multi-modality with multi-purpose effectiveness” called the Cargobox (Hilders, n.d. para 8). The Cargobox claims to provide secure code locking and unlocking, state-of-the-art RFID technology with near real time visibility and damage and pilferage prevention. Furthermore, the company claims to have FAA approval in progress. Considering the overall goal of RFID technology is cradle to grave tracking, this organization is very close to bringing the RFID vision to fruition.

Social. The air cargo industry has much more to contend with in the future than technological advancements. Another ever-present threat to financial success is the potential for a modal shift in cargo transport. As demand for goods and products steadily increases throughout the world and as companies shift to just-in-time supply chain management, organizations that move freight are consistently vying for a larger piece of the pie. Currently freight can be moved by one of four modes, truck, rail, air and water (U.S. Department of Energy, 2013). Freight transport, no matter the mode, is generally measured in tons, ton-miles and value of goods. The break-down of each modes share of this transport in 2010 can be seen in Figure 3 below.

Figure 3. Freight mode shares. Retrieved from U.S. Dept. of Energy 2013.



Air transport is included in columns labeled as air (include truck-air) and multiple modes and mail. The reason presented at this time for the relatively low share of air transport is mainly cost. Despite the comparatively high price, air cargo does present some advantages. Should cargo be of a time-sensitive nature, air transport provides the fastest delivery relative to the distance of the customer. In addition, despite the fact that total volume of air cargo appears to be significantly lower, the average shipment value is actually much higher.

There are many factors which can affect modal choice of freight shipment. In the realm of modal characteristics, companies may look at time constraints, capacity of the shipment, availability of equipment and customer service (U.S. Department of Energy, 2013). Considerations are also made for commodity characteristics such as shipment size, shelf life, value and density. In regards to logistics, companies must consider access to modes, cost, reliability and length of haul. One final consideration may be if the shipment requires a particular level of security. These factors will all influence any potential modal shift.

One of the largest factors influencing modal shift is price (U.S. Department of Energy, 2013). Unfortunately, price has very limited potential to result in a modal shift to air transport. Growth projections in freight movement show air freight market share increasing from .08% to .2% by weight but significantly higher by value from 8% to 16%. This is still relatively low in comparison to other available modes. The factors which have the ability to provide the most influence on modal shift to air transport remain that it is the fastest, most reliable and most visible of all available modes. Additionally, air transport has an edge in regards to high-value, high security cargo which may be time-sensitive in nature. Lastly, with the continuing shift toward a more global market and economy, air transport has a significant advantage over sea transport in all of these factors excluding price.

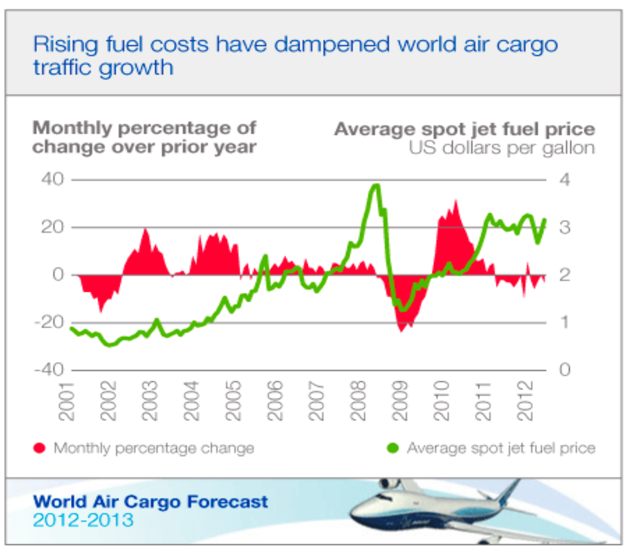
Environmental. Price is not only a concern for consumers; it is also a driving force within the air cargo industry. While oil prices may be motivation to pursue alternative fuels, air cargo is also sensitive to environmental concerns. The International Air Cargo Association has responded to both fuel consumption concerns and environmental issues posed to the industry. It is currently reported that aviation is responsible for approximately 2% of man-made Carbon Dioxide (CO2) emissions (The International Air Cargo Association, n.d.). This number is expected to climb to 3% by 2050. The industry has answered this data with a commitment for carbon-neutral growth by 2020. One way in which air cargo intends to keep this commitment is by utilizing biofuel. In an effort not to displace food crops, the intention is to develop sustainable fuels with plants and algae. Aircraft that employ these types of fuels only release carbon which is absorbed by feedstock plants and therefore achieve carbon-neutral growth. Additionally biofuels are much less susceptible to geopolitical instability and price spikes.

Another way in which the industry intends to reduce CO2 emissions is by working toward more efficient flight (The International Air Cargo Association, n.d.). The next-generation air traffic system has the ability to allow for more direct routes which will significantly reduce fuel consumption and contribute to a reduction in greenhouse gas emissions. It is currently estimated these reductions could provide a 12% decrease in both consumption and CO2 emissions. NextGen is already being successfully employed in many locations, including the United States by United Parcel Service (UPS) (NextGen, n.d.). UPS not only gives newly adopted NextGen technology credit for a decrease in greenhouse gas emissions, the company claims the advances will allow for a 30% reduction in aircraft noise footprint (Pew, 2008).

Clearly air cargo is responding to regulation regarding imposed noise restrictions enforced by the FAA (The International Air Cargo Association, n.d.). FAA guidance on airport noise can be located on 14 CFR Part 150 under environmental policy and guidance (Federal Aviation Administration, 2014). This guidance is in response to the Aviation Safety and Noise Abatement Act of 1979 which authorized the FAA to set standards for aircraft noise. In response to the demand for more efficient freight aircraft which not only met but exceeded these standards, Boeing developed the 787 Dreamliner. Boeing boasts this new airliner will have an approximately 60% smaller noise footprint than similar aircraft (Choi, 2011). Credit for much of this improvement was given to the addition of new generation engines such as the Rolls Royce Trent 1000. Additional design improvements receiving recognition were advanced acoustic linings, new engine inlets and nozzles and more aerodynamic lightweight composite materials. Mark Sandstrom, a Boeing noise engineer, stated, “if you climb higher on the same amount of energy and fuel, you've gotten further away from ears and microphones” (Choi, 2011, para 9). The freighter version of this airframe will be the 787-9 scheduled for first delivery in 2014.

Political. One of the greatest hindrances to air cargo transport over the past decade has been fuel prices (Boeing, 2014). Jet fuel prices have nearly tripled over the past 8 years. The effect this has imposed on air cargo traffic growth can be seen in Figure 4 below.

Figure 4. Rising fuel cost and air cargo. Retrieved from Boeing 2014.



There is some light at the end of the tunnel. Despite the spikes experienced the last several years, prices are predicted to remain around mid-2012 levels or even potentially decline over the next 3 to 5 years (Boeing, 2014). Global instability has played a large role in the rise and fall of oil prices. Any perceived or actual political or natural instability affects the ability of oil producers to supply the market (LeVine, 2013). It is this sparse supply that drives prices upward. The reason the next few years look favorable is due to what is forecasted to be spare capacity in the oil market.

