COVER PAGE

Title of Design: **Technology-based Communication Solutions for Reduced Fuel Consumption in the Airport Environment**

Design Challenge addressed: **Airport Management & Planning Challenges - Innovative strategies for reducing airline fuel consumption, such as new ways to reduce gate-to gate time or revise procedures**

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Technology-based Communication Solutions for Reduced Fuel Consumption in the Airport Environment

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Executive Summary

The University of Nebraska at Omaha selected a team of three students to research and compose an innovative strategy to reduce fuel consumption. This paper, entitled Technology-based Communication Solutions for Reduced Fuel Consumption in the Airport Environment, attempts to provide an innovative strategy using communication as the cornerstone for reducing fuel consumption.

Fuel is an important resource to many stakeholders in the aviation industry. Airports rely on fuel to power vehicles and maintenance equipment. Ground handlers rely on fuel to power tugs, baggage belts, and other service equipment. Finally, airlines rely on fuel to power the aircraft and move passengers from point to point. High energy prices and a renewed effort to reduce harmful emissions led to several new technologies and procedures aimed at mitigating these two issues. The following research is in response to the Federal Aviation Administration's Airport Design Competition, specifically looking at ways to reduce fuel consumption in the airport environment. Two technologies have been identified that can reduce fuel consumption for airlines, both on the ground and in the air; ADS-B and data link.

ADS-B and data link are technologies that are generally thought of as a component of a modernized air traffic management system. They are designed to enhance efficiency and safety for pilots and controllers. However, in light of the need to reduce fuel consumption, efficiency gains can lead to a reduction in fuel consumed.

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1. Problem Statement and Background

Through the years, fuel consumption in aviation has been a major issue for all stakeholders. However, the recent increase in fuel prices during the summer of 2008 highlighted the need for refocused efforts to mitigate the cost increases. Many different strategies have been or are being looked at, including the use of alternative fuels for aircraft, electrification of ground service equipment, and revised procedures designed to conserve fuel use. Airlines have even taken such measures as initiated new fees for the flying public to offset the higher fuel bill.

Fuel accounts for millions of dollars in airline budgets annually. Over the years, many attempts have been made to reduce this dollar amount for the airlines' bottom line including the upgrade of older aircraft, engine upgrades for older aircraft, reducing customer amenities, altering engine usage procedures and many other things. During the summer months of 2008, fuel prices soared to their highest level ever recorded. In July of 2008 when fuel was at its peak price, airlines spent a combined $4,245,239,544 on fuel, buying 1,146,723,139 gallons (Air Transport Association [ATA], 2009a). Airlines were forced to spend more and more of their budgets to pay for fuel and as a result were unable to remain profitable.

Currently, airlines use single-engine taxiing procedures when possible, reduce and measure more accurately onboard weight while redistributing belly cargo, tanker extra fuel on certain flights to avoid refueling at more expensive locations, cruise longer at higher altitudes and employ shorter, steeper approaches to landing (ATA, 2009b). These procedures have assisted airlines in some respect; however, much more can be done.

While biofuels and other measures being studied may lead to realistic cost savings for airlines and other industry stakeholders, these savings may be years away or too inconsequential to have the necessary impact. However, there are ways using current technology to not only reduce fuel consumption within the aviation industry, but also improve the efficiency in the National Airspace System.

Miscommunication and slower than necessary communication between air traffic control and pilots is one area that has been identified as having the potential to produce real fuel savings and create a more efficient system. Several technologies have undergone extensive testing have shown great promise. While these technologies were thought to be tools to create a more efficient air space system, they also have the ability to produce real savings in fuel consumption. Quickening the pace that messages are received in the cockpit from air traffic control leads to less time waiting which in turn means less fuel wasted while the plane idles awaiting its instructions. This is just one example of the potential these new technologies hold in reducing fuel consumption.

The following sections provide an overview on two specific technologies, ADS-B and data link which can help create this environment of efficiency and reduced fuel usage. These technologies are examined in detail to demonstrate how exactly they can mitigate wasteful fuel usage and the types of fuel and cost savings that can be achieved through their implementation.

2. Summary of Literature Review

When researching methods of fuel conservation, the team looked at several new technologies available to airlines, airports, and air traffic control facilities. The team discovered three main advances in technology including Automatic Dependant Surveillance-Broadcast (ADS-B), digital data link, and Sensis Aerobahn. The following is a brief summary of each new technology and how it can help with the issue of fuel consumption.

