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

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Sorenson Best Paper Award Recipient
ACHIEVING RECOGNITION AS A WORLD CLASS AIRPORT THROUGH EDUCATION AND TRAINING

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ABSTRACT

The need and requirement exists for the implementation of proper safety oversight systems by airport operators and management. The ability to achieve world-class airport operations can occur only if airport personnel receive the proper education and training to manage safe operations and increase operating efficiency. This paper addresses the current requirements of the International Civil Aviation Organization for the certification of airports and means by which to obtain a proper safety oversight system, provides examples of airports making progress toward meeting world class standards, and describes a program for certifying airport personnel as a means to achieve world class airport operations.

INTRODUCTION

The management and operation of airports is becoming more complicated and sophisticated due to advancing technology and user demands. Outside forces such as airport users, tenants, customers, and government agencies exert additional demands requiring change and growth on the part of airport management and employees to meet those requirements. These demands require a more highly skilled and knowledgeable work force. A safety conscious society also requires airport operation and maintenance personnel to be qualified in their respective areas. Though education and training have always been integral to effective airport operations, its significance has certainly increased in recent years due to global competition for passenger, cargo and economic development.

If the goal of an airport is to improve safety and security, meet International Civil Aviation Organization (ICAO), International Organization of Standards (ISO 9000), or state government standards, or be competitive in the global marketplace, then airport management and their employees must keep pace with changes in society and the industry if they expect to meet customer demands for a world class airport. World class is a term that is defined as an organization's ability to provide a product and/or service as good as, or better than, any other competitor in the world through some competitive advantage (Dessler, 1995).

Recently, ICAO adopted new Standard and Recommended Practices (SARPs) governing the operation and management of airports. Compliance with the SARPs will require both increased education and training of personnel. Amendment 4 to the *ICAO Annex 14 Volume I Aerodromes* spells out the requirements for the certification of airports serving international air carrier operations (Rao, 2002). It recommends that all public use airports and not just international ones be certified as well.

To accomplish these goals, it is important to remember that airport organizations are made up of people and they exist to fulfill the mission or goal of the airport. It is an airport's mission statement that forms the basis for all activities at the airport, including training. Education and training efforts must be directed in such a manner that the airport *organization* can accomplish its mission and goals. This focus on the purpose of the organization entails looking at what an airport does and then describing the types of things the organization should be doing.

ICAO, through its SARPs, identifies training and record keeping as a means of demonstrating compliance with agreed upon regulations and satisfactory operation. Together, they reflect the safety oversight system in place at the airport. Additionally, labor contracts will often contain a clause for the employer to provide educational opportunities or training of labor members.

Education and training are often viewed as one and the same. However, scholars will point out a distinction between the two. Training is a response to a need and should stem from gaps in knowledge or performance. Training is performed as a short term focused response to organizational and individual job task needs. A training need will exist when an employee's performance differs from what the situation or task requires. More specifically, a training need exists when a current employee's knowledge, skills, or attitudes should be changed to help bring about desired performance. In general, training prepares individuals to do their current jobs.

In contrast to training, education provides a broader, more generalized acquisition of knowledge and development that prepares an individual for a future job or position. Education also enhances the ability of an individual to understand and appreciate the larger perspective of how things work in their organization and in the world. It is educational development that allows a person to understand how they fit into the broader context and meaning of airport operations and it promotes overall intelligence about how things and people work and function. For customer service oriented airports, both education and training are necessary.

EDUCATION AND TRAINING IN THE AIRPORT ENVIRONMENT

From an organizational standpoint, the environment in which airports operate is one of turbulence and uncertainty. Additionally, airport management constantly faces pressures and demands from the government, traveling public and users of the airport. To cope with this environment of political, social, regulatory and economic forces, airport staff must maintain a high degree of flexibility and productivity. Education and training help to provide the means by which airport personnel can optimize operations. It has been found that a better-trained work force will be more productive (Cocheu, 1990; Wexley & Latham, 1981) and provide higher quality services (Gilbert & Parhizgari, 2000).

Other studies have shown that the more training and education an individual receives related to his or her job, the more satisfied and motivated he or she is (Rush, 1987). Lawler observed that a highly motivated and satisfied work force tends to be more stable and better able to adapt to changes (Lawler, 1987). Employees also want to feel in control of their work. When their skills and knowledge are increased and alternatives for doing things differently or better are known, employees have an increased ability to cope with the pressures and demands of the workplace (Duncan & Weiss, 1979).

The environment in which an airport operates lends itself to many training and educational opportunities. For instance, the Hartsfield Atlanta International Airport provides more than 100 development and training opportunities annually to its employees and tenant service providers to enhance their professional, personal and organizational development. The airport environment also presents many challenges and problems. Questions to answer include: What kind of training and education should we do? When should we train? How should we carry out training? In many respects, airports are no different in their general training requirements than other organizations in business and industry. However, airports have

specific needs and skills requirements that cannot be provided by regular training organizations.

For instance, specialized training would focus on areas such as airfield inspections, pavement maintenance, ground vehicle operation, airfield lighting and maintenance, tower control and operations, hazard awareness, construction monitoring, security, fueling, fire and emergency response, snow removal, wildlife mitigation, terminal operations, and baggage system handling, to name a few. Each of these would have specialized application to an airport and require specialized training.

The airport operating environment also requires administrators, managers, maintenance and operations personnel to have an overall understanding of many different aspects of airport operation, to include how all their specialized area fits into the larger frame of operating a world class airport. This larger understanding comes from having education sessions that provide a broad perspective of how an airport system is interdependent and interrelated to the aviation system. Achieving understanding of how each area of an airport impacts the other and how the airport then impacts other businesses and the community is the goal of broad education.

Determining and analyzing training needs is the starting point for all training efforts. Needs analysis is the collection of information to determine whether there is a gap between current performance and expected performance (Rummler, 1987). There are different ways to determine the performance or need gap. This information can be culled through five primary methods: interviews, documents, surveys, observations, or focus groups (Wexley & Latham, 1981). Analyzing and identifying the gap that may exist between what the airport organization is supposed to be doing and what it is doing points toward areas for education or training.

Unfortunately, airports do not generally have the luxury of skilled trainers or resources to conduct or fulfill all the airport's training needs and requirements. As a result, personnel within the organization who frequently do not have a background in education or training methods conduct much of the required training on a piecemeal or as needed basis. This circumstance may result in a poor or ineffective training process because successfully proven training and education procedures are not used. The improper or nonexistent training and education of airport personnel is often identified as one of the major factors that contribute to the shortcomings of airport operations.

ICAO emphasizes the importance of civil aviation training by initiating projects that support the training activities of its Contracting States. ICAO's Aviation Training Program assists Contracting States in establishing and/or developing their own civil aviation training capability by providing training opportunities abroad and by providing guidance on training curriculum. Other organizations, such as the International Association of Airport Executives (IAAE), International Air Transport Association (IATA), universities, and private organizations or individuals can provide primary assistance as well.

One important principle under which the ICAO training program functions at an airport is that aviation training is the responsibility of the Contracting States. It is because many States are now starting to privatize their operations that ICAO believes the safety oversight responsibility of the airport organization may be compromised. For this reason, Amendment 4 was adopted to ensure that safety management systems continue to remain in place and are upheld. As a note, airports in the United States of America (U.S.A.) serving domestic and international air carrier operations have been required to be certificated since 1976.

EDUCATION AND TRAINING FOR WORLD CLASS AIRPORTS

During the 1990s, several new international airports opened around the world. In particular, two were beset with major opening day snafus that otherwise spoiled the accomplishments of having the airports constructed. Other airports, both new and old, have experienced increases in operational errors or delays in responding to customer service requests.

The Incheon International Airport Corporation (IIAC), the organization charged with building and operating the new airport that superseded the aging Gimpo Airport in Seoul, Korea, was one airport that was keenly aware of the problems that can beset new airports. They had studied the earlier snafus and startup problems at other airports and were determined to avoid similar startup problems.

In conducting analyses as to why previous airports experienced the difficulties they did, IIAC officials concluded it was because of two basic underlying reasons: a) the various operational systems of the airports were not adequately tested before opening, and b) the personnel were not properly trained to manage the operations or handle problems that did arise (H.J. Kim, personal communication, April 13, 2000). IIAC sought to address the later issue by engaging several internal and outside training institutions to better prepare their employees for the opening. They did this

because their goal was (and continues to be) to operate a world-class airport.

IIAC had a successful opening in May of 2001 and is off to a good start toward meeting its goal (Hiscock, 2002). Their success had been due in large part to senior management supporting the initial training and education of all of its employees in every discipline. Broad educational sessions coupled with specific system and operational training were conducted using several means. After the opening, IIAC officials continued to provide the educational and training experiences necessary to maintain their opening day success (Quilty, 2001).

IIAC understood the value of education and training in order to achieve world-class status. Other airports attempting to remain or increase competitive advantages on the global playing field are recognizing the same. In April of 2002, the Indian government came under world scrutiny for the way in which their airports were managed. In response to that criticism, Civil Aviation Secretary K. Roy Paul announced the preparation of a strategic master plan for developing and modernizing all airports in the country in order to reduce political interference. To do so, however, he said the skills of the Airports Authority of India would have to be upgraded so as to equip it for overall management of world-class airports (NDTV, 2002).