Oil prices are not the only global issue affecting the air cargo industry. Globalization of trade has completely changed the dynamic. An ambitious organization must consider where it fares in the world economy rather than simply the national realm. As relationships improve between governments, trade agreements and open skies agreements are opening up world trade like never before. New concepts in supply chain management which thrive from the move to globalized trade are heavily reliant on air transport as the modal venue to success. Lawrence H. Summers, former U.S. Department of Treasury Secretary, was quoted by the Bureau of Transportation in 2000 as stating, "transportation is the industry that connects other industries...it is the key to globalization" (Department of Transportation, n.d., para 6). If the globalization concept is to be successful, it will depend on the ability of nations to trade materials and goods. When considering something as simple as a commonly used piece of electronics such as a television, a staggering number of items must be transported for one television to arrive on a store shelf. One television manufactured in China will rely upon shipments of numerous parts and supplies for its construction prior to any realized shipment of the end product. At every step in the evolution of the television from manufacturing facility in China, to a warehouse in the United States and finally to the living room of a consumer, transport must be factored. The end product can realize the dream of becoming the center of family entertainment by one of two modes, by sea and by air. Should the product travel by sea, it will take a considerable amount of time to arrive. Additionally, this particular type of cargo, electronics, is considered a high value item which is not ideally suited for travel by sea. Air transport accounts for approximately 40% of the value of international trade (Rodrigue, 2007). One of the reasons for this high percentage is goods with a high value to weight ratio such as electronics. Many similar items being manufactured all over the world are accounting for a surge in international air transport. This surge has driven a rise in specialized cargo-only air transport companies becoming the dominant figure in globalized air shipment.

Conclusion

"A truly global firm in 2020 should have the ability to be domestically relevant to consumers in both developed and developing markets at the same time" (Nagpal, n.d., para 23). The air cargo industry is not immune to this necessity in an ever-growing globalized economy. In an effort to become a truly global industry, air cargo will need to consistently adjust how business is conducted to meet consistently changing market needs. Air transport organizations must continue to adapt to technological, social, environmental and political changes. In a post 9/11 global market security has become paramount. It has driven a rise in regulatory compliance not witnessed since deregulation of the airline industry. Air cargo companies have responded with RFID technology which has allowed for increased security in every part of the supply-chain. Additionally RFID technology has enhanced the efficiency of supply-chain management allowing the industry to remain viable in the global economy. This is not the only response necessary to sustain position. Air transport companies must consider the potential for a modal shift to sea transport. The response is to cater to what the industry does best, move high-value items globally and more rapidly than sea transport can accommodate. Furthermore, air cargo companies must deal with increased pressure from the global community to address environmental issues such as CO2 emissions. Companies throughout the industry have responded with new efficient aircraft fleets which can be fueled by alternative means such as biofuels. Lastly, but certainly not the least important, is the consistent threat looming over air transport of rising fuel costs. These costs are often beholden to political and natural occurrences. Regardless of this fact, due to an impending surplus in global spare capacity of oil, the next few years look favorable. The air cargo industry response and adaptation to all factors presented which have potential to impede the organization, coupled with the growing reliance on air transport in an expanding global economy, forecast a promising future.

Comprehensive Exam Question # 4

Statement of the question. It is widely believed in the aviation industry that NextGen technology will make the skies safer and less congested (“NextGen Technology,” n.d.). National economic success and air traffic growth are purported to hinge upon the success or failure of NextGen incorporation. This new immerging technology is intended to enhance safety and efficiency by utilizing satellite communication technology versus the current ground based radar. Current air traffic control technology has been determined to be antiquated for increasing air traffic control demands and imposes significant cost to the airline industry and society in general. The forecasted increase in operations over the next decade cannot be sustained by the system in place. NextGen technology is believed to address this as well as many additional concerns. A few of the acknowledged benefits are improved operational efficiency, reduced fuel consumption, lower emissions and operating costs. NextGen has the potential to increase capacity by more precisely spacing aircraft and increase productivity by flying more direct routes which will directly impact fuel consumption. The overall benefits of implementing NextGen technology are intended to outweigh the suggested financial impact on global organizations (Schank, 2013). In addition to gains in efficiency, NextGen has environmental benefits to consider. Fuel efficiencies introduced by direct routes can contribute to a reduction in greenhouse gas emissions. Lastly, and perhaps most significant, the technology will improve safety. NextGen will allow pilots to enjoy better situational awareness by providing a more enhanced picture of where they are in the airspace with respect to other aircraft. The system is already being successfully utilized in many locations, including here in the United States by United Parcel Service (NextGen, n.d.). This will lead to social impacts regarding multimodal intercity planning and national policy. One such impact is the implementation of Ground-Based

Sense and Avoid (GBSAA) technology being researched by the military for use with unmanned aircraft. Research and determine the overall impact of NextGen technology in terms of safety, environmental benefits and financial gains. What affect will the release of NextGen have on GBSAA implementation? Examine the potential effect NextGen will have on the certification process and new training requirements imposed on pilots. Determine the social impact it may impose on the number of regional air traffic control centers and the local politicians fighting for the centers to remain.

Program Outcomes that will be addressed by this question:

Program outcome #1

Students will be able to apply the fundamentals of air transportation as part of a global, multimodal transportation system, including the technological, social, environmental, and political aspects of the system to examine, compare, analyze, and recommend conclusion.

The ***technological*** aspect will be addressed by examining and comparing NextGen technology to the current air traffic control technology. A determination will be made regarding the ability of NextGen technology to successfully replace current technology by examining locations where NextGen is already in use.

The ***social*** aspect will be addressed by examining NextGen technology for its potential impact on the global economy. The affects upgrades can have on global oil consumption and the feasibility of upgrade costs versus benefits will be analyzed and weighed.

The ***environmental*** aspect will be addressed by researching the impact NextGen technology can have on greenhouse gas emissions compared to current levels based on existing data. Current airlines and regions utilizing NextGen technology will be examined for environmental impact in those regions and conclusions will be drawn regarding environmental impact on a global scale.

The ***political*** aspect will be addressed by analyzing the potential reduction in current regional air traffic control centers for impact on facility closures and job loss. Current congressional push back regarding these potential closures will be examined and conclusions will be drawn regarding future congressional actions.

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

A ***qualitative research methodology*** will be utilized to evaluate the ability of NextGen technology to reduce congestion in the skies, potential environmental impact on a global scale, and future congressional actions regarding possible closure of regional air traffic control centers and job loss. The impact of the technology in regions currently utilizing NextGen will be investigated and problems with implementation on a global scale will be identified. The ***hypothesis*** will be offered in which NextGen technology will significantly reduce delays and environmental impact.

The Impact of NextGen Technology

Introduction

Globally, air travel is on track to nearly double over the next 20 years according to the Federal Aviation Administration (FAA) (Karp, 2012). As demand for limited airspace continues to expand the current air traffic control system will be overwhelmed and insufficient. The current antiquated system will stifle any potential growth to air travel. If any growth is to be sustained, this technology must be upgraded. Additionally, this new technology must address more than congested skies. New advancements must take into account fiscal hindrances, safety of passengers and crew and environmental concerns. NextGen technology has the ability to address all of these issues and many more. NextGen will purportedly transform the current National Airspace System from a ground-based system to a satellite-based system of air traffic control (Federal Aviation Administration, 2013b). The benefits from this transformation will result in a better travel experience for passengers, economic vitality for the industry and enhanced safety overall. The skies stand to become less congested due to more direct routes. These more efficient routes will result in increased efficiency and less fuel consumption. Less fuel consumption results in cleaner skies and less impact on the environment. Lastly, enhanced communications between air traffic controllers and crew will result in better identification of potential hazards. Overall, NextGen contributions to air travel on a global scale will be tremendous. Despite the potential success, the move to NextGen technology will pose some challenges. Pilots and air traffic controllers will have to be trained to utilize the new systems. New automation means new equipment to master in the cockpit. This equipment must be standardized and take into account numerous cultural backgrounds if it is to be effective on a global scale. If these challenges can successfully managed this proposed overhaul to the current air traffic control system will be an industry game changer.