ADS-B

In August 2007, the FAA awarded a $1.8 billion contract to ITT Corporation to build and manage the foundation of the nation's next-generation air-traffic control system through 2025. In December 2008, ITT successfully deployed the ADS-B essential services system in southern Florida. The system has the ability to broadcast services of air traffic, as well as weather and aeronautical data information, from 11 ADS-B ground stations in southern Florida. Extensive testing proves that the services meet all operational, functional, and performance requirements, are safe and secure, and are supportable as a part of the National Airspace System (ITT, 2009a). To accomplish this, ITT plans to build an estimated 794 ground stations, four data control stations at AT&T Data Hosting Centers for message processing, and two network operations centers to run the system and provide redundancy. NextGen data will be delivered to the FAA at 271 Service Delivery Points located at FAA Air Traffic Control (ITT, 2009b).

ITT is also deploying "critical services" to four test locations including the Philadelphia International Airport, Louisville, Ky., the Gulf of Mexico, and Juneau, Alaska. Critical services use GPS to display aircraft position to air traffic controllers for traffic separation. This is a service that, in theory, will allow the FAA to eliminate secondary surveillance radar in many locations (ITT, 2009a).

UPS plans to begin using ADS-B early next year on its Boeing 757 and 767 operations at its Louisville International Airport hub in Kentucky. The carrier plans to deploy the systems slowly over 2008, and have 107 of its 757s and 767s equipped by the first quarter of 2009.

The aircraft will also be equipped with SafeRoute, an ADS-B "In" enabled software program. Based on test results, the airline predicts ADS-B operations will be "very effective" in cutting emissions (McKenna, 2007). During its first year of ADS-B utilization, UPS has saved between 250 and 465 pounds of fuel per flight. During the last 25 minutes of flight, aircraft saved between 21% and 31% in fuel burn (McKenna, 2009).

Delta Air Lines recently completed the first phase of a continuous descent approach (CDA) trial at Atlanta Hartsfield-Jackson Airport. Trial data indicated an average savings of 400 pounds of fuel per flight. This would compare to 13 million gallons per year in Atlanta alone (McKenna, 2007).

Digital Data Link Technologies

Due to increased levels of air traffic, frequency congestion has become a major issue at many airports across the country, which causes both sector and national airspace delays. These same increases in traffic have also resulted in increased controller and pilot workloads. To combat this frequency congestion, data link technologies are being implemented and tested. Data link is a digital means to transmit information from the ground-based controller to the airborne pilot (Navarro & Sikorski, 1999).

Massimini, Dieudonne, Monticone, Lamiano, and Brestle (1999), conducted a study to evaluate the application of the Total Airspace & Airport Modeller (TAAM) tool for determining the impact of new Communications, Navigation, and Surveillance (CNS) ground-based and avionics technology on the efficiency of the National Airspace System (NAS). By using TAAM to simulate aircraft movements (using rules that mimic actual operations,) the authors were able to produce a measure of voice channel occupancy (VCO) in a sector of the NAS. By completing this TAAM simulation to determine VCO, the authors were able to estimate the potential benefits and costs of using Controller-Pilot Data Link Communications (CPDLC) versus voice only instructions for flight and ground operations. The results estimated the savings of implementing two-way data link ATC communication to system users nationally at over 337 million dollars annually (Massimini et al., 1999).

Unfortunately, in the United States, data link technologies are not used to their full extent. While data link communication could be used to replace many of the repetitive messages between pilots and air traffic control, currently data link is only used for the initial clearance delivery to pilots.

Bolczak, Gonda III, Saumsiegle, and Tornese (2004), concurred with the findings of Massimini et al, (1999) and stated that implementing CPDLC in en route airspace is expected to improve air traffic throughput by reducing voice frequency congestion that contribute to delays. CPDLC allows controllers to better distribute communications responsibilities to all members of the sector team, which allows for increased sector productivity. Since Initial Daily Use (IDU) of CPDLC Build 1 at Miami Air Route Traffic Control Center (ARTCC) on October 7, 2002, the estimated time savings for the Miami ARTCC sector was over 2,600 minutes upon completion of the study. They also concluded that CPDLC has the ability to reduce the occurrence of ATC communication errors that affect flight safety and efficiency. Errors such as acoustic confusion and transposition of alpha-numerics, pilot “read-back” error, controller “hear-back” error, misinterpretation caused by poor pronunciation, and many other communication errors that are inherent to the voice radio system will be reduced or eliminated with data link (Bolczak et al., 2004).