The Hartsfield Atlanta International Airport has as its mission statement to become the world's best airport by exceeding customer expectations. In accomplishing this mission, the airport recognized the need to have people demonstrate the skills, knowledge, abilities, and motivation necessary for achieving recognition as a world-class airport. They do so by expending approximately $18,500 per employee annually in training, either through onsite training and education or by outside tuition reimbursement (C. Alston, personal communication, June 20, 2002). The programs offered cover management development and education topics as well as specific skill training. The end result is that Atlanta was rated best in overall passenger satisfaction by the IATA for 2001 for mega airports handling more than 40 million passengers a year (Hiscock, 2002).

Throughout the U.S.A., training and education is a legal requirement at airports. The U.S. Federal Aviation Administration (FAA) places emphasis on the subject of training in federal regulation 14 CFR Part 139 under Sec. 139.303: "Each certificate holder (airport) shall maintain sufficient qualified personnel to comply with the requirements of its airport certification manual or airport certification specifications and the applicable rules of this part" (FAA, 1988).

There are specific sections within the FAA regulation that address training, such as rescue and fire fighting, basic emergency medical care, handling and storing of hazardous substances and materials, fueling, snow removal, low visibility operations, emergency plan implementation and wildlife hazard management. To strengthen its emphasis on training and education, the FAA issued in 2000 a notice of proposed rule making (NPRM) for modifying Part 139 that upon enactment will require the specific training and education of inspection personnel (FAA, 2000).

Throughout the current and proposed FAA regulations, the words *shall include procedures* are found. Procedures must be communicated and explained to individuals to ensure compliance. Under the terminology, airport procedures can be viewed as the framework or infrastructure that brings together personnel, equipment and facilities to accomplish airport organizational goals. Airport policies and procedures form the basis for the development of a training program. Together, policies and procedures represent the safety management system of an airport and are indicative of what ICAO seeks to have its members implement.

Poor employee or organizational performance can often be attributed to employees not following proper procedures, or by not having the proper tools, materials or equipment available to adequately perform the job. If airport management is not prepared to consider changes in the work environment to support training, or fails to provide a commitment to training and education due to budget constraints or other factors, then management cannot expect to meet the world-class standards or goals of the organization. There has to be an organizational and resource commitment to conduct education and training for an organization to be successful (Cresswell, 1989). Training and education are not one-time activities that organizations do, but rather must be part of an ongoing process that has management commitment and emphasis.

CERTIFICATION OF AIRPORT PERSONNEL

As noted previously, education and training were important considerations for the IIAC. IIAC also was looking to achieve possible certification of its personnel as a means for demonstrating its airport would be operated by trained individuals and as a means for continual improvement and implementation of ISO processes. Certification, by definition, is the voluntary process instituted by a non-governmental agency in which individuals are recognized for advanced sets of skill or knowledge (Shenenberg & Smith, 1999). The purpose of certification is to inform the public that selected individuals have demonstrated a particular

degree of competency. IIAC's search for certification led it to the American Association of Airport Executives (AAAE) as having the only program that offers the accreditation and certification of airport employees globally.

AAAE is the largest professional organization for airport executives in the world, representing thousands of airport management personnel at airports in the U.S.A. and internationally. AAAE's goal is to help airport executives fulfill their responsibilities to the airports and communities that they serve.

There is an International Association of Airport Executives (IAAE), an affiliated AAAE organization, which exists to advance airport management education and professional development across the globe. In carrying out its mission, AAAE and IAAE conduct numerous seminars, conferences, and training workshops in the U.S.A. and the world.

AAAE conducts two key education and training sessions for airport operations personnel. They are known as Airport Operations and Safety Schools (ASOS), which are either Basic (B-ASOS) or advanced (A-ASOS). The basic course is an instructional classroom approach to the dissemination of safety related material, while the advanced course uses more group activities and case studies in the classroom environment as an approach to improving airport problem solving.

AAAE is also the largest organization that has an accrediting and certifying process for airport personnel which attests that they have met a recognized skill and/or knowledge standard. There is both an American and an International process. For accreditation, the process involves a management thesis paper, a comprehensive written exam, and a final oral exam before a panel of accredited executives. A person passing the full accreditation process is recognized as an Accredited Airport Executive (A.A.E.).

The U.S.A. written and oral exams utilize a set of fifteen different modules which cover a wide range of airport-related topics and represent the body of knowledge reasonably expected of an airport executive to manage an airport (Quilty, 1999).

Both the U.S.A. and international accreditation processes are available only to those individuals actively engaged in the management of airports. For individuals who do not meet the basic airport employment experience requirements or who may be engaged in airport-related activities such as consulting, engineering, or service provider, those individuals can demonstrate their knowledge and affiliation to the industry through the Certified Member (C.M.) program. To become a C.M., an individual must

pass the same comprehensive written exam, as an accredited member must pass.

For the international certification, a set of 10 individual modules were developed that reflect a similar body of knowledge as the 15 modules in the U.S.A. version, but which incorporate ICAO requirements (Quilty, 2000). A listing of the module topics for comparison purposes is provided in tables 1 and 2.

The difference between the two sets of modules lies in the more evolved aspect of aviation legislation and regulatory requirements in the U.S.A. as compared to other nations. For that reason, an international certified member course and the 10 related modules are customized to the individual airport for the specific country.

Table 1. AAAE U.S.A. Accreditation and Certified Member Modules

1. Introduction to Airports and the Federal Aviation Administration
2. The Management Functions
3. Management Roles, Theories, Motivation, and Communication
4. Airport Capacity and Delay
5. Air Traffic Control, Airspace and Navigational Aids
6. Environmental Regulations
7. Airport Noise and Land Use Compatibility
8. Financial Management and Accounting
9. Airport Fees, Rates, and Charges
10. Airport Capital Development and Funding
11. Airport System Planning and Airport Master Planning
12. Airport Layout Plans
13. Terminal Planning, Design and Operation
14. Airport Operations and Federal Aviation Regulation Part 139
15. Response to Emergencies and Airport Security

Table 2. AAAE International Accreditation and Certified Member Modules

1. Introduction to Airports and Management
2. Airport Capacity and Delay
3. Airports and the Environment
4. Airport System and Master Planning
5. Air Traffic Services, Airspace and Navigational Aids
6. Airport Finance and Economics
7. Airport Design and Layout
8. Airport Terminal Planning, Design and Operation
9. Airport Operations
10. Airport Emergency Response

The module format for the exam and reference material was developed because of the need for material that could be readily updated to reflect changing airport regulations and operations. The format also allows for easy dissemination or training of a single subject. It should be noted that the AAAE and IAAE certified member process is restricted to defined subject area knowledge as demonstrated by a written exam. Airport experience does help considerably in successful attainment of the credential. Full accreditation through AAAE or IAAE balances the academic knowledge exposure of the certification process with the application of that knowledge and skill through experience.

There are many different education and training methods in existence for airport personnel. Without a needs assessment, there is no simple way to decide which method is best in any one situation. An individual or organization versed in providing a structured learning environment can be of value. And in keeping with efforts to be considered a world-class airport, many airports strive to become ISO 9000 certified for their processes and procedures. Integral to such certification is the continual training and education of its employees in order to provide quality management services and continuous process improvement to ensure that its products and services conform to the customer's requirements. Therefore, an education and training program that leads to the certification of airport personnel can be of particular importance to an airport, whether or not they are pursuing ICAO or ISO 9000 certification. The certification can represent to the world that the airport values and encourages a world-class operation.

CONCLUSION

Airports are becoming more complicated and sophisticated due to advancing technology and user demands. The environment in which airports operate is one of turbulence and uncertainty. To cope with this environment of political, social, regulatory and economic forces, airport staff must maintain a high degree of flexibility and productivity. These qualities are achieved through the continual education and training of employees and customers.

The objectives of education and training programs are to improve individual *and* organizational performance. Education and training are planned efforts to improve individual and organizational behavior and knowledge. Professional competence is attained when knowledge is acquired through training and education efforts, skills are developed through practice and experience, and there is a continuous application and

evaluation of these knowledge and skills as they apply to the work environment.

For organizational effectiveness, the airport organization must be committed to having and conducting education and training programs and to providing the necessary resources to accomplish its mission and goals. In carrying out initiatives to have a world-class airport, airport administration should consider as a necessity the establishment of educational and training programs that will support their processes and procedures. Certification of airport personnel is one means to obtain a more knowledgeable workforce to accomplish that end. Certification of airport personnel brings together the knowledge and experience of the whole airport industry for the benefit of the individual, the airport organization, and the community in conducting safe airport operations.

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ETHICS EDUCATION IN UNIVERSITY AVIATION MANAGEMENT PROGRAMS IN THE U.S.: PART TWO A—THE CURRENT STATUS

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ABSTRACT

This three-part study examines how four-year universities in the United States with baccalaureate programs in aviation management include ethics instruction in their curricula. Part One justified the need for ethics education and developed hypotheses to evaluate the current status of ethics instruction. Part Two of the study continues with an extensive survey conducted in 2000 of all collegiate aviation management department heads. Part Two A, the first of two reports on the results of the survey, describes the current status of teaching ethics in the nation's aviation management education programs. It was found that ethics is not widely included in collegiate aviation programs at levels expected in light of current industry problems.