Purpose

The purpose of this research is to identify all potential benefits NextGen technology can provide nationally and on a global scale. Benefits related to necessity of technological advancement in current air traffic control, global fiscal impact, environmental challenges and current political atmosphere will be investigated to analyze the influence each will have on the implementation and future success of NextGen technology.

Method

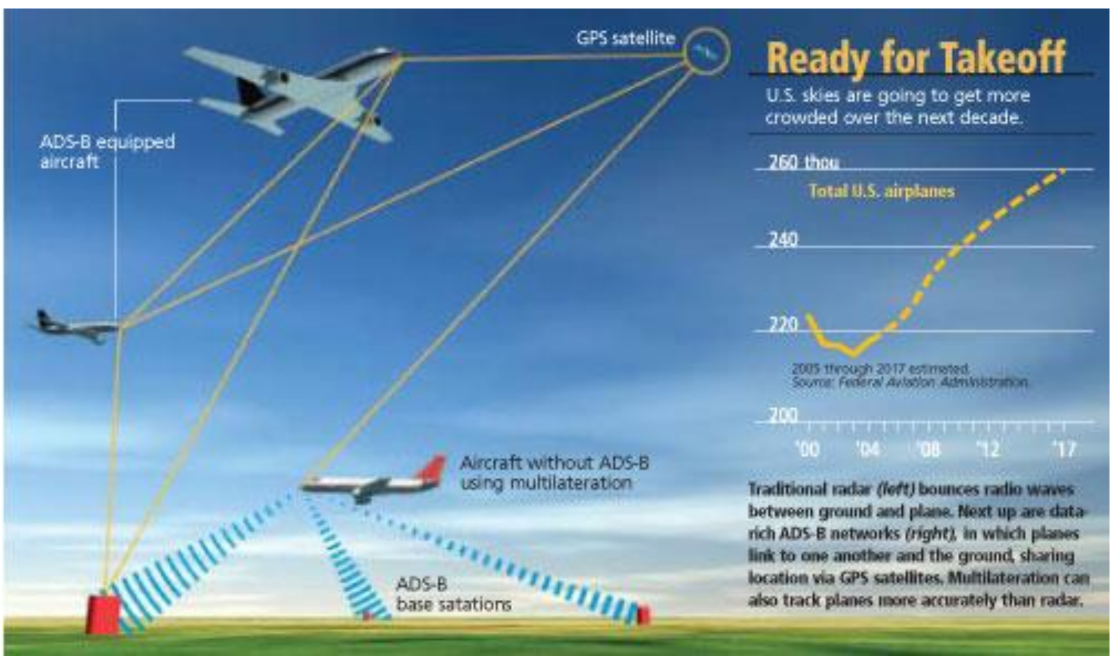
Methodology

A qualitative research methodology will be utilized to evaluate the ability of NextGen technology to reduce congestion in the skies, potential environmental impact on a global scale, and future congressional actions regarding possible closure of regional air traffic control centers and job loss. The impact of the technology in regions currently utilizing NextGen will be investigated and problems with implementation on a global scale will be identified. Research will be conducted utilizing all available electronic means including web engine searches and ERAU Library Database. A thorough review of relevant literature will be performed and a conclusion included. The findings will be examined and a recommendation offered utilizing a critical thinking approach.

Review of Relevant Literature

Technological. The current technology available in air traffic control simply cannot sustain predicted growth over the next 20 years. This system depends on radar, a series of ground beacons and radio communication between pilot and air traffic controllers (Mayerowitz, 2009). Essentially, controllers radio pilots regarding direction and altitude and guide them from ground-based way-point to ground-based way-point. The biggest issue is the lack of precision this system affords. While air traffic controllers have data in regards to aircraft location, it is not 100% accurate. Additionally, this way-point to way-point system of flying is not efficient as these routes are many times not the most direct. In terms of safety, it is not that the current system is not safe, but the sacrifice for safety is substantial losses in speed, efficiency and fuel. Figure 1 below depicts the difference between current ground-based radar and the Automatic Dependent Surveillance-Broadcast (ADS-B), a modernized system related to NextGen technology.

Figure 1. Ground based radar vs. ADS-B. Retrieved from FAA 2014.



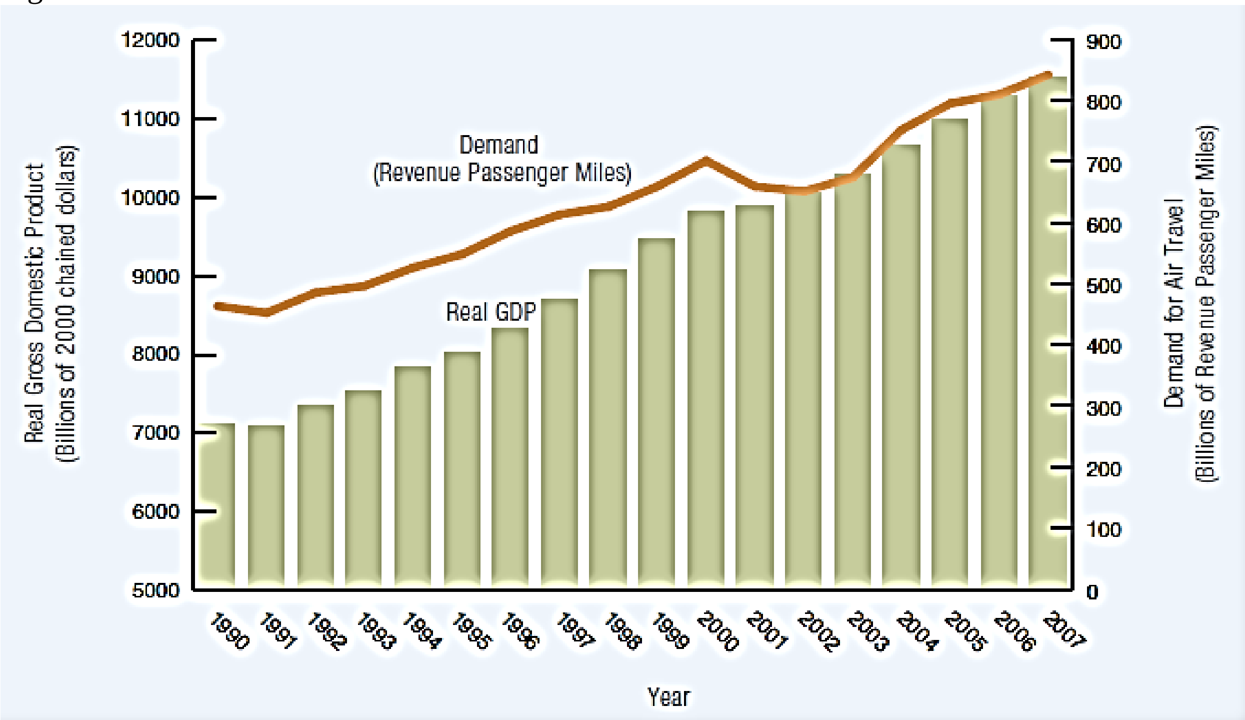
ADS-B, which allows far better precision over a larger percentage of the earth's surface, represents the beginning of the move with NextGen technology to a satellite-based Global Positioning System (GPS) (Richards, W. R., O'Brien, K. & Miller, D. C., 2010). ADS-B utilizes a system of satellites, transmitters and receivers to better inform crews about specific location and speed of aircraft. The system works at low altitudes and on the ground allowing it to additionally monitor traffic on runways and taxiways. A substantial benefit is the system also works in areas which have limited or no radar coverage. As of February of 2013, more than 500 ADS-B ground stations had been deployed (Federal Aviation Administration, 2013c). Saturation of this system throughout the network is forecasted for the year 2020.