Rakas, Hansen, Jirajaruporn, and Bolic (2003) explored the benefits of integrating User Request Evaluation Tool (URET) and CPDLC by analyzing voice-communication messages and aircraft traffic flows and conflicts in one representative, URET-operating en route sector. The study concluded that at minimum, frequency use was reduced by 27%, and after removing the non-time-critical messages from the scenario, the total reduction was 59%. Integrating URET and CPDLC significantly reduced frequency usage and could potentially reduce communication errors (and the consequent air traffic control workload), as well as the operational errors that are associated with the communication errors.

Airport Automation Tools

The Sensis Corporation has developed the Aerobahn Service which is already in effect at many airports across the country including Houston's Bush Intercontinental Airport (IAH), Newark Liberty International Airport, and JFK Airport. By using this ground radar display, ramp tower controllers can make pushback procedures more orderly. They can also locate an aircraft that is running slightly behind schedule, and use the program tools to get it to its preferred gate as efficiently as possible to decrease any delays.

This program is not only used by airlines, but can also serve airport operators, air traffic control towers, air route traffic control centers, and terminal approach control facilities (PR Newswire, 2009). Aerobahn contains several tools that allow operators to reduce taxi times, increase fuel efficient operations, and improve safety through better situational awareness (Sensis, 2009). One tool that Aerobahn offers is QuickView. This tool "provides a quick and accurate assessment of airfield operations with real-time status of arriving and departing flights" (Airport Business, 2009). "TaxiView provides situational awareness and enables users to monitor real-time operations such as traffic flow into and out of the ramp area, and the impact of irregular operations" (Sensis, 2009). A third tool offered by Aerobahn is OpsView. This tool "enables users to conduct detailed analysis of operations, quantifiably measure results, identify trends and better predict the impact of future events" (Sensis, 2009). Finally, AssetView allows users to view the type of work being performed as well as the status of assets in real-time through the use of its two-way messaging and alerting capabilities (Sensis, 2009).

3. Problem Solving Approach to the Design Challenge

In order to solve the problem of reducing fuel consumption, this project proposes the utilization of new technologies available through the FAA, airlines, and airports. Two forms of technology were evaluated and analyzed. These advancements include ADS-B and data link. Sensis Corporation’s Aerobahn software underwent extensive consideration for inclusion in the Problem Solving Approach. However, due to the proprietary nature of the product, the research team was unable to quantify the abilities of the software. As a result, the research team chose to exclude Aerobahn from the Problem Solving Approach.

ADS-B

One form of new technology is the automatic dependent surveillance-broadcast (ADS-B) program. “This program uses ground stations, aircraft avionics, and satellite data” to give air traffic controllers and other pilots a more accurate picture of what the national airspace system (NAS) actually looks like (Broderick, 2008, p. 17). It will improve the ability of airlines to manage aircraft fleets and better predict arrival and departure times (Broderick, 2008). This will hopefully lead to less congestion at the gate, allow aircraft to move more smoothly between taxi-in and taxi-out, and therefore reduce fuel consumption. ADS-B will “make it possible to monitor the positions of aircraft and ground vehicles” during poor visibility and reduce the risk of incursions (deNeufville and Odoni, 2003, p. 547). Because of this capability, ADS-B may eventually replace airport surface detection equipment (ASDE) which is very costly and requires a high amount of maintenance.