INTRODUCTION

In the aftermath of the tragic events of September 11, 2001, many news stories have been published about the sorry state of U.S. aviation security. However, problems in airport security existed long before September 11. And if the long list of problems had been carefully analyzed for commonalities from one instance to another, a recurring item that would certainly surface would be the lack of ethics on the part of individuals and whole organizations in dealing with airport security.

Within the past few years the security problem first became prominent as a result of drug smuggling operations involving airline and contractor employees. These employees used their insider status and restricted area access badges to aid and abet drug smuggling operations at a number of

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airports, most prominently Miami (Loney, 1999). Such incidents certainly indicate ethical problems with individual employees, but they are also indicative of organizational problems. Organizations like airlines and airports "are very vulnerable because they dont want to spend the money it takes to screen the people that work at their facilities" (Loney, 1999). The government sting operation that netted 58 suspects at Miami is just one of a number of similar incidents (Airline Worker Admits, 2000; Anderson, 2000; Loney, 1999). And obviously, a major worry is that if employees can be bribed for drug smuggling, they can be bribed for other security related issues.

Other security problems related to poor ethical standards existed prior to September 11. For example, Argenbright Holdings Ltd. was fined $1.6M on October 20, 2000, for falsifying training and background investigation checks on employees who manned security checkpoints at 68 U.S. and European airports (Slobodzian, 2000). Personnel employed by Argenbright included people with criminal records. AirJet Airline World News (2000) reported that Aviation Safeguards of Florida, Inc., pled guilty to similar charges, and that Delta Air Lines, in an effort to hire workers for low paying security jobs, coached prospective applicants on what to include and not include on their job applications. This included altered addresses so background checking firms would not discover criminal activity on their records. Evidence of employer-altered application forms was also found (AirJet Airline World News).

Following September 11, many more similar stories appeared in the media, and once again, although the term ethics never appears in the news reports, lack of ethics was foundational to the events discussed in every news report. Even after the fine against Argenbright Holdings mentioned earlier, Argenbright was charged again in October 2001 with improper employment application screening and falsified records at 14 airports (Levin, 2001). In December 2001, the Department of Transportation indicted 69 workers at Salt Lake City International Airport for falsifying applications for airport security screening positions (Barnes, 2001). In January 2002 another company responsible for security screening at Miami International Airport pled guilty to similar charges (Yanez, 2002). Finally, a February 2002 report cited more of the same at Boston's Logan Airport and Las Vegas' McCarran Airport (Mehren, 2002).

As if report after report of falsified employment applications and intentional duping of the security background investigation system were not enough, new reports of deliberate government suppression of information about the poor state of airport security hit the media in February 2002 (Morrison, 2002). It seems that the Federal Aviation Administration's (FAA) Red Team, an undercover government team

formed to inspect airport and airline security systems for vulnerabilities, was able to routinely penetrate existing security screening systems in 1998 and 1999. When the team reported the results of their activities, they were ordered not to make reports, they were ordered to provide advance notice of their inspections, and their data was manipulated "in order to protect the airline industry" (Morrison, 2002). It is especially interesting that these reports are surfacing again after September 11, because they were originally published in late 1999 (Associated Press, 1999; Levin, 1999).

All of these reports over the past couple years serve as an indicator that organizations and individual supervisors and employees are willing to sacrifice ethical principles in the interest of financial well-being. Part One of this study (Oderman, 2002) investigated ethics education in aviation management programs at the university level. Due to the lack of any published articles in this area, the assumption was made that little was being done to discuss ethics with students in such programs. Part One established the need for and justified ethics education at the higher education level. Through an extensive literature review, the author developed a series of hypotheses based on what other curricular areas have done to bring ethics education to their programs and also based on some general education principles dealing with educational change. The author went on to study these hypotheses in relation to collegiate aviation management programs in the U.S. The following reports on that study. Due to the volume of data gleaned, this part of the study will be reported in two separate articles. Part Two A will describe a survey conducted by the author and will report on responses received in an effort to describe current practices used by collegiate aviation management programs to teach ethics. Part Two B (in an article to be published) will cover the statistical analysis of the data reported in Part Two A.

RESEARCH DESIGN AND METHODOLOGY

An author-designed survey instrument was sent to department heads of all colleges and universities that offer baccalaureate degrees with aviation administration as an academic major. Data was collected regarding departmental and department head demographics, departmental methodology for including ethics in the curriculum (if any), and department head opinions about ethics and its incorporation in aviation administration programs. Additionally, each department head responded to questions about obstacles faced in establishing ethics instruction and about his or her department's organizational culture as related to ethics. Independently derived data on funding and sponsorship categories of the colleges and universities in the study and about their Carnegie

classification were added to the database for statistical analysis as well. The responses to this instrument were statistically analyzed to describe current practices used to incorporate ethics in aviation management curricula.

Peterson's Guide to Four-Year Colleges—2000 (1999) lists a number of colleges and universities in the U.S. that offer baccalaureate programs in aviation administration, aviation technology, or both for undergraduate students. By crosschecking this list with another more detailed list in the *Collegiate Aviation Guide* (Kiteley, 1999) and with information found for schools on their Internet web sites, a list of 62 higher education institutions that offer four-year aviation administration programs was generated. Each of the schools was categorized in two ways for use in statistical analysis. First, each school was classified by funding or sponsorship source as public, private-secular, or private-religious. Second, the author determined the Carnegie classification for each school using the millennial edition of the Carnegie Foundation's typology (Carnegie Foundation, 2000).

Survey Instrument

The survey instrument was sent with a cover letter and a participant consent form to department heads at all 62 colleges and universities. The survey instrument was developed based on: (a) information gained from a literature review concerning the incorporation of ethics instruction in non-aviation academic programs, and (b) educational change concepts described by Fullan and Stiegelbauer (1991). The instrument has 52 multiple-choice or short answer questions plus two open-ended questions. The survey was designed to obtain information about the inclusion of ethics education in the undergraduate aviation management programs of all universities in the U.S. offering them. If ethics is part of the curriculum, the survey asks whether it is taught from inside or outside the department, the degree of faculty participation in teaching ethics, and whether it is a required or elective course(s) or both. The questionnaire also asks for the department heads' opinions related to offering ethics as part of the curriculum. Survey questions also sought evidence of other artifacts of an ethical organizational culture, such as ethical codes, seminars and educational meetings on the subject, curriculum development, faculty research in the area, guest speaker presentations, and departmental ethics committees.

The author pre-tested the survey instrument with department heads from eight departments in the School of Technology at Purdue University. Although the survey specifically addresses aviation, a similar study concerning ethics inclusion could be made in the disciplines represented by these eight technology departments because they have a similar association between their educational goals and the industries to which they provide

students. In a cover letter, test participants were asked to substitute their academic disciplines each time the term "aviation administration" appeared on the survey instrument. Seven of eight department heads responded to the test survey instrument. Their responses led to correction of some minor wording problems in a few of the questions on the instrument, and also provided an estimate of the time needed to complete the survey.

In addition to relying on the survey responses, the author conducted searches of college catalogs of four-year institutions with an aviation management major. The searches were done using an on-line database of college catalogs that is maintained by the Career Guidance Foundation (2000). All catalogs in this database were current as of the 2000 academic year except for five; for these five schools the author used current catalogs available on their individual Internet sites to conduct the searches. The searches were conducted on two groups of institutions. First, a search was made of schools that responded that they either require students to take an ethics course, that they allow elective credit for ethics courses, or that they teach aviation courses that have ethics as a planned topic of instruction. This search was done in order to determine if departments publish evidence of the inclusion of ethics in plans of study or course descriptions. The second search was conducted on schools that did not respond to the survey instrument in an attempt to learn if these non-responding schools publish anything about the inclusion of ethics in their programs.

Definitions of Variables

A number of variables were defined and investigated in the survey instrument. These variables have been suggested by the Part One literature review (Oderman, 2002) as factors that could be associated with the initiation or adoption of effective ethics instruction programs in academic curricula, and they are listed below:

> **Department head's experience**—three quantitative variables which indicate the number of years the department head has spent as a department head, as a faculty member before becoming department head, and as an employee in the aviation industry (not including his or her time in collegiate aviation education).
>
> **School size**—a quantitative variable indicating the total number of undergraduate students in the department.
>
> **Funding or Sponsorship category**—a categorical variable indicating the type of college or university of which the department is a part by funding or sponsorship source. Three categories are used: public, private-secular, or private-religious.

Carnegie classification—a categorical variable determined by reference to the Carnegie Classification of Institutions of Higher Education (Carnegie Foundation, 2000).

Administrative approval—a categorical variable indicating whether or not the department head has already supported the inclusion of ethics in the curriculum.

Administrative disapproval—a categorical variable indicating whether or not the department head has already disapproved decisions to include ethics in the curriculum.

Administrative concern—a quantitative variable based on a five-point Likert scale to indicate the importance the department head places on including ethics as part of the curriculum.

Administrative involvement—a categorical variable indicating whether or not the department head has actually taught ethics as a planned part of the curriculum.

Administrative funding—a quantitative variable based on a five-point Likert scale to indicate the willingness of the department head to commit current departmental resources to include ethics instruction in the curriculum.

Extra-departmental support—two categorical variables indicating whether or not the department has received resources to include ethics instruction in its curriculum from: (a) outside of the university or (b) inside the university, but outside the department.

Administrative position on non-aviation professors teaching ethics—a quantitative variable based on a five-point Likert scale to indicate the department head's opinion about utilizing professors outside the aviation department to teach ethics when ethics is part of aviation curricula.