Another up and coming system which NextGen must consider is the use of Ground Based Sense and Avoid (GBSAA) technology. This system, primarily designed for use with unmanned aerial vehicles, utilizes three-dimensional radar and sensor inputs, data fusion and software algorithms to provide for collision avoidance (Carey, 2012). While the GBSAA system addresses current issues for unmanned aircraft in regards to flying in national airspace, it must also consider the ability to adapt in the new NextGen environment. One technological upgrade which proposes to overcome this challenge is to potentially equip the unmanned vehicles with the same global positioning system transponder that will be utilized in NextGen aircraft (Government Accountability Office, 2012). The far reaching goal is for the unmanned systems to also utilize the ADS-B sense and avoid technology, but for the time being the GBSAA is being successfully tested.

NextGen will also rely heavily upon another technology called Performance Based Navigation (PBN). This system has been referred to as the "mainstay of the Next Generation Transportation System" (Federal Aviation Administration, 2013d, para 1). The technology purportedly is responsible for the majority of the benefits provided by NextGen. PBN utilizes Area Navigation (RNAV), which consist of performance-based sensors or procedures like GPS for greater precision and flexibility of flight path. A combination of RNAV and redesigned airspace are set to greatly increase efficiency in the current system. In the FAA implementation plan released in 2013, three sites were on track to complete implementation of these systems during the fiscal year, Houston, north Texas and Washington D.C. (Federal Aviation Administration, 2013c).

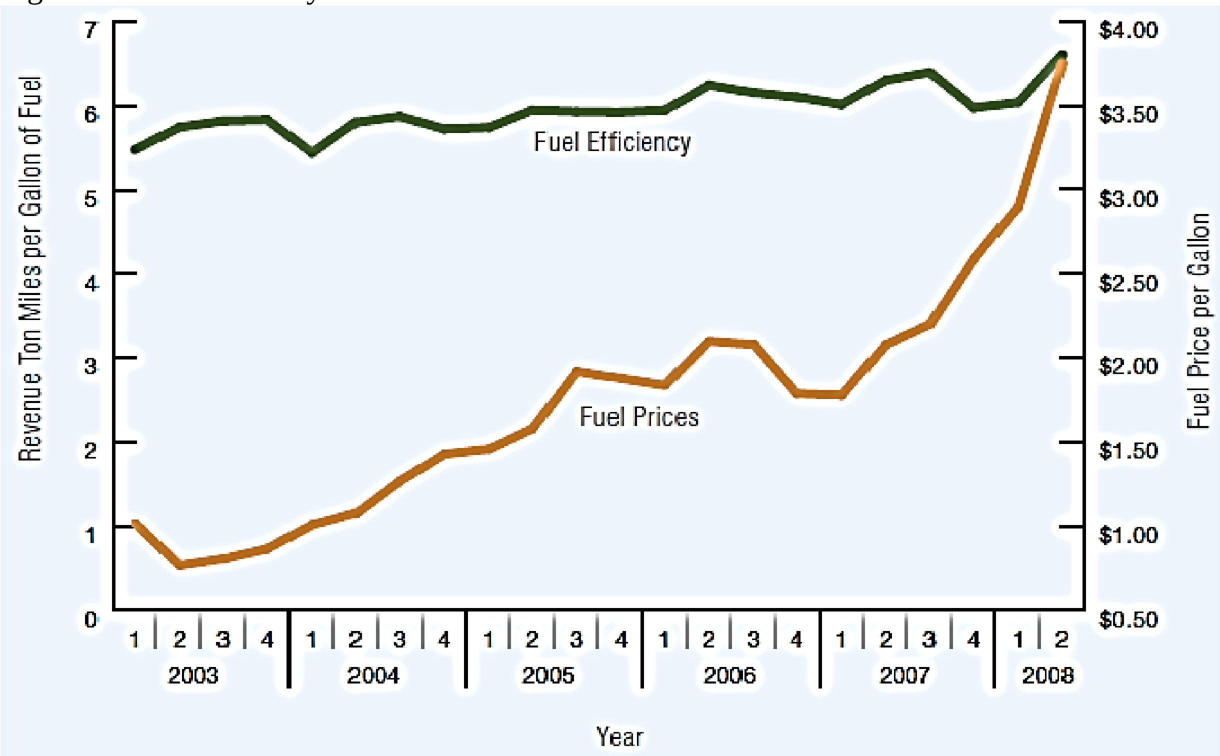
Social. The success of the aviation community is tightly woven into the fabric of the U.S. economy. The Gross Domestic Product (GDP), the market value of all goods and services produced in a country, has a significant effect on air transportation (Federal Aviation Administration, 2008). As GDP in the U.S. increases, the demand for all services, including air transportation, also increases. Unfortunately, the same opposite but negative reaction can also occur. Figure 2 below illustrates the close link between GDP and the demand for air travel.

Figure 2. Real GDP and Demand for Air Travel. Retrieved from FAA 2008.



One significant factor which can influence GDP is the economies productivity (FAA, 2008). The efficiency with which any economy handles and produces goods and services can enhance productivity. NextGen technology is in a position to substantially effect productivity in air transportation. Productivity improvements will be seen with the increased use of automated services for communication, navigation and surveillance. Technology such as ADS-B and PBN will enable crews and air traffic controllers to handle more traffic safely and efficiently. Additionally, NextGen technology will have a significant impact on fuel economy. While this fuel savings may have a negative impact on the amount of oil consumed and purchased in the nation, one noteworthy enhancement will affect GDP positively. As the air industry begins to burn fuel more efficiently, it will have the economic flexibility to increase the number of passengers and freight transported. Increased numbers of passengers and freight means increases in products and services. Since GDP is directly affected by increases in products and services, these improvements are significant to the U.S. economy. Figure 3 below illustrates the direct correlation between fuel efficiency, fuel prices and airline revenue.

Figure 3. Fuel Efficiency vs. Fuel Prices and Revenue. Retrieved from FAA 2008.