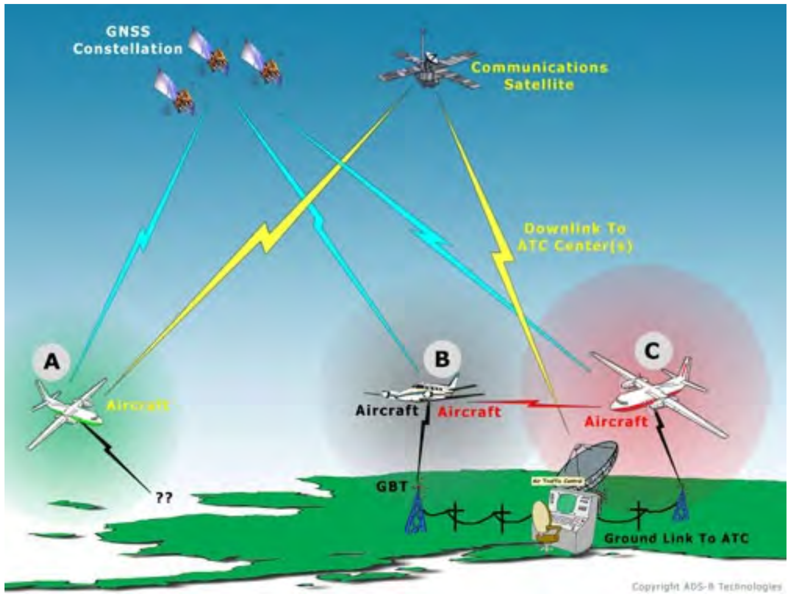

Figure 3.1: Overview of ADS-B

ADS-B uses a combination of ground stations located on or near airports, GPS satellites, and aircraft avionics to give pilots and controllers an accurate depiction of traffic, both on the ground and in the sky. This depiction is then used by air traffic controllers and other pilots to gain awareness of what is happening around them. The system relies on continuous broadcasts of aircraft position, speed, and other information that is sent to ground stations and other properly equipped aircraft. Because aircraft position data is obtained through satellites, ADS-B is much more accurate than current ground-based radar and is highly effective during periods of severe weather and poor visibility. It operates on two levels: ADS-B “out” and ADS-B “in.” The first level transmits the aircraft’s position via satellite to other aircraft and ground stations. The second level receives aircraft position signals and ground station data to display a real-time picture of air traffic (McKenna, 2009).

Many of the features that comprise ADS-B will reduce fuel consumption in a number of ways. As stated previously in the Literature Review, UPS is in the process of installing an ADS-B software program on their Boeing 757s and 767s operating out of its Louisville, Kentucky hub.

The cargo airline expects to cut 1,581 hours of excess taxi time out of Louisville alone simply by using this application. By reducing taxi times, UPS hopes to reduce emissions on the ground and save up to $936,000 a year in fuel burn. Additionally, by using ADS-B to manage arrivals, aircraft can be separated by a fixed time rather than a fixed distance. This minimizes the gaps between aircraft in high-density airspace and can increase runway capacity. During its first year of ADS-B utilization, UPS saved between 250 and 465 pounds of fuel per flight. During the last 25 minutes of flight, aircraft saved between 21% and 31% in fuel burn (ITT, 2009a).

ADS-B will also be able to assist in continuous descent approaches (CDA). Standard approaches involve “stepping down” from flight levels, whereas CDAs incorporate a constant descent angle. During ideal conditions, aircraft could potentially be able to “glide” in with their engines at idle. CDAs have the potential to greatly reduce both fuel consumption and emissions. Delta Air Lines is currently experimenting with CDAs in Atlanta. Preliminary data indicates that the airline could save 400 pounds of fuel per flight into Atlanta Hartsfield-Jackson Airport. At this rate, Delta could save nearly 13 million pounds of fuel in one year at Atlanta alone (McKenna, 2007).

Data Link

Data link technology has been touted to provide numerous benefits including increased safety, increased capacity of the national airspace system, faster and more accurate communication between pilots and air traffic control, and decreased workload for air traffic controllers. In Massimini et al (2000) an application known as Total Airspace & Airport Modeller (TAAM) was used to determine the impact of new Communications, Navigation and Surveillance (CNS) ground-based and avionics technology on the efficiency of the National Airspace System (NAS). By simulating aircraft movements using rules that mimic actual operations, a realistic picture of aircraft movement was developed and used constructively to quantify the potential benefit and savings of using said new technologies (Massimini, 2000).

> *"By using data link technology, voice communication is significantly reduced between the pilot and air traffic control. According to a national sector survey, 42 sectors throughout the NAS account for delays in 9,600 flights nearly every day due to communications-related saturation. Since voice frequency congestion is blamed for a large percentage of aircraft taxi and operational delays, data link will reduce frequency congestion and allow nearly instantaneous text-based messages to be sent and received between aircraft and air traffic control without affecting other aircrafts' line of communication to air traffic control. There is no easy way to measure or extrapolate the actual benefits of data link since full implementation of the technology has not been achieved, however by using TAAM, a conservative estimate of cost savings was deduced (Massimini, 2000)."*

To simulate the potential savings data link could produce from en route phases of flight, the FAA conducted a human-in-the-loop simulation with controllers and pilots in Atlanta approach and departure sectors. This demonstrated the communication saturation issues from a miles-in-trail approach (MIT). It was hypothesized that by utilizing the increased communications capabilities provided by CPDLC and reducing the time a controller needed on the voice channel, ground delays could be alleviated by permitting the relaxation of routinely implemented miles-in-trail restrictions. The extrapolation of benefits to the entire NAS system was based on the assumption that some fraction of the Atlanta benefits would be realized in each of the saturated sectors (Massimini, 2000).