Administrative position on aviation professors teaching ethics—a quantitative variable based on a five-point Likert scale to indicate the department head's opinion about utilizing professors within the aviation department to teach ethics when ethics is part of aviation curricula.

Obstacles faced—a series of seven categorical variables indicating whether the department head had faced or would expect to face the following obstacles in establishing ethics as a part of their curricula: (a) lack of higher-level administrative support, (b) lack of support from outside the university, (c) lack of funding, (d) lack of course

materials, (e) lack of trained faculty, (f) lack of time in an already-packed curriculum, and (g) lack of faculty support for including ethics.

Accreditation requirements—a categorical variable signifying whether any of the school's accrediting agencies require ethics to be a part of an aviation department's program. Aviation departments may have multiple accrediting bodies to include the regional accrediting body of the institution as a whole, an accrediting agency that deals only with aviation programs, and/or accrediting bodies affiliated with those institutions that are sponsored by religious organizations.

Departmental code of ethics—a categorical variable indicating whether the aviation department or its university has a published code of ethics.

Faculty member research—a categorical variable which indicates whether the aviation department has any faculty members who have conducted research in the area of ethics and aviation.

Speakers or seminars on ethics—two categorical variables signifying whether the aviation department has hosted guest speakers, seminars, or educational meetings to address: (a) including ethics in departmental curricula or (b) ethical problems in the aviation industry.

Departmental ethics committee—a categorical variable indicating whether the aviation department has an ethics committee within the department.

Faculty interest in teaching ethics—a categorical variable indicating whether the aviation department has any aviation faculty members who have demonstrated an interest in teaching ethics or have initiated efforts to do so.

Ethics Instruction Delivery Method as a Variable

Another data set collected during the survey consisted of the methods used by schools to bring ethics to the students in their programs. The five general instruction delivery methods are: (a) a required ethics course taught outside the aviation department, (b) a required ethics course taught by aviation professors, (c) an elective ethics course taught outside the department, (d) an elective ethics course taught by aviation professors, and (e) an aviation course in which ethics is only a planned topic in a course principally devoted to teaching another aviation subject.

The Ethics Inclusion Scale

An author-developed construct called ethics inclusion was determined using responses to several of the questions on the survey. As suggested by the findings in Part One (Oderman, 2002), academic programs have varied levels of commitment to teaching ethics. The Ethics Inclusion Scale (EIS) assigns a number from one through nine to each department as a measure of its commitment to include ethics instruction in its curriculum. The entire scale is charted in Table 1. This scale was developed in order to identify factors associated with schools at varied levels of the scale. By assigning scale levels, statistical analyses could be done later to see if other variables are associated with the spectrum of ethics inclusion, from schools that do not include ethics in any way in their current curriculum to schools that are currently including ethics in many facets of their curriculum.

The lowest level of the scale (Level 1—None) indicates that ethics is not included in the curriculum at all. The top end of the scale (Level 9—Pervasive) indicates that ethics is included in the curriculum using the pervasive method. As one goes from a lower level to a higher level, the

Table 1. Ethics Inclusion Scale

Level of Planned Ethics Inclusion in the Curriculum	Required Ethics Course Taught outside department	Required Ethics Course Taught within department	Elective Ethics Course Taught outside department	Elective Ethics Course Taught within department	Aviation Courses with ethics as planned topic
1. None					
2. Isolated					X
3. Elective A			X		
4. Elective B				X	
5. Elective C			X OR	X	X
6. Required A	X				X
7. Required B		X			X
8. Required/ Elective	X OR	X	X OR	X	
9. Pervasive	X OR	X	X OR	X	X

Note. An X indicates the inclusion of ethics courses in an institutions plan of study as denoted by the column titles in the table. A blank box indicates that ethics courses indicated by the column titles above are not included in an institutions plan of study.

scale indicates increasing commitment by department members to include ethics in their curriculum. At Level 2 (Isolated) one or more professors in the department is interested enough in ethics to include it as a planned topic in one or more of their courses, but ethics does not receive department-wide recognition. At Level 3 (Elective A) there is enough departmental commitment to allow students to incorporate an elective course principally devoted to teaching ethics in their plan of study as part of their graduation requirements. In going from Level 3 to Level 4 (Elective B), the increased commitment of the department is demonstrated in that an aviation professor (as opposed to a professor from outside the department) is responsible for teaching the elective ethics course. The fact that an aviation professor rather than a professor from another department teaches the course is important because the course will more likely be directly related to aviation and because students will see that the subject is so important that aviation professors actually teach it themselves rather than farming it out to someone in another department.

At Level 5 (Elective C), departmental commitment increases again. Such departments permit students to take an elective course principally devoted to teaching ethics, for which they receive credit toward degree requirements. In addition, ethics is a planned topic in one or more aviation courses; thus, ethics is not isolated to just one ethics course. Level 6 (Required A) is the first level at which an ethics course is required of all students in order to meet baccalaureate degree requirements; however, this level is lower than that of Level 7 (Required B) because at Level 7 the required course is taught by faculty members within the aviation administration department. Level 8 (Required/Elective) is similar to Levels 6 and 7 except that elective courses principally devoted to teaching ethics are offered in addition to the required ethics courses. Level 9 is called pervasive because ethics is infused in the whole curriculum—as a required ethics course, as elective ethics course options, and as a planned topic in other applicable aviation courses. The nine levels of the EIS, as described above, meaningfully capture the variations in a departments commitment to teaching ethics.

There is good reason for using both instructional delivery method and the EIS in this study. The EIS is derived from a combination of ethics delivery methods and indicates a department's overall commitment to teaching ethics. However, a department that only teaches ethics using one of the delivery methods may have many things in common with institutions of differing levels of planned inclusion which share use of the same delivery method. For example, suppose a school teaches ethics by including it as a planned topic in aviation courses primarily devoted to other subject areas, but this school does not require or offer courses

principally devoted to teaching ethics. This school would have a level of 2 on the EIS. Other schools at higher EIS levels also offer aviation courses with ethics as a planned topic. Using this delivery method (aviation courses with ethics as a planned topic) as a variable allows comparison of all colleges and universities that use this delivery method. In other words, using delivery method as a variable cuts across the grain of the level of planned inclusion and provides another valuable way to look at the data.

RESULTS

During Part Two of the study, the author sent survey instruments to the department heads of 62 universities with four-year aviation management programs. One department head returned his instrument with the annotation that the school did not have an aviation administration program, so this school was dropped from the study. Of the remaining 61 colleges and universities, replies were received from 41 for a response rate of 67.2%.

The responses to all questions on the survey instrument are charted in tables below, and key findings are discussed. For those questions having a numerical answer, the mean, standard deviation, and range of the variables are listed. For those questions having categorical responses, the distribution of the responses is shown. For categorical responses, if department heads left some questions unanswered on the survey response, the total responses to individual questions may not equal the total number of responding institutions (n = 41). Cross tabulation of data is not presented in tabular form due to the multiple possibilities for doing so.

As noted previously, the author also conducted searches of college catalogs of four-year institutions with an aviation management major. It is important to note that even though catalogs may have a current date, they may not be current due to curricular changes approved subsequent to publishing. Furthermore, courses listed in an institution's catalog may not be regularly or recently taught. Therefore, catalog data may not provide a completely accurate picture of a department's current program. For purposes of this study, survey responses took precedence over catalog data whenever there was disagreement.

College or University Classifications

The 61 schools in the study were categorized using two classification systems: (a) sources of funding or sponsorship and (b) the Carnegie Classification. Table 2 shows the number of schools surveyed within each category of the first classification system along with the number and percentages of responses received by category.

**Table 2. Funding or Sponsorship Sources of U.S. Institutions with Aviation
Management Programs, 2000**

Category	Number of Schools Surveyed	Number of Schools Responding	Percent Responding
Public	39	28	71.8
Private-Secular	13	7	53.8
Private-Religious	9	6	66.7
Total	61	41	67.2

Table 3 charts the number of colleges and universities that were
surveyed in each category of the Carnegie Classification System, and it lists
the number of schools and percentages of those actually responding to the
survey instrument. Not all categories in this classification system were
represented in the database for this survey, and those categories in the
Carnegie System not represented by institutions in this study are not shown.

The overall response rate to the survey instrument was slightly higher
than two-thirds. Though less than the desired 100 percent response rate, the
responses appear to be representative of what is being done across the
board especially considering the categorization of schools used in the
survey. As can be seen in Tables 2 and 3, all major categories of the

**Table 3. Carnegie Classification of U.S. Institutions with Aviation Management
Programs, 2000**

Classification	Number of Schools Surveyed	Number of Schools Responding	Percent Responding
Doctoral/Research UniversitiesExtensive	12	10	83.3
Doctoral/Research UniversitiesIntensive	9	6	66.7
Masters (Comprehensive) Colleges and Universities I	28	17	60.7
Masters (Comprehensive) Colleges and Universities II	3	3	100.0
Baccalaureate Colleges General	6	4	66.7
Baccalaureate/Associates Colleges	1	0	0.0
Specialized Institutions	1	0	0.0
No Carnegie Classification	1	1	100.0
Total	61	41	67.2

institutions using both categorization methods were represented at a rate close to the overall response rate. Indeed, chi square statistical tests were done using both classification systems to see if there were any significant differences between schools that responded and those that did not respond, and no significant differences between groups were noted regardless of classification system used. Thus, one can be confident that all types of aviation management programs received relatively equal representation in the overall statistical results, and that no one type of college or university dominated the statistical data. Nonetheless, it is not known whether and how non-respondents (and the programs they represent) differ from the responding department heads and their programs.