The largest negative economic impact of NextGen to the air transportation community initially will be investment. According to the FAA, costs related to NextGen over the first decade is expected to range from $8 billion to $10 billion and continuing through the year 2025 costs will increase to $15 billion to $22 billion (FAA, 2008). The majority of these costs will be related to infrastructure and will undoubtedly place a burden on the industry. Regardless of this initial strain, the FAA predicts the financial impact of not implementing NextGen and the resulting losses in productivity could cost the U.S. economy $22 billion by the year 2022 and increase to $40 billion by 2033 (FAA, 2008). In terms of simple arithmetic it is clear the U.S. economy stands to gain from NextGen implementation.

Environmental. Environmental goals in aviation are based on a five pillar approach (Federal Aviation Administration, 2012, February). Those goals are “better scientific understanding and improved tools for integrated environmental analysis, mature new aircraft technologies, develop aviation alternative fuels, develop and implement clean, quiet and energy efficient operational procedures and policies, environmental standards, market based measures and environmental management system” (FAA, 2012, February, p. 2). Great pains have been taken to ensure NextGen implementation addresses each of these pillars.

Pillar one: Better scientific understanding and improved tools. In response to pillar one, NextGen will utilize the Aviation Environmental Design Tool (AEDT) (FAA, 2012, February). This tool consists of software which models aircraft performance. The software will evaluate aircraft noise, fuel consumption and emissions. This data will provide the designers of NextGen the ability to consistently optimize and redesign throughout NextGen implementation and beyond.

Pillar two: Mature new aircraft technologies. In response to pillar two, NextGen will be utilizing PBN as previously discussed. The direct routes which will be enabled by the new satellite air traffic control technologies will significantly reduce greenhouse gas emissions. According to the FAA aviation greenhouse gas emissions reduction plan, new technologies have the potential to improve fuel efficiency by 20 to 30 percent by the year 2020 and 25 to 50 percent by 2030 (Federal Aviation Administration, 2012, June). The plan predicts this reduction will additionally result in 1.4 billion less gallons of fuel utilized which equates to 14 metric tons of Carbon Dioxide (CO2) reduction by the year 2020.

Pillar three: Develop aviation alternative fuels. In response to pillar three, NextGen will incorporate the Commercial Aviation Alternative Fuels Initiative (CAAFI) (FAA, 2012, February). This initiative is focused on the continued exploration of alternative jet fuel use. CAAFI is consistently working to develop and employ alternative fuels which offer significant environmental enhancements when compared to petroleum-based fuels.

Pillar four: Develop and implement clean, quiet, energy efficient procedures. In response to pillar four, NextGen will adopt the Continuous Lower Energy, Emissions and Noise (CLEEN) program (FAA, 2012, February). This program is a collective partnership among five aviation manufacturers with the purpose of developing technologies to reduce emissions and employ alternative fuel use (FAA, 2012, June). In addition to reduced emissions, CLEEN will also address the development of quieter engines and aircraft to reduce the environmental impact of noise in areas surrounding airports. The federal government is anticipated to invest approximately $125 million in the program which the collective partnership has stated it will match.

Pillar five: Policies, standards, measures, environmental management system. In response to pillar five, the FAA has initiated the NextGen Environmental Management System (EMS) Framework (FAA, 2012, February). The purpose of this program is to address aviation-related environmental issues and collaborate within the aviation community for solutions. EMS will ensure NextGen implementation remains in the framework of the National Environmental

Policy Act (NEPA).

Political. NextGen technology is bursting with benefits to the global community but unfortunately some smaller factions may feel the pinch. When words like re-organization and streamline come into play, it is often followed with words like cut-backs and phasedown. This is also the case for NextGen air traffic control. It is only a matter of simple mathematics that more precise routes equal fewer towers. Many areas in the country have a litany of regional air traffic control centers which cause airspace to be divided into “corridors and shelves that make little sense” (Voss, 2011, para 7). One such area is New York City which many believe has too many regional air traffic control centers for the small metropolitan area (Voss, 2011). The only way in which this issue can be alleviated is through one of the catch terms like re-organization. Unfortunately this re-organization will undoubtedly lead to the following catch term, cut-backs. In terms of politics, cut-backs mean unhappy constituents who take their dissatisfaction to the polls. For this reason, NextGen is faced with mounting local government push back in some cases as politicians forcefully defend regional centers and constituent jobs. Proponents for NextGen are faced with the arduous task of convincing special interest groups and attorneys to permit flight paths to be adjusted in a manner which would bypass the regional centers.

In some instances, NextGen is indirectly impacted by political fervor. The recent sequestration events in early fiscal year 2014 did hamper the advancement of NextGen (Clark, 2013). The proposed sequester will force substantial budget cuts on the FAA. In July 2013, the House allocated funds for NextGen which were well below sequestration levels. The end result would be a 22 percent cut in funds for facilities and equipment upgrades which are vital to NextGen expansion and implementation. Despite the critical and overwhelming necessity to upgrade the current air traffic control system, fiscal constraints will ultimately decide the haste with which the FAA can accomplish this crucial goal.

Conclusion

"The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency" (Gates, n.d., p. 1). NextGen certainly possesses the capacity to apply automation in such a way as to implement efficient operations on a global scale. In terms of technology, NextGen stands to vastly improve current air traffic routes by utilizing enhanced satellite technology. These new routes will alleviate the financial burdens of ever increasing fuel prices and reduce congestion in the skies. In terms of social profit, NextGen has the potential to provide a much needed fiscal boost to the GDP and global financial wellness. On the heels of a global economic crisis, increases in productivity are vital to recovery. In terms of environmental benefits, NextGen, in combination with the five pillars of the aviation greenhouse gas emission reduction plan, stand to significantly reduce CO2 in the environment for future generations. All of these technological, social and environmental benefits would seem to identify NextGen as a technological advancement in efficiency which merely magnifies the current system. Unfortunately there is yet another aspect to consider. The current political climate is hindering the haste with which NextGen efficiencies can be applied and implemented. Sequestration accompanied by local government official push back for political gain will slow equipment upgrades and make arduous the task of adopting more efficient routes. In terms of automation being applied to an operation in which inefficiencies currently reside, NextGen could not be up against a more formidable opponent than the U.S. government. It is clear that implementing new automation into the inefficient system which is the current political process will only magnify the inefficiencies currently present. NextGen has proven it can reduce air traffic delays and environmental impact, the question remains; can it reduce the political machine enough to survive?

Comprehensive Exam Question # 5

Statement of the question. Recent accident and incident reports, news stories, and results of investigation and audits have raised concern that Crew Resource Management (CRM) has been eroded as a cornerstone of Flight Safety in the current environment ("Human Factors", n.d.). Current human factors incidents in the aviation industry would seem to solidify the perceived deterioration of CRM. Poor pilot training and pilot error are reported to be the leading cause of almost 80 percent of commercial airline accidents (Federal Aviation Administration, 2013a). These accidents are attributed to a wide variety of human error related incidents such as self-imposed stress, skill-based errors, misperception errors, and judgement and decision-making errors. For this reason, CRM encompasses many training areas including communication, workload management, decision-making, conflict resolution, leadership, team management and stress management (Jensen, 1995).CRM training has long been targeted on controlling these aspects in the cockpit but the goal of current training is to understand that CRM starts and ends with the entire crew, both inside and outside the aircraft. The training has now evolved to include aircraft dispatchers, flight attendants, maintenance personnel and air traffic controllers. The last decade has interjected a whole new arena of awareness into aircrew training which must deal with the consistent threat of terrorism. This has added another element to training referred to as threat management. Another element imposed on situational awareness and training is the advancements in unmanned flight operations and the unique human factors associated with this area of flight operations. Additional considerations affecting current training are advances such as NextGen technology, which will alter the approach to CRM and associated training requirements. The introduction of NextGen, which demands enhanced situational awareness, will make CRM skills even more crucial. As NextGen continues to drive operational changes, it will become even more important for CRM training to focus on interactions with crew members outside the cockpit. Hypothesize the ability of NextGen technology to impact currently perceived CRM shortfalls in the industry. Research the extent to which NextGen technology can have an impact on Air Traffic Control (ATC) situational awareness and determine what potential impact CRM changes in this environment can have on the program.