In summary, the study showed direct user benefits associated with the performance achieved is depicted by a reduction in ground delays from 1795 minutes to 687 minutes with the use of data link and no restrictions in effect. Results also showed a reduction in flight time and distance flown by 20 percent (Massimini, 2000).

> *"Data link was also tested in an arrival sector where the primary task is to sequence inbound aircraft to the Atlanta airport. Without using data link, the average aircraft flew 111 miles over 18 minutes. By using data link in this experiment, the same case resulted in a reduction of the average miles flown to 89 miles over a 14-minute period. Additionally, data link reduced voice channel occupation time by 78-84% and allowed for a better distribution of communications responsibilities among all three members of the control team which permitted optimal use of the communications channel and increased sector productivity. By exploiting data link's full potential, the estimated cost savings for the NAS was more than $337 million annually (Massimini, 2000)."*

A more fuel-efficient NAS relies on faster and more accurate communications procedures by air traffic control and system users. Data link is one way for the NAS to reduce fuel consumption. By improving communication time between pilots and air traffic control, aircraft are able to reduce distance flown and time en route.

4. Description of Technical Aspects

ADS-B

In order to achieve the full benefits of ADS-B technology, airports must develop a system of ground stations to receive the ADS-B signals from all properly equipped aircraft and use them in air traffic control displays. Furthermore, aircraft can receive the ADS-B reports from other aircraft and use them in a “Cockpit Display of Traffic Information (CDTI) for increased situational awareness and collision avoidance practices.” (Hicok & Lee, 1998, p.F34-1)

Figure 4.1: Potential ADS-B Cockpit Display (CDTI)

The broadcast data link that supports ADS-B services is the Universal Access Transceiver (UAT). It uses an operating “frequency of 978MHz” (ICAO, 2003, p. 3) to minimize the impact on distance measuring equipment (DME) (which operates on the same frequency) and to ensure it can withstand extreme levels of interference. This ADS-B transceiver link uses a “two-state frequency modulated signal with 0.96-microsecond bits for an effective data rate of about 1.04MHz” (Samuelson, Valovage, & Hall, 2005, p. 4). Aircraft short messages contain up to 144 bits, long messages may contain 272, and ground uplink messages contain approximately 4448 bits. Transmissions are divided by two segments which consist of the ground segment (176 milliseconds) and the ADS-B segment (800 milliseconds). Each segment is then divided into Message Start Opportunities (MSO) which “are assigned in 250-microsecond divisions and encompass the complete segment” (Samuelson et al., 2005, p. 5). The ground uplink segments are divided into 32 segments to provide enough time for a complete ground uplink message to be transmitted. The ADS-B segment is divided into 3200 MSOs, and each aircraft has an equal chance of randomly selecting any MSO.

To combat security issues including eavesdropping, interfering, or disrupting the data link communication by non-users, ADS-B is capable of operating under two methods. The first method is authentication. This method uses a “Message Authentication Code (MAC) where a secure hash is calculated on the message information and employs a secret key” (Samuelson et al., 2005, p. 2) which is then sent for view by all users. However, the MAC is still attached to the message to provide authentication for those participants for whom security is important and for those who have the key to verify authenticity. The second method is called encryption. This method is similar to authentication; however, the message data is not understandable to non-participants. Data is sent only to a specific participant and is run “through an encryption algorithm using a secret key” (Samuelson et al., 2005, p. 2). It is then sent over the link to a receiver that locates the participant’s key from a database, and non-participants are unable to decrypt the message without the secret key.