Aviation Department Demographics

Table 4 indicates data related to department heads' experience. As can be seen, the average aviation department head has not been in his or her position very long. The typical department head has about four and one-half years experience as a department head and just over eight years as a faculty member prior to that. However, the typical department head also has over 18 years of experience in the aviation industry which means that he or she has spent more time in the aviation industry than in academic circles.

Table 4. Department Head Experience, U.S. Aviation Management Programs, 2000

Position	Mean	Std Dev	Range
Years as Department Head	4.63	3.63	0.5 to 15.0
Years as Faculty Member prior to being Department Head	8.19	6.72	0.0 to 30.0
Years in Aviation Industry (excluding academic years)	18.33	11.19	0.0 to 39.0

Table 5 tabulates numerical data related to aviation department characteristics such as the size of the aviation administration program, the number of courses taught in the department, the expected teaching load of the faculty, and the actual teaching load of faculty and the department head. The number of courses taught within the department in which ethics is a planned topic is also listed; these numbers only include the 20 institutions that responded with the number of courses taught in this way. The typical aviation management department has close to 100 students enrolled and teaches about 13 to 14 courses specifically related to aviation management. The aviation faculty members have an actual teaching load that is slightly higher than their expected teaching load. The department head typically

teaches courses as well as administers, but the department head's teaching load is lower than that of the typical aviation professor.

Table 5. Department Characteristics, U.S. Aviation Management Programs, 2000

Characteristic	Mean	Standard Deviation	Range
Number of Students in Program	97.5	89.4	2 to 350
Number of Aviation Courses in Department	13.5	8.5	3 to 50
Number of Courses Taught by Department Head	2.5	1.6	0 to 6
Expected Faculty Teaching Load (Courses/Semester)	3.7	0.7	1.5 to 5
Actual Faculty Teaching Load (Courses/Semester)	3.8	0.9	1.5 to 6
Number of Aviation Courses Having Ethics as Planned Topic	2.9	2.3	1 to 10

Methodology for Including Ethics in the Curriculum

Within Table 6 is a tabulation of whether or not ethics is included in an aviation departments curriculum. The three principal methods for inclusion are: (a) as a required course for graduation, (b) an elective course for which a student receives credit toward graduation requirements, and (c) as part of other aviation courses in which ethics is a planned topic of discussion in a course whose primary subject matter is something other than ethics. Directly below the listings for departments with required ethics courses and for those with elective ethics courses, a further breakdown appears with a tabulation of schools which teach those courses from within the department and those having the courses taught outside the department. Finally, for each of the three methods of inclusion, the number of department heads who have taught such courses is listed. Discussion about how colleges are currently incorporating ethics into their curricula will be broken down by method of inclusion.

Table 6. Inclusion of Ethics in the Curriculum, U.S. Aviation Management Programs, 2000

Methods for Including Ethics in Curriculum	Yes	No
A Required Course for Graduation	12	29
Taught within aviation department	4	
Taught outside aviation department	8	
Department Head has taught required course	2	
An Elective Course Counting toward Graduation Credit	24	15
Taught within aviation department	1	
Taught outside aviation department	23	
Department Head has taught elective course	0	
A Planned Topic in Other Aviation Courses	22	16
Department Head has taught such a course	17	

A Required Ethics Course

Only twelve of the responding department heads (29 percent) reported that their school requires students to take an ethics course to graduate, and of those twelve, only four actually teach such a course within the department. Considering the fact that the author could find nothing written by professors from an aviation department on the subject of ethics during Part One (Oderman, 2002) of this study nor was anything published about any aviation departments teaching on this subject, it is not surprising that the percentage of institutions that have ethics as a requirement is so low. This is reinforced by the fact that of the twelve schools reporting that they require an ethics course for graduation, one-half state that ethics is required by their accreditation standards. One wonders whether the requirement for students to take an ethics course at these schools would be eliminated if there was no requirement for teaching ethics in the accreditation standards.

A catalog search was made of published plans of study to locate the ethics course requirements for those schools that stated they required an ethics course for graduation. Each of the four schools that said they taught a required ethics course from within their aviation department had an ethics course listed on their suggested plan of study. It is especially interesting to note, however, that two institutions actually house their aviation management programs within their schools' business departments. One school does it with a dual degree program. In this case, a local two-year community college offers the aviation coursework while the four-year college's business department grants the baccalaureate degree. The required ethics course resides in the baccalaureate college's business department. In the other university with aviation housed in the business department, the aviation management faculty are actually part of the

university's business and management department, and the required ethics course has a business course code. Because many business administration schools offer ethics courses, it may be that the basis for the ethics requirement in these two aviation programs is their association with their school's business program.

Of the eight colleges and universities that stated that they require students to take an ethics course that is taught by a non-aviation department, two did not list an ethics course on their suggested plans of study for students in their catalogs. Follow-up telephone conversations confirmed that the institutions do require an ethics course, but the requirement was not obvious from reading the college catalog.

Finally a catalog search was made of the 20 colleges and universities that did not respond to the survey instrument to see if they publish a requirement for students to take an ethics course. Only three of the 20 publish a requirement for such a course (15 percent), and two of those three teach the course internally. Therefore, summing up the activity of all 61 schools in the country with aviation management programs shows that less than 25 percent require an ethics course from their graduates, and only 40 percent of those teach the course internally.

An Elective Course

About 62 percent of schools responding to questions about permitting students to take ethics courses as electives for graduation credit allow such practices, but only one school allowing such electives actually teaches the course within the aviation department. In responding to a series of questions about obstacles to including ethics in the curriculum, department heads acknowledged "lack of time in an already-packed curriculum" as the obstacle with the highest percentage of "yes" votes (see Table 9). Nearly 72 percent of department heads stated they had faced or expect to face this obstacle to include ethics in their curriculum. Indeed, of 28 department heads responding to an open-ended question on what the greatest obstacle to ethics instruction was, 16 (57 percent) listed lack of time in the program. If lack of time is a problem, adding elective courses would probably be perceived as only compounding the problem further.

Additionally, that only one aviation department actually teaches an elective ethics course is not surprising given the fact that, in general, the actual aviation course teaching load is slightly higher than the expected course teaching load (see Table 5). Even department heads have a fairly substantial teaching load considering their administrative responsibilities. Only five of 40 department heads responding to a question on this subject report that they do not teach any courses; the remaining 35 teach an average of 2.7 courses per semester (compared to the normal faculty expected

teaching load of 3.7). Adding optional courses to a curriculum is not usually done under these circumstances because professors are already fully committed with their currently scheduled teaching load.

A catalog search was made of the 20 schools that did not return their survey instruments. Seventeen of the schools (85 percent) appear to allow aviation students the freedom to take humanities and/or business electives, and all of these schools have either a general ethics course taught in their philosophy department or a business ethics course taught by business administration faculty. It is impossible, though, to determine whether this percentage is correct from a catalog search alone. Many catalogs simply show the general education requirements for all students at the university. The catalogs list such items as Humanities Elective, but some departments within the university restrict the course choices for such electives without stating them in the course catalog. Thus, in this present search, 17 is the maximum number of schools in this category, but it may be fewer.

A Planned Topic in Other Aviation Courses

Department heads in the 41 departments responding to this study reported that their departments teach a total of 552 aviation administration courses. Ethics is a planned topic in 57 of those courses (10 percent). This appears to be adequate; however, only 22 of 38 aviation department heads responding to a question about offering ethics as a planned topic in other courses (58 percent) stated that their department teaches ethics in this manner. Although 22 departments represents a slight majority of the responding schools, the number appears low when considering the prevalence of ethical problems within the aviation industry. It would seem essential that somewhere during a student's four-year aviation course of study that educators would plan to expose these future aviation management professionals to the fact that they will have to deal with difficult personal and corporate issues having an ethical component.

A catalog search was made of all schools that reported in their survey responses that ethics is offered as a planned topic of discussion in courses that had other subjects as the principal focus. Using the descriptor, ethics, a comprehensive search was made of every aviation course listed in the current catalog of the 22 schools in this category. Only three courses were found in all of the catalogs that list ethics in the course description. Department heads of these 22 schools reported a total of 57 courses that have ethics as a planned topic, but in only three of them is ethics listed in the course description. Again, ethics may be covered in every one of those 57 courses; however, it is important to note that ethics is only significant enough to make the course description of three of them.

A similar search was conducted of the catalogs of the 20 non-responding institutions to see if they offered ethics as a published topic of study in any of their aviation courses. The author found no courses at any of the 20 universities in this search. This reinforces the findings covered in the previous paragraph. Thus, in all of the aviation courses published in the catalogs of the 61 colleges and universities in the United States with aviation management programs, there are only three courses with ethics mentioned in the course description. This is markedly different than what the author discovered in other curricular areas while doing the catalog search of ethics in aviation curricula. Other curricular areas like business, nursing, computer science, engineering, communication, journalism, and education list ethics in multiple course titles and descriptions.