Program Outcomes that will be addressed by this question:

Program outcome #3

The student will be able, across all subjects, to use the fundamentals of human factors in all aspects of the aviation and aerospace industry, including unsafe acts, attitudes, errors, human behavior, and human limitations as they relate to the aviators adaption to the aviation environment to reach conclusions.

The ***human behavior*** aspect will be addressed by comparing recent incidents where human error and CRM training were directly related. The behavior of the flight crew in the incident will be examined for attributes of the CRM training program and a determination made regarding the success of the incident due solely to training experience.

The ***unsafe acts and errors*** aspect will be addressed by examining current research on aircraft accidents and incidents where human error is identified as causal. The percentage of human error related accidents prior to the requirement for CRM training and current percentages will be evaluated for the ability of CRM training to alleviate incidents.

The ***attitudes and human limitations*** aspects will be addressed by investigating CRM as it applies to currently perceived shortfalls in existing programs. Human limitations will be examined regarding the increased situational awareness new technologies will impose on flight crews.

Program outcome #4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of aviation / aerospace related topic.

An ***ex-post facto research methodology*** will be utilized by examining human error identified in previous aircraft accidents and incidents. The facts and circumstances will show crews are in need of updated and reinforced training taking into consideration new technologies. The ***hypothesis*** will be offered in which CRM training must adapt to new technology to remain valid. Additionally, research will show new technology such as NextGen will solidify the transition to a more robust flight deck system.

Crew Resource Management for the Future

Introduction

Captain A. G. Lamplugh, a British aviator in the early 1930's, coined a relatively well known phrase among British aviation circles. He stated, "aviation in itself is not inherently dangerous. But to an even greater degree than the sea, it is terribly unforgiving of any carelessness, incapacity or neglect" (Lamplugh, 1930, para 3). Although in Captain Lamplugh's time, Crew Resource Management (CRM) was not an implemented program; his words state the very reason why it is a necessity. In the 1970's investigators began gathering accident data which alluded to human error as the principle cause in approximately 70 percent of aviation accidents (American Psychological Association (APA), 2014). In response to this phenomenon, at a NASA workshop in 1979, CRM came to fruition. At that time, CRM was broadly defined as "the active process employed by crew members to identify existing and potential threats and to develop, communicate, and implement plans and actions to avoid or mitigate perceived threats. CRM supports the avoidance, management, and mitigating of human errors" (APA, 2014, para 3). It has been over 30 years since the inception of CRM. It would be rational to suppose the number of aviation incidents related to human error had declined with over 30 years of specialized attention paid to the subject. This is unfortunately not the case. At present, poor pilot training and pilot error are reported to be the leading cause of almost 80 percent of commercial airline accidents (Federal Aviation Administration, 2013a). According to current statistics, the number has not declined with instituted programs in place, but has actually increased since the 1970's. It is because of such data that emphasis has been placed on restructuring this training. Creators of CRM training have begun to look outside the box, or in this case, outside the cockpit to further understand the necessary cooperation required by all facets of the flight crew for success.

Trainers are now targeting aircraft dispatchers, flight attendants, maintenance personnel and air traffic controllers along with pilots in the CRM vision. Training has expanded to include such subjects as communication, workload management, decision-making, conflict resolution, leadership, team management and stress management (Jensen, 1995). In addition, programs must continually adapt to rapidly changing technology. Despite the seemingly never-ending litany of program alterations necessary, CRM is vital to the continued success of the aviation industry and an indispensable part of crew training.

Purpose

The purpose of this research is to examine human factor incidents within the aviation community to identify which technologies are in a position to have the most impact on CRM training. Additionally, the manner in which CRM training must adapt to these new technologies will be assessed for the purpose of addressing the future potential of the program to endure and provide necessary longevity.

Method

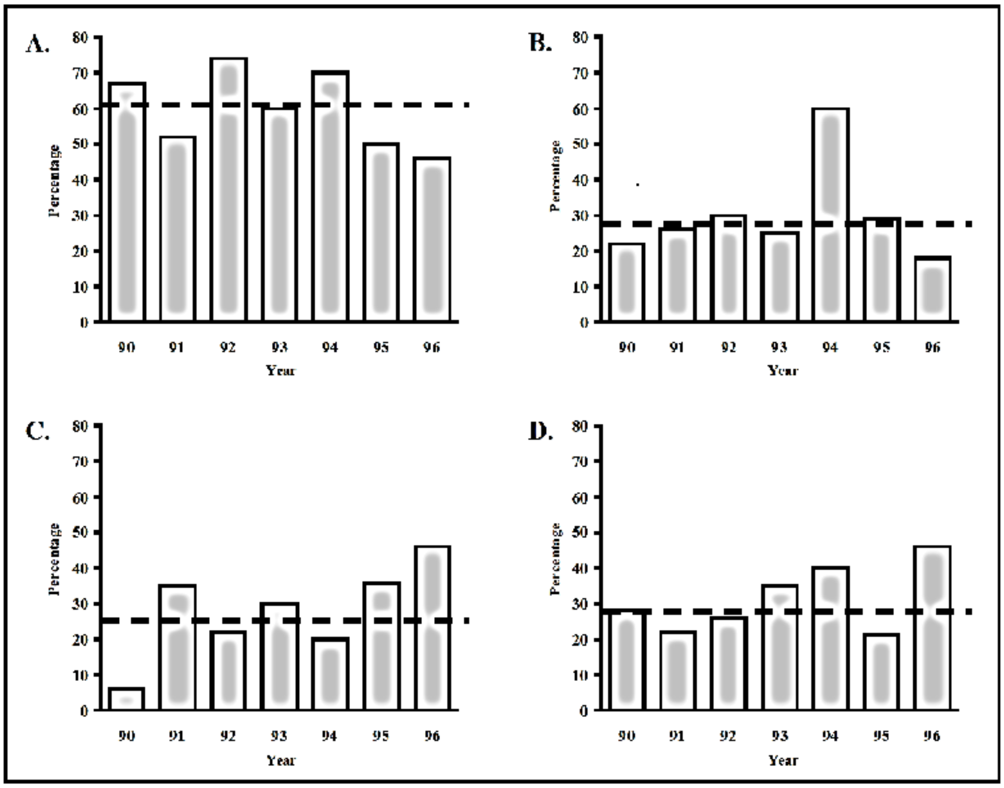
Methodology

An ex-post facto research methodology will be utilized by examining human error identified in previous aircraft accidents and incidents. The facts and circumstances will show crews are in need of updated and reinforced training taking into consideration new technologies. Research will be conducted utilizing all available electronic means including web engine searches and ERAU Library Database. A thorough review of relevant literature will be performed and a conclusion included. The findings will be examined and a recommendation offered utilizing a critical thinking approach.