Data Link

Data link is a digital means to transmit information from the ground-based controller to the airborne pilot (Navarro & Sikorski, 1999). Unlike conventional voice-based air traffic control (ATC) communications technology, the Controller Pilot Data Link Communication (CPDLC) system allows pilots and controllers to exchange text-based messages via specifically designated data links, thereby reducing voice communication congestion (Baik & Trani, 2005). CPDLC currently uses Very High Frequency (VHF) or satellite communication link to route text messages that are then displayed on the Flight Management System (FMS) or Aircraft Communication Addressing and Reporting System (ACARS) screens in the cockpit (Nolan, 2004). CPDLC build 1 consists of four basic services: Transfer of Communications (TOC) for directing a pilot to change the assigned voice frequency, Initial Contact (IC) for verification of the pilot's assigned altitude, Altimeter Setting (AS) for up-linking barometric pressure data, and Menu Text (MT) for up-linking a predefined set of text messages. In the current national airspace system, the vast majority of communication between ATC and pilots is through voice communication. Flight operations in the national airspace system (NAS) depend on the timely and accurate exchange of information between ATC and pilots in the cockpit (McGann, A., Morrow, D., Rodvold, M., & Mackintosh, M., 1998).

Airport Automation Tools

Airport automation tools such as Sensis Aerobahn are utilized at several airports across the country including the Continental Airlines hub at George Bush Intercontinental Airport (KIAH) in Houston, Texas. The research team had the privilege of meeting with Wayne Eastus, ATC ramp manager for Continental, to explain the Aerobahn concept. Such programs implement a series of "sensors located strategically throughout the airfield, receive a signal from the aircraft's transponder, and then triangulate the exact location of that aircraft using those signals" (W. Eastus, personal interview, February 27, 2009). The program is able to mark that position on a screen display of the airport's layout to allow controllers see the aircraft's position in real time and with respect to other aircraft or sensor-equipped vehicles on the airport.

5. Safety and Risk Assessment

In 2005, the International Civil Aviation Organization (ICAO) amended Annex 14, which requires member states to establish a Safety Management System at certificated airports (FAA, 2007). The FAA, in accordance with standards set forth by ICAO, developed a Safety Management System. This system provides guidelines and procedures for industry stakeholders in assessing potential risks for a given decision or action (FAA, 2007). The following are potential risks identified and the mitigation measures necessary to reduce the likelihood of such risks occurring.

Any computer-based software is inherently susceptible to any range of system problems. Home or office-based computers often fall prey to hackers. Aviation computer systems are no different. Both data link and ADS-B systems have shown vulnerabilities to hackers. Australian authorities delayed the launch of a nationwide ADS-B system after reports of hackers, or spoofers as they are known, created fake targets on the screens of air traffic controllers. An article from *Avionics Magazine* noted that spoofers have the ability to produce as many as 50 false targets on a controller's screen (Evans, 2006). In "Enhanced ADS-B Research", it is noted that ADS-B operates "in the clear" which allows other users to listen in to broadcasts not intended for them (Samuelson et al., n.d., pg 1). The research notes that this presents a safety risk to those depending on the transmissions as, in the same way spoofers created fake targets, they are able to create fake broadcasts (Samuelson et al., n.d.). Mitigation measures for spoofers of ADS-B signals include data encryption and data authentication. Both techniques allow for the secure transmission of ADS-B signals (Evans, 2006).

Several human factors issues must also be considered with the implementation of a data link and ADS-B system. Potential human factors issues with respect to the implementation of ADS-B and data link include an overreliance on automated cockpit systems, the potential for ADS-B to be a distraction, and pilots reducing the amount of time spent on visual traffic scans (Funk, Mauro, and Birdseye, 2008). While ADS-B and data link systems are introduced to create a more efficient national airspace system and create a safer cockpit for pilots, these potential hazards must be analyzed. A study seeking to identify human factor issues related to the use of both of ADS-B and cockpit displays of traffic information, including systems like data link found several potential issues. Among the issues noted in the study was the potential for pilots to overuse any cockpit display, thus reducing the amount of time spent visually scanning for traffic. The study also noted that the positioning of a cockpit display system such as data link is important, as poor positioning may make the display difficult to read for the flight crew (Funk et al., 2008). A study conducted by the Idaho National Engineering Laboratory noted that pilots cannot be familiar with all technology in new advanced technology cockpits because of the sheer complexity of such advanced systems (Nelson, Byers, Haney, Ostrom and Reece, 1995).