It should be emphasized once again that none of the written survey response data were changed on the basis of the on-line college catalog searches mentioned above, and the statistical data following from this point does not include any results from the catalog search. The catalog search will be used only to supplement some of the points made in the conclusion of this report.

Department Head Actions and Opinions

Table 7 lists the distribution of responses to questions concerning a department head's support for or disapproval of actual or proposed decisions to include ethics in the aviation administration curriculum of his or her school. While many department heads reported having supported decisions to include ethics in their departments' curricula by the various methods to do so, no department heads reported disapproving the inclusion of ethics.

Several questions were asked in the survey instrument concerning department heads' opinions about ethics and the delivery of ethics instruction. Table 8 lists the distribution of responses to those questions. Each question had a five-point, Likert-style response. For each item, department heads were asked if they strongly agree, agree, have no opinion,

Table 7. Support or Disapproval of Department Heads for Ethics Courses, U.S. Aviation Management Programs, 2000

Issue	Yes	No
Have supported decision to require ethics course	14	27
Have disapproved decision to require ethics course	0	41
Have supported decision to allow elective ethics course	17	22
Have disapproved decision to allow elective ethics course	0	39
Have supported decision to include ethics as planned topic	21	19
Have disapproved decision to include ethics as planned topic	0	40

disagree, or strongly disagree with the statement in the question. Two noteworthy distributions are seen on the agreement side of the response spectrum. Department heads generally support the ideas that ethics should be taught in all applicable aviation courses and that aviation professors should receive training to do this. For all other statements, department head opinion was not as conclusive, and the average level of agreement or disagreement was just above the no opinion response.

Table 8. Department Heads Opinions about Ethics and Ethics Instruction, U.S. Aviation Management Programs, 2000

Issue	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Ethics should be a required course in aviation curricula	12	11	6	10	2
Ethics should be an elective course in aviation curricula	6	18	9	5	3
When taught, ethics should be taught outside the aviation department	1	14	9	15	1
When taught, ethics should be taught within the aviation department	4	13	10	13	0
Ethics should be taught in all applicable aviation courses	23	16	0	1	0
When taught in an aviation department, professors should receive training in teaching the subject	15	20	3	2	0
Willing to devote present funds to train aviation professors to teach ethics	1	23	5	9	2
Willing to devote present funds to initiate or enhance teaching of ethics	1	19	10	8	3
Willing to devote present funds to develop course materials in ethics	1	20	6	11	2

Department heads were asked if they had faced or expect to face various obstacles in beginning a program to include ethics in their curricula. Table 9 tabulates their responses. Additionally, department heads were asked in an open-ended question to list the greatest obstacle they would have to overcome in order to include ethics instruction in their aviation curricula. Responses follow in Table 10. It should be noted that a large number of department heads (13) either listed the word, "None," or left the answer blank. The most commonly listed responses to the general questions about

obstacles were lack of time in an already-packed curriculum, lack of funding, and lack of trained faculty, in that order. By far, the obstacle cited as the greatest obstacle to be overcome was the lack of time in the curriculum.

Table 9. Obstacles Faced or Expected to Face in Establishing Ethics as Part of Curricula, U.S. Aviation Management Programs, 2000

Obstacle	Yes	No
Lack of higher-level university administration support	6	34
Lack of support from outside university (industry, professional groups, etc.)	4	35
Lack of funding 18 21 Lack of good course materials	11	26
Lack of trained faculty	17	21
Lack of time in an already-packed curriculum	28	11
Lack of faculty support for teaching ethics	11	27

Table 10. Greatest Obstacle to Overcome in Including Ethics in Curricula, U.S. Aviation Management Programs, 2000

Obstacle	Number of Responses
Lack of time in an already-packed curriculum	16
Lack of faculty support	4
Lack of trained faculty	4
Lack of funding	2
Lack of higher-level administrative support	2

Organizational Culture

Department heads were asked a series of questions about the organizational culture of their departments and about other issues related to the inclusion of ethics in their departments' programs. Authors from non-aviation curricular fields suggested the indicators listed in Table 11 as being characteristic of higher levels of interest and commitment to including ethics in their programs. For example, one would expect that if a department had taken the time to formulate its own code of ethics, it would probably have a higher level of interest in ethics and resultantly would include ethics instruction in their curricula. Table 11 charts the distribution of responses concerning the indicators suggested in Part One of this study (Oderman, 2002). Several indicators show virtually nothing to support the

inclusion of ethics in the curriculum: gifts and grants from outside or within the university, departmental ethics committees, and faculty members who have conducted research in aviation ethics. A number of departments (or their parent universities) publish a code of ethics, but that is the only indicator with more "yes" than "no" responses.

**Table 11. Organizational Culture Regarding Ethics,
U.S. Aviation Management Programs, 2000**

Indicator	*Yes*	*No*
Department has received gift or grant from outside university to teach ethics	0	40
Department has received gift or grant from within university to teach ethics	0	40
Ethics is required as part of curriculum for accreditation	10	31
Department has published code of ethics	30	10
Department faculty have conducted research in aviation ethics	3	38
Department has hosted guest speakers or seminars about including ethics in curriculum	12	29
Department has hosted guest speakers or seminars about ethics in aviation industry	18	23
Department has ethics committee	1	39
Department has faculty members who demonstrated interest in teaching ethics	11	30

Level of Planned Ethics Inclusion

As explained earlier, each responding department was classified using the EIS (see Table 1). Departments were categorized on this scale using survey responses to questions dealing with how ethics is or is not incorporated in their aviation administration curriculum. Of the 41 responding departments, 39 were assigned a level of planned ethics inclusion in the curriculum. Two colleges or universities were not included in this listing because the responding department heads omitted data needed to completely define their departments' levels. Table 12 reports the results of this classification.

As can be seen by comparing the EIS distribution with the EIS descriptions found in Table 1, the numbers in Table 12 indicate very low levels of ethics inclusion for 20 of the 39 responding schools (51 percent). Their EIS scores of 3 or less indicate low levels of including ethics in the curricula. Sixteen colleges and universities (41 percent) have levels of 1 or

Table 12. Level of Planned Ethics Inclusion in the Curriculum,
U.S. Aviation Management Programs, 2001

Level of Planned Inclusion	Number of Institutions Within Each Level
1. None	8
2. Isolated	4
3. Elective A	8
4. Elective B	0
5. Elective C	9
6. Required A	1
7. Required B	2
8. Required/Elective	2
9. Pervasive	5

3, meaning that they either have no ethics component in their program at all or that if ethics instruction exists, it is only an elective course wholly taught outside the aviation department. Students at schools with an EIS of 3 could easily go through their entire aviation curricula with no ethics instruction if they choose a non-ethics general education elective. In contrast to the high number of schools on the low end of the EIS, only 5 schools (13 percent) are in the highest category, that is, they include ethics instruction as a pervasive part of their curricula. This supports the previous discussion about the low percentage of colleges and universities with an ethics component in their aviation management curricula.

The obvious questions at this point are: (a) why do so few aviation departments include ethics as part of their curricula, and (b) why do they often leave this task to others outside the department. Statistical analyses of data from the survey instrument provide some answers, and these tests will be discussed in detail in Part Two B of this report.

CONCLUSION

In summary, an investigative survey instrument was distributed to department heads of collegiate aviation management programs throughout the U.S. to analyze the current state of ethics education within such departments. A very representative sample of responses was received, and a preliminary evaluation of the data was made by looking at the statistical distribution of those responses. This preliminary evaluation supported the initial assumption that not much is being done at the present time to incorporate ethics education into the curricula of collegiate aviation management programs. Before discussing any implications of this data, it is necessary to perform more thorough and rigorous statistical tests on the data. Those tests and their results will be reported in Part Two B of this study.

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BLIND FLYING ON THE BEAM AERONAUTICAL COMMUNICATION, NAVIGATION AND SURVEILLANCE: ITS ORIGINS AND THE POLITICS OF TECHNOLOGY: PART ONE—FORM AND FUNCTION

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ABSTRACT

In this first part of a three-part series, the technological and political progress from the earliest attempts at wireless communication to research on *fog signaling, blind flying* and early Post Office attempts at surveillance are examined. During this period, government agencies such as the War Department, Navy, Post Office and the National Bureau of Standards pursued various projects while testing technologies and methodologies for aerial electronic communication and navigation. Their research relied on administrative funding that could be very substantial or non-existent, depending on the national political climate. The second part of the series considers the effect of Federal regulatory and administrative policy on the development of aeronautical communication and navigation in the United States (U.S.). The third part analyzes the effect of the continued Federal oversight during the Great Depression and the progress of aeronautical telecommunications research and the deployment of such technologies in support of aviation.

INTRODUCTION

For more than 33 hours nobody knew where he was or if he was even alive. There were reports that he had been seen over St. Johns, Newfoundland, and a second sighting positioned him some 500 miles from the coast of Ireland. Then at 10:21 p.m. on May 21, 1927, young airmail pilot Charles Lindbergh guided his aeroplane, the Spirit of St Louis, onto the grassy runway of Le Bourget Aerodrome, Paris, France. He had made

history—the first to successfully negotiate the mercurial weather of the Atlantic Ocean, flying alone, non-stop from the U.S. to Europe (Knight, 1997; State Department, 1927).

Of the many technological challenges facing *Lucky Lindy*,[1] pre-flight weather information and in-flight navigation were critical to the success of his venture. What distinguished Lindbergh's flight was not only that it was the first solo transatlantic crossing in an aeroplane, but that he had completed it without any of the communication and navigation capabilities employed in aircraft of today (Lindberg, 1953).