Review of Relevant Literature

Unsafe acts and errors. According to the Human Factors Analysis and Classification System (HFACS), human factor failures can be classified into four levels, unsafe acts of operators, preconditions for unsafe acts, unsafe supervision and organizational influences (Wiegmann, 2001). Unsafe acts of operators can include errors and violations. Under the category of preconditions for unsafe acts, substandard practices of the operator can be found. This is the category in which crew resource mismanagement can be located. This will include failures in and out of the cockpit in terms of communication with crew, air traffic control and ground personnel. Unsafe supervision can include inadequate supervision as well as failure to correct problems. Lastly, organizational influence failures stem from three issues, resource management, organizational climate and operational processes. Utilizing this HFACS organization, a comprehensive accident review was conducted between January 1990 and December 1996 for the purpose of investigating how many accidents could be attributed to human factors. During this time frame 119 accidents were identified as crew related with 319 human causal factors (Wiegmann, 2001). These accidents were further broken down to analyze the percentage of accidents associated with skill-based errors, decision errors, violations and CRM failures. Figure 1 depicts the breakdown with A as skill-based errors, B as decision errors, C as violations and D as CRM failures. In the research it was observed that a large percentage of errors were attributed to CRM and decision errors. Perhaps most disturbing was the realization the error rate for these types of failures remained relatively constant over the six year period. In fact, at the time of the study it was estimated that 70 to 80 percent of accidents overall could be attributed to human error. In 1998 Advisory Circular number 120-51C was initiated by the Department of Transportation and the FAA (Krey, n.d.). This advisory mandated CRM training

Figure 1. Percentage of aircrew related accidents. Retrieved from Wiegmann 2001.



under Title 14 of the Code of Federal Regulations (14 CFR) part 121 for pilots. In addition, it outlined what a CRM training program should include. Since this mandate was initiated, over 15 years ago, the estimated rate of accidents attributed to human factors related issues remains at 80 percent (Federal Aviation Administration, 2013a).

Human behavior. When investigating why statistics do not show significant improvement, perhaps the phrase, “to err is human” (Pope, n.d., para 1) may shed some light. While CRM training can mitigate some error, there is always the human condition. “You’ll do the same thing correctly 1 million times and then not do it correctly one time”, says Ben Berman, a former NTSB investigator. He goes on to say, “things like a moment of stress, a spike in workload, a change in routine—all these things can throw humans off track” (Levin, 2008, para 10). The most seasoned of pilots and crews are susceptible to the human condition. Often basic human error can be attributed to fatigue, stress or interruptions in daily routine. Even the best

CRM training program cannot completely alleviate human reaction to these factors. Regardless, there are steps pilots and crews can take to mitigate many of these basic human errors. For example, fatigue can be controlled by adjusting crew schedules so enough rest can be acquired prior to flight. Although humans are inherently prone to making mistakes, CRM training has proven beneficial in high stress circumstances.

It is only necessary to look as far as the US Airways flight 1549, Husdon Miracle flight, co-piloted by Capt. Chesley Sullenberger, for an example of CRM training in action. In this particular flight, CRM training would have a significant impact on a high stress situation. The professionalism displayed by Captain Sullenberger and his crew to safely land the Boeing 737 in the Hudson River with no casualties is a testament to teamwork and years of training. Key elements in the CRM program are adaptability and flexibility, both of which were elements in the success of this flight. Captain Sullenberger, who had been the co-pilot, heard the geese hit the engines. He quickly took over the controls and stated, “My aircraft!” The first officer responded, “Your Aircraft” and began running a checklist to restart engines (Paulin, 2009, para 14). Captain Sullenberger’s quick adaption to the situation, taking over controls for the less experienced Captain and first officer coupled with the crews’ quick adaptability to his actions clearly saved many lives aboard US Airways flight 1549 that day. Despite the heroic actions of Captain Sullenberger, the Co-Captain Jeffery Skiles stated, “we were lucky in several respects. We had just the right crew to handle the emergency that presented itself. Really, after hitting the geese, everything worked in our favor" (Paulin, 2009, para 2). Regardless, the impact CRM training had on that fateful day cannot be ignored. Captain Sullenberger has a long and distinguished record of safety. He served as a fighter pilot for the U.S. Air Force as a flight leader and training officer (Sullenberger, n.d.). After leaving the Air Force, he became a pilot for US Airways, where he received much attention for the Hudson Miracle flight. In his time with US Airways, Captain Sullenberger performed accident investigation duties and was an Air Line Pilots Association (ALPA) representative for a National Transportation Safety Board investigation. Probably most significant to his handling of this famous flight is the fact that he was instrumental in developing and implementing the CRM course utilized by US Airways. Captain Sullenberger is responsible for training hundreds of US Airways crew members in CRM principles. Additionally he travels internationally as a keynote speaker for educational institutions and corporations regarding the importance of aviation safety and crisis management. Clearly Captain Sullenberger's expertise and training cannot be overlooked for the potential influence on the outcome of the Husdon Miracle flight. Would US Airways flight 1549 be the miracle it has become without Captain Sullenberger on board that day? No one will ever be able to answer that question. What is clear is 155 souls aboard that plane are grateful for their lives and have the CRM skills Captain Sullenberger possessed to thank for it.

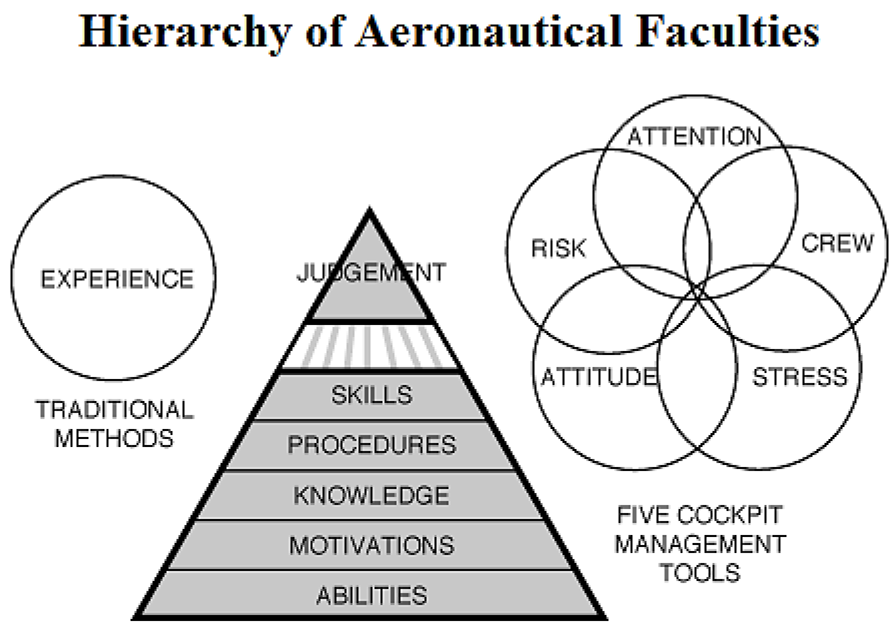
Attitudes. Throughout the 1960's and 1970's the National Transportation Safety Board discovered attitudes in the cockpit may be a contributing factor in accidents. Many pilots perceived their crewmembers as subordinates who should act on orders when directed and not question. This attitude was ultimately contributing to accidents because crewmembers found themselves too intimidated to speak up regarding observed pilot error. This intimidating atmosphere could no longer be ignored following a United Airlines crash on December 28, 1978 that killed 10 people. Due to a minor gear problem, the pilot was instructed to remain in a holding pattern while awaiting landing in Portland Oregon. The first officer knew the aircraft was low on fuel but could not convince the captain. The airliner crashed because it ran out of fuel (National Transportation Safety Board, 1998). It was because of attitudes and accidents of this nature that merely a year later NASA developed the concept of CRM. Not only did this mentality spawn the fruition of CRM but it eventually also redirected the program to focus on cooperation of the entire crew. In response, a CRM expert named Todd Bishop developed a five step assertiveness statement method (Tippet, 2002). In this method, Bishop suggests that crew can express a difference of opinion in a non-threatening manner. The following steps were recommended:

> 1) Opening/attention – Say the person's name. Example – Hey Captain.
> 2) State concern/owned emotion – Example – I'm concerned we may not have enough fuel.
> 3) State the problem as you see it – real or perceived. Example – We only have 20 minutes of fuel remaining.
> 4) Offer a solution – Example – We should alert the tower we need to land.
> 5) Obtain agreement – Example – Do you agree Captain?
> (Tippet, 2002, p. 8)

While this solution does offer a democratic way to approach a touchy situation, the author also points out the lack of a solution to a perceived problem should not prevent a subordinate from acknowledging a potentially dangerous situation. This also only highlights one potential solution to a litany of human limitations with the realm of CRM.

Human limitations. The majority of countermeasures taken to combat human error, such as the CRM program, are focused on improving six human faculties deemed as fundamental to flying (Diehl, 1991). These are generally referred to as the hierarchy of aeronautical faculties. This hierarchy proceeds systematically from the base of a triangle to the apex beginning with abilities, then motivations, knowledge, procedures, skills and finally judgment. Figure 2 depicts the hierarchy of aeronautical faculties. Abilities, motivations, knowledge, procedures and skills are all generally addresses early in pilot training. CRM training becomes more engaged at the judgment level. It could be said that CRM incorporates judgment training. In response to the perceived need for judgment training, five cockpit management tools were developed (Diehl, 1991). The five tools are also depicted in Figure 2 below.

Figure 2. Hierarchy of Aeronautical Faculties. Retrieved from Diehl 1991.



The first of the five components is attention management. This component concentrates on understanding distractions and avoiding error chains. The second, crew management, focuses on communications, division of responsibilities, leadership and teamwork. The third, stress management, addresses life stress as well as in-flight stress. The fourth, attitude management, works to control hazardous attitudes and behavior. The fifth and last component, risk management, evaluates qualitative and quantitative data regarding hazards. If all of these tools are to come together and form a comprehensive system aimed at improving crew performance, it will be necessary to build a more robust human system.

This more robust human system or robust flight deck is thought to be possible utilizing Oshry's organization development principles (Stasio, 2013). These principles encompass four basic elements, differentiation, homogenization, integration and individuation. The question remains, can these principles be successfully applied to new technology of the verge of implementation such as Next Generation (NextGen) technology?

Differentiation. Differentiation deals with how pilots and crews operate in a complex dynamic environment (Stasio, 2013). This principle focuses on the leadership dynamic real or perceived in the cockpit in which the pilot is dominant and not to be questioned. Oshry suggests that training coupled with open dialogue regarding how to use CRM principles to deal with threats and errors has the ability to gradually eradicate this boundary. When considering NextGen technology, roles of controllers and pilots will become more interdependent (Lyall, B., England, Harron, Hoffa, Jones, Lyall, M., Taylor & Wilson, 2011). It will be crucial for both to have a shared understanding of roles and responsibilities. This feeling of shared responsibility is necessary if true teamwork is to be established.

Homogenization. Homogenization refers to shared values, professional norms and standard operating procedures (Stasio, 2013). This principle focuses on commonalities as pilots generally fly with the same crew. The core of this principle is that standard procedures and norms can alleviate some decision making overload. It is under the heading of homogenization that error can be found with new NextGen technology. While NextGen promises many benefits, the increased situational awareness necessary to facilitate the new system will hinder pilot ability to "switch attention without omission errors" (Stasio, 2013, p. 4). The high level of situation awareness necessary in NextGen operations is thought to be less effective in some cases than traditional voice communications. This high level of complexity may outweigh any benefits homogenization has to offer if proper training is not established. Experts suggest CRM training will need to be integrated throughout any NextGen training program (Lyall et al, 2011). If CRM is to have any impact with the implementation of NextGen, it must encompass realistic training scenarios. Scenarios which are programmed with recent safety data as a reference have been found to be particularly useful to pilots in training. This safety data allows trainers to identify errors which may be trends with new technology and consistently adjust training deficiencies.

Integration. Integration refers to the ability of crews to utilize every member of the team, in and out of the cockpit for error management (Stasio, 2013). The principle behind integration is creating an environment where every individual feels open to critique or advise when something is witnessed that is not right. It is suggested the pilot can invite this attitude early on in the pre-flight briefing by welcoming observations from crew. Additionally integration aims to set the pace of the crew at that of the most task saturated member. NextGen technology will not eliminate but only enhance the need for CRM programs to focus on communication with the entire crew to include air traffic control, dispatchers and maintainers.

Individuation. Individuation follows closely with differentiation in that it deals with individuals being perceived as having unique responsibilities and therefore differentiated among the crew. In this particular case it is more of a distinction from the crew. In situations where rank structure or a rigid patriarchal command structure exists, power sharing can be a glaring issue. Once again, to combat individuation the same training and dialogue is suggested for that of differentiation. Because individuation so closely resembles differentiation, many of the same concerns with NextGen implementation will apply here. One additional suggested improvement in regards to individuation and NextGen is to allow controllers familiarization rides from a jump seat perspective which may provide beneficial insight into the world in which the pilot resides.

Conclusion

An aviator named David L. Baker once stated, “flying is so many parts skill, so many parts planning, so many parts maintenance, and so many parts luck. The trick is to reduce the luck by increasing the others” (Stoller, 2000, para 1). This is the ultimate goal of the aviation

CRM training program, to increase the others. While it may be true that human error is an unfortunate circumstance which can never be completely mitigated, it can certainly be controlled. Current statistics may not reveal a grandiose reduction in percentage of accidents attributed to human factors incidents since the inception of CRM training but it may be important to note that it has not increased. Consider the increasingly congested skies in with crews soar daily. Add to the congestion the litany of new technology imposed on crews in the last two decades. CRM training may not have made a statistically visible impact but it has kept at bay what could have been a deluge of incidents in this modern environment. Advances such as NextGen technology are in a position to test the wear withal of CRM training once again. If the program can continue to apply the principles of a robust flight deck to NextGen technology training programs, CRM has an opportunity to remain not only viable but vital to the industry.

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