Mitigation of these potential risks is crucial, as they range in severity from hazardous to minimal according to the matrix provided by the FAA's SMS Manual (FAA, 2008). As previously mentioned, potential mitigation techniques for technical issues related to ADS-B and data link include forms of data encryption and data authentication. Some of the human factors issues discussed could be mitigated through comprehensive education for pilots about the new systems, specifically the systems limitations so pilots are well versed on the safety risks associated with an over reliance on these systems. Other issues discussed including the placement of the equipment in the aircraft are easily remedied through testing to determine the ideal location for these new systems.

6. Description of Interactions with Industry Experts

Interaction with industry experts was achieved through a series of face-to-face interviews with leading management at Continental Airlines. Continental Airlines' leading management team accommodated the research team on February 27, 2009 both at the Continental Airlines headquarters building in downtown Houston, Texas and at the Continental Hub Operations Center at the nearby George Bush Intercontinental Airport.

Continental Airlines prepared a series of meetings for the research team to meet with key management involved in fuel efficiency and flight operations. Included in these meetings was the Vice President of Flight Operations, the Operations Fuel Efficiency Project Manager, multiple Senior Managers of Propulsion Engineering, the Manager of the Air Traffic Control Ramp at IAH, the Managing Director of Operations Planning at IAH, and several employees involved with daily operations at the Continental Airlines Operations Center.

Throughout these interviews the research team was able to ask questions and receive feedback about procedural issues, best practices, ways to potentially save time and money through the use of technology, as well as how Continental Airlines has been able to work with the FAA and the airport to improve efficiency and save fuel.

Contact was also made with the Sensis Corporation, the developer of the Aerobahn web-based performance system used by Continental Airlines, Northwest (now Delta Air Lines), and John F. Kennedy International Airport in New York. Sensis Corporation was able to provide valuable information about the Aerobahn system and its capabilities to enhance efficiency in airport environment and the national airspace system.

7. Description of the Projected Impact on the Industry

The goal of this design category is to introduce innovative strategies or procedures to reduce fuel consumption at the nation’s airports. The proposed solution combines multiple technologies to achieve this goal. While reducing fuel consumption is the primary goal, the proposed solution also achieves several other goals which in turn creates a more efficient air transportation system. These secondary goals include an increase in safety, both in the sky and on the ground, as pilots have access to information previously unavailable, and an increase in capacity in the national airspace system. As noted in the safety assessment, measures will need to be undertaken to ensure that the potential risks these technologies present are mitigated.

Costs estimates associated with data link and ADS-B implementation vary. In Europe, it was noted that the cost of a data link system would be in the range of $60,000 to $120,000 per aircraft (Marsh, 2004). This figure can vary depending on the type of aircraft and the amount of equipment that would need to be retrofitted or installed in that particular aircraft. The cost to introduce data link technology to each European airspace control center (ACC) would be between $6 and $12 million (Marsh, 2004). This figure is quoted in 2004 dollars.

In 2002, the FAA began a data link pilot program in Miami, Florida. The data link pilot program counted American Airlines, ARINC, and the Miami Air Route Traffic Control Center as key partners. Several data link ground stations had to be installed around South Florida as well as on three Caribbean islands. In terms of controller training, controllers spent four days undergoing instruction on data link. Costs for both the installation of data link ground stations and the training of air traffic controllers is unknown, however, the information is able to help illustrate the type of infrastructure and training needed to operate such a system (Marsh, 2004).

ADS-B ground infrastructure can cost less than typical radar stations. A report from Air Services Australia noted that a typical ADS-B ground station costs anywhere from $100,000 to $400,000 whereas a radar station can cost anywhere from $1 to $4 million (Dunstone, n.d.). In August 2007, the FAA awarded ITT Corp. a $1.86 billion contract to build the ground network for ADS-B in the United States (FAA Union protests ADS-B Certification, 2009).

Appendix A- List of Complete Contact Information

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Appendix B- Description of the University

The University of Nebraska at Omaha is a public university located in the largest city in the state of Nebraska. The university has a student population of 14,959 undergraduate and graduate students. The University of Nebraska at Omaha was founded in 1908. The university moved to its current Dodge Street campus in 1938 and was housed in what is now Arts and Sciences Hall. Today the university has two campuses, the Dodge Street campus and the Pacific Street campus separated by Elmwood Park.

The university offers approximately 110 bachelor's degree programs, 42 master's degree programs, and five doctoral programs. The university is comprised of the College of Arts and Sciences, College of Business Administration, College of Education, College of Fine Arts and Media, College of Information, Science, and Technology, and the College of Public Affairs and Community Service. Many of the programs within these colleges are highly ranked and respected. US News & World Reports ranked the Public Administration program as the 27^{th} best in the country. The same rankings consistently rate the university as one of the best in the Midwest.