The Spirit of St Louis's primary navigation instrument was a compass. There were no electronic navigation aids (NAVAIDS) for guidance, and communication technology was still in its infancy and considered unreliable by Lindbergh. He preferred to take on more fuel rather than sacrifice it to the additional weight required by an undependable radio (Lindbergh, 1953).

His greatest challenge, navigation over open water, had to be accomplished by computing flight time, the effects of wind velocity and direction, and correcting for compass error. The exact location of the aircraft was, at best, an approximation (Komons, 1978; Snyder & Bragnaw, 1986). Even though direction-finding concepts and technologies for aircraft were being developed and refined by the National Bureau of Standards, the Army and the Navy, they were not yet placed in general use (Lindbergh, 1953).

Navigation was not the only obstacle with which Lindbergh had to contend. He faced the challenge of unforeseen weather as well—not knowing what weather he would encounter enroute or upon his landing in France. Without a radio, it was impossible for anyone on the ground to communicate the changing weather patterns he might encounter. Such unforeseen weather did, in fact, force him to deviate from his planned flight during the night, leaving him unsure of his position by morning. As he continued his flight eastward, he sighted land, flew towards it and happily discovered he was over Ireland.

> A fjorded coast stands out as I approach…. Yes, there's a place on the chart where it all fits—line of ink on line of shore—Valentia and Dingle Bay, on the southwestern coast of Ireland!
>
> I can hardly believe it's true. I'm almost exactly on my route, closer than I had hoped to come in my wildest dreams…. What happened to all those detours of the night around the thunderheads? Where has the swinging compass error gone? (Lindberg, 1953, p. 463)

Lindbergh was back on course and less than five hours from Paris.

His experience in navigating from New York to Paris was not unlike what he had encountered flying the mail in the U.S. At home, navigation

technology consisted of a series of lights spaced ten miles apart connecting important cities. They worked well when there was no weather or fog obscuring their view but were of little value when the pilot encountered obstructions to visibility (Komons, 1978). If aircraft were to be dependent on the whims of changing weather patterns while lacking the capability to communicate with each other or those on the ground, commercial aviation would never be able to develop as a viable transportation mode. If air transportation operations were limited to pilotage, navigating when the weather allowed identification of landmarks, or dead reckoning, calculating aircraft position by time in the air and heading, then the precise navigation required to support high-altitude, all weather flight would be impossible. Aviation radio expert Henry Roberts commented, "That is why *radio navigation* is the mainstay of modern air transportation" (1945, p. 3).

As early as 1920, the impact electronic navigation and communication would have on aviation was clearly understood. The Manufacturers Aircraft Association, commenting in the *Aircraft Year Book, 1921*, pointed out that the result of such aids "will be that aircraft will be navigated with a safety and dependability far exceeding that now obtained on steamships" (p. 87). What began as an experiment with airborne telegraphy in the early part of the twentieth century has evolved into a sophisticated aeronautical communication system that not only employs, but is dependant upon aeronautical telecommunications technologies. As aviation historian William Leary (1995) points out, the utility of the airplane is dependent upon such technologies.

AERONAUTICAL TELECOMMUNICATIONS

Aeronautical telecommunications are systems employed for the purpose of transmitting navigational information, voice communication, and aeronautical data, including aircraft surveillance, via telephony, telegraphy, radio or cable in support of two-way air-to-ground, air-to-air and ground-to-ground (point-to-point) communication. These technologies define the three constituent elements of aeronautical telecommunications: communication, navigation and surveillance (CNS).[2]

As used in this paper, aeronautical telecommunications is electronic two-way, air-to-ground and point-to-point transmissions, while navigation encompasses electronic aids enabling flight between defined points. Both communication and navigation make possible the third element of aeronautical telecommunications—surveillance. Surveillance communicates the aircraft's position both on the ground and in flight and end users of such information may include air traffic controllers, pilots, company managers and dispatchers. The acronym CNS was introduced to clarify the

roles and function of technologies that make possible Air Traffic Management (ATM). ICAO's CNS rubric will be used in this and the following papers to help frame the early development and evolution of aeronautical telecommunications (ICAO, 1994).

Experimentation with aeronautical telecommunications in heavier-than-air aircraft began in 1910, only seven years after the Wright brothers' first powered flight (Roberts, 1945). As the aeronautical telecommunications system began to form, electronic airways would emerge; air-to-ground and point-to-point communication systems would be created, and wire-based telephonic and telegraphic circuits supporting weather reports, flight data (an early form of surveillance) and administrative messages would evolve.

Radio aids to navigation and communication technologies enabled aircraft to fly at any time and in almost any type of weather. They provided the key elements that permitted scheduled flight with regularity and safety (Leary, 1995). The early development of aeronautical telecommunications is based on the work of a small group of government officials and bureaucrats, physicists, scientists, and test pilots. Their tenacity and creativity built a navigation and communication system that was emulated by other nations and provided the essential infrastructure that made possible the realization of the commercial aviation industry in the U.S. (Leary, 1995).

One government official, Herbert Hoover, the Secretary of Commerce during the Harding and Coolidge administrations, and later President, was in a position to wield great influence on the development of the aeronautical telecommunications system. As Secretary, Hoover oversaw the operations of the National Bureau of Standards (NBS). This organization assisted the Navy and War Department in the development of aeronautical radio in World War I, and beginning in 1918, assisted the Post Office in solving aircraft navigation problems. Hoover also supervised the operations of the Bureau of Navigation, the only governmental organization prior to 1927, charged with developing regulations for radio broadcasting. The Department of Commerce was responsible for assigning radio frequencies, keys to protecting aeronautical telecommunications broadcasts. In 1926, Hoover was given another mandate. The Department of Commerce was charged with the administrative oversight of aviation, and a new bureaucratic structure was added: the Aeronautics Branch. Hoover directly supervised it as well as the other organizations affecting the development of the aeronautical telecommunications system.

RESEARCH QUESTIONS

This series has two goals. The first examines the role federal administrative policy played in the development of the aeronautical telecommunications system. From the beginning, the government sponsored not only the development, but also the employment of technologies to further military and commercial aviation progress in the U.S. What, then, was the effect administrative policy had on the development of the aeronautical telecommunications system?

The second is to chronicle the development of technologies that became not only the foundation of commercial aviation in the U.S., but the schema upon which modern CNS technologies are based. What technologies were developed and how were they employed to form the aeronautical telecommunications system?

The two questions are interrelated. The relationship between the scientists of the NBS and regulators, those within the Aeronautics Branch as well as Hoover, would affect the design and deployment of the aeronautical telecommunications system and thereby affect the aviation industry. William P. MacCracken, an aviator, expert aviation law attorney, and the first Assistant Secretary of Commerce for Aeronautics, observed the existence of such a relationship and its importance in a speech in 1928 (Osborn & Riggs, 1970). He pointed out that when coordination between the agencies, the scientists and the regulators was disrupted, it had a profound effect on the aviation industry.

> In order to achieve success in the application of aviation to civilian activities…it is necessary to have the closest possible co-operation between those two important agencies. Their problems and methods of dealing with them must of necessity be quite different, though their mutual aim is to increase the scope of air transport service. (Science, 1929)

Overall responsibility for coordination and cooperation between the regulators in the Aeronautics Branch and the scientists at the NBS rested in the Secretary's office. Hoover's policies and political agenda could either encourage or discourage the development of aeronautical communication and navigation technologies and thereby affect the growth of commercial aviation in the U.S.

Prior Research

The origin and evolution of the aeronautical telecommunications system and the interrelationship between scientists, researchers, politicians and bureaucrats who built the system has not been widely researched. Various aspects of the system have been discussed in other works. For instance, development of telephony and radio work conducted by the NBS is

documented in Cochrane's (1976) *Measures For Progress* and Snyder and Bragaw's (1986) *Achievement in Radio*. Aviation telecommunications development is but one of many activities undertaken by the NBS and an in-depth study of aeronautical telecommunications development and its application to aviation is not the focus of either Cochrane or Snyder and Bragraw.

Likewise books such as *Bonfires to Beacons* (Komones, 1978) and *Aerial Pioneers* (Leary, 1985) chronicle the historical and political development of the Aerial Mail Service and the Aeronautics Branch but devote little attention to the technical development of the aeronautical communication and navigation system.

Aviation historian William Leary (1995) offers insight into the technological advances made by the Post Office Department and research conducted by the NBS in the development of the Instrument Landing System (ILS) in his article "Safety in The Air," appearing in *Airships to Airbus*. His investigation of the origins of the ILS, a component of the larger aeronautical telecommunications system, are detailed but other communication and navigation technologies that make up the larger telecommunications system are not considered in his work.

WIRELESS TECHNOLOGY

When Herbert Hoover entered the Department of Commerce in 1921, wireless communication was experiencing a significant paradigmatic shift that would define the form and function of technologies to be used in aeronautical telecommunications. The spark transmitter that had dominated the wireless world was giving way to a new technology—transmitters that could produce continuous waves. These transmitters made radiotelephony possible. Such changes also brought with them new expressions such as *radio* instead of *wireless*. The term broadcasting which had been defined in terms of cable and landline telegraphy was beginning to include present-day concepts.