The Aviation Institute at the University of Nebraska at Omaha is located within the College of Public Affairs and Community Service. The program moved into a brand new space within the renovated CPACS Building in the fall of 2008. The new facility provides students with an Aviation Resource Center, a Simulator Flight Lab, and state of the art classrooms. The Aviation Institutes offers students degrees in both Professional Flight and Air Transport Administration. The Air Transport Administration program is accredited by the Council on Aviation Accreditation and the Aviation Accreditation Board International.

Appendix C- Description of Non-University Partners

Contact	**Title**	**Company**	**E-mail**	**Phone**
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Wayne Eastus	Manager ATC Ramp	Continental Airlines	Wayne.eastus@coair.com	281-553-8739
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Appendix E- Evaluation of the Educational Experience Provided by the Project

The Student Team

1. Did the FAA Design Competition provide a meaningful learning experience for you? Why or why not?

The design competition proved to be a valuable learning experience for all the team members. It taught the team the importance of looking at different aspects of the aviation industry from every perspective. It also gave the team a closer look inside the industry and the valuable tools available to increase safety and efficiency. Finally, it forced the team to work with each other and with industry experts on topics that, at the time, were foreign to the members. It therefore enhanced their abilities to discuss unfamiliar topics and taught them to take full advantage of the new information received during those discussions.

2. What challenges did your team encounter in undertaking the competition? How did you overcome these challenges?

The largest challenge the team faced during the development of the proposal was narrowing the topic. As the team investigated deeper into the research, they quickly realized the overwhelming amount of detailed information available. They also realized that the solution to their problem statement was not simply one resolution, but it involved a combination of technologies and procedures.

3. Describe the process your team used for developing your hypothesis.

To develop a hypothesis, the team evaluated several issues plaguing the aviation industry. After brief discussion about a number of topics, the team decided to focus their research on fuel consumption. More specifically, the team looked at new technologies and procedures that airports and airlines can implement to reduce fuel consumption, and overall reduce costs.

4. Was participation by industry in the project appropriate, meaningful, and useful? Why or why not?

The participation of Continental Airlines in the project was essential to the development of the design proposal. Their generosity and knowledge gave the team the foundation they needed to focus their research on the design challenge. Continental also gave the team an inside look at industry procedures, technologies and challenges, and enabled them to gain a real-world perspective on the impact these factors have on the aviation industry.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

The team leaned about the various procedures and technologies available to airports and airlines that can assist in fuel consumption reduction. This project also enabled the team to enhance their skills and knowledge required to pursue a career in the aviation industry. The sources obtained and the networks created throughout the research process will prove to be invaluable in further studies and future careers of the team members.

The Faculty Member

1. Describe the value of the educational experience for your student(s) participating in this competition submission.

The value of this educational experience for Michael, Joseph and Jess was tremendous. The amount of industry experience and insight gained far surpassed my expectations. Throughout the interviewing process the students reported a great understanding for the technical issues that surround airline and airport operating environment.

2. Was the learning experience appropriate to the course level or context in which the competition was undertaken?

The University of Nebraska at Omaha's Master of Public Administration program that Michael and Jess are currently enrolled in as well as the Bachelor of Science in Air Transport Administration that Joseph is enrolled in have a specific emphasis on aviation policy and legislation. This experience allowed the students an opportunity to take what they learned in the classroom and apply their knowledge to the workings of the industry to solve a legitimate problem. The experience was absolutely appropriate to the course level in which the competition was undertaken.

3. What challenges did the students face and overcome?

The students faced a variety of common research challenges including focusing on a topic and finding relevant literature on the subject material. Since some airline fuel conservation techniques are considered proprietary, finding answers to some of their questions was a challenge. Overall the students overcame a mixture of challenges, all of which they were able to overcome.

4. Would you use this competition as an educational vehicle in the future? Why or why not?

Absolutely, the students that participated in this design competition were able to take an advanced topic and gain a tremendous understanding of the subject manner, as well as a perspective on the airline and airport industry. This competition was an invaluable asset to the students.

5. Are there changes to the competition that you would suggest for future years?

The competition offers a variety of topical areas, which is good, but I hope that the categories or areas of inquiry are updated to accommodate new issues as they arise in the industry.

Appendix F- Reference List

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