Wireless broadcasting in the early decades of the Twentieth century was based on Guglielmo Marconi's technique of wireless telegraphy. His system was built around the spark transmitter, an instrument that could create radio waves by producing a series of sparks between a gap built in the transmission circuit. The transmission of Morse code was achieved by controlling these sparks (Aitken, 1985).

Marconi began experimenting with wireless telegraphy in 1895. He understood the benefits and utility of wireless telegraphy especially for marine communication by successfully demonstrating its potential in England. He later formed the Wireless Telegraphy and Signal Company.

Marconi's first customer was the British Government who paid his company £3,200 for an initial order of six land-based and twenty-six transmitting and receiving sets for use onboard ships, making Marconi its sole supplier in 1903 (Headrick, 1991).

Marconi continued improving his system, but even with improvements, this form of radio transmission had its limitations. The spark transmitter was incapable of generating a true continuous sine wave. The reason was simple. As each spark discharged, it created a wave of energy that quickly dissipated in amplitude. The effect is best illustrated by listening to a bell being rung. As soon as the bell is struck, the vibrations in the bell begin to diminish, and more so if the bell is dampened. An electronic dampening phenomenon was inherent, to a varying degree, in all spark transmitters, and the wave produced by a spark transmitter formed a train of damped oscillations containing numerous oscillations within each oscillation. These individual oscillations created a number of constituent frequencies and wavelengths (see Figure 1).
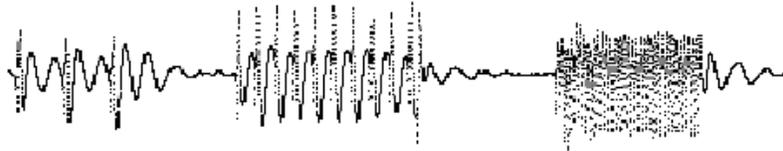
Figure 1. Damped Oscillations from a Spark Transmitter

From *The continuous wave: Technology and American radio, 1990-1932* by H.G.J. Aitken, 1985, p. 5. Copyright Princeton University Press, 1985. Reprinted with permission.

The resulting transmissions created frequency pollution since components of individual sine waves, produced by each oscillation, could be received throughout the frequency spectrum. Since the frequency spectrum is finite, transmissions would only serve to create interference among competing broadcasts. But most experimenters at the turn of the century sought only to improve the spark transmitter. They worked within a technological paradigm that had been proven, and one, which they believed, they could improve (Headrick, 1991). Not all saw it that way. There were a few who understood the limitations of spark technology—its inability to reproduce voice, music or broadcast within a narrower bandwidth. Some of the early experimenters recognized a different approach was required (Headrick).

Continuous sine waves (see Figure 2) were believed to be the solution, but how to generate them was another issue. Radio historian Hugh Aitken

(1985) pointed out that such a transmitter, one capable of generating radio frequencies with the required power, did not exist in 1900. "In the circumstances to believe that continuous wave radio could and should replace spark called for an act of faith" (p. 7).

One believer and experimenter was Reginald A. Fessenden who had begun experimenting with voice transmissions using spark technology in 1900. Unhappy with the results, he sought a way to produce a continuous wave transmission that could be modulated. In 1901, his work resulted in the first wireless telephony patents. He had also invented a way of receiving continuous wave transmissions and named it the heterodyne method. The receiver mixed the incoming radio frequency with a different, internally generated frequency, thereby producing a third, audible, frequency. His methodology initially made no impression in a world of spark transmitters, but would grow in importance as radio technology and the radio industry developed (Snyder & Bragnaw, 1986). It was his methodology that would become the standard for all future radio receivers.

By 1906, Fessenden had successfully demonstrated the feasibility and utility of continuous wave broadcasting. He had done so by using a specially designed alternator built by General Electric. The alternator produced 500 watts at a frequency between 50 and 60 kHz. The technique worked, but it would be years before greater power output and higher frequencies could be attained. Fessenden's alternators were not the only technique for generating continuous waves. A variation of the spark technology, the arc transmitter, had come close to producing the desired sine wave. The Danish scientist Valdemar Poulsen had perfected a transmitter that could utilize an arc as an oscillator (Aitken, 1985).

The most profound breakthrough in wireless technology, however, was the vacuum tube. Lee de Forest is credited with its introduction. Lee de Forest had added a third element in a two-element thermionic vacuum tube,
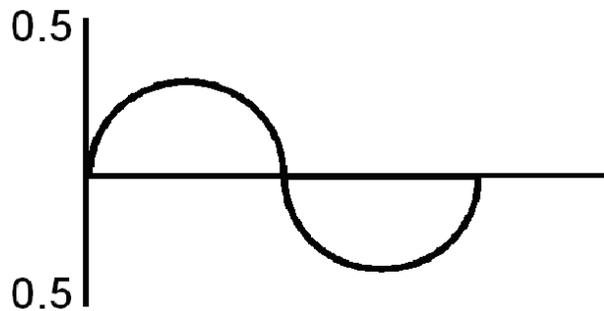
Figure 2. Continuous Wave Transmission

or *fleming* valve.[3] His device, known as an *audion*, enabled him to achieve greater receiver sensitivity, and it shortly became the key to producing continuous wave transmissions (Headrick, 1991; Snyder & Bragraw, 1986).

EARLY UNITED STATES TELECOMMUNICATIONS POLICY

European nations such as Germany had worked more closely with their inventors and industry to advance the art of radio. In the U.S., the Navy was competing with the Army's Signal Corps, the Weather Bureau and, ultimately, the private sector. By 1904 President Theodore Roosevelt, weary of the infighting, appointed an Interdepartmental Board of Wireless Telegraphy. But it would be another ten years before the U.S. could achieve a technological level equal to that of Britain or Germany (Headrick, 1991).

As radio became increasingly important to the U. S. armed forces, the NBS, in 1908, offered both the Army and Navy space for radio research. The relationship between the services and the scientists in the NBS's Radio Laboratory allowed close cooperation and an exchange of ideas and information in the areas of radio communication. Although the NBS became a clearinghouse for radio research, it did not have the political stature required to set the agenda. Each service had its own funding and parochial interests. The synergistic relationship between these administrative bodies was clearly helpful, but without a clear national agenda, each military service's narrow interests would always compete with a greater goal.

The Military

The military was the first to attempt to utilize radio communication in aircraft. Experimenting with wireless telegraphy in November of 1912, a young Army aviator Henry H. Arnold and radio operator Second Lieutenant Follet Bradley successfully transmitted the first air-to-ground messages from an airplane (Roberts, 1945).

During World War I, the NBS became the focal point for radio research. The NBS noted the nation was lagging in the application of radio communication in strategic and tactical warfare. In just a few short years, in close association with the military, the NBS Radio Laboratory made progress in the development and application of radio technologies. The NBS reported, "the absolute necessity of radio in modern warfare is apparent" (War, 1920). Problems requiring telecommunications solutions had to be solved quickly, including transoceanic communications, locating enemy units, development of radiotelephony and training the military in their use. The NBS and military would work together to solve these

problems and in so doing would greatly advance the art and technology of radio (War).

Radio Laboratory projects during WWI included research and application of vacuum tube technology and coil antennas as well as work on radio interference and shielding. The Laboratory also produced an important work on radio communication adopted by the Army, Navy and numerous colleges as a radio textbook (Fishbein, 1995).

The most important work surrounded the use of the vacuum tube. In 1917, a scientific mission from France brought with it a number of experiments and radio applications using vacuum tube technologies. The Radio Laboratory report, "the use of electron tubes was practically unknown in the military forces of the U.S. prior to 1917" (Fishbein, 1995, p. 3). The vacuum tube made possible transmitters that could broadcast at higher frequencies than those built around older damped-wave (spark) technologies. Receivers built using the vacuum tubes were much more sensitive and made possible signal amplification. Vacuum tubes also made possible continuous wave transmissions that could be used to carry multiple signals on a single pair of wires thereby increasing the efficiency of landlines. So significant was the impact that the American military required 25,000 tubes weekly. The Radio Laboratory pointed out, "Not much needs to be said to convince the reader that these important applications justify the most extensive and profound research, development, and application" (Fishbein, 1995, p. 3). Vacuum tube technology made possible the efficient amplification of radio signals and would have a significant impact in the world of aviation. Such technology meant aeronautical radios and antennas could now be smaller and lighter—important considerations for aircraft (Cochrane, 1976; Snyder & Bragaw, 1986; Some war-time, n.d.).

During the summer of 1917, the Army, Bell Telephone Laboratories and Western Electric Company successfully demonstrated aeronautical radiotelephony. Western Electric reported that "for the first time in history, airplanes in flight were directed…from the ground…and reports and directions were given and received in clear speech" (Some war-time, n.d.). The tremendous technological strides made were due, in large measure, to the installation of the vacuum tube in radios and related research conducted by the NBS and military services (Snyder & Bragaw, 1986).

NBS involvement in aeronautical telecommunications was just beginning. Even before the end of the war, Post Office officials expressed an interest in radio devices that would enable a pilot to perform a blind landing. Their work for the Air Mail Service and the Army laid the cornerstone for form and function of the future aeronautical telecommunications system (Snyder & Bragaw, 1986).

The Post Office

In July 1918, the Post Office approached the NBS for assistance in developing a type of aeronautical navigation device that would aid a pilot in locating the airfield in conditions of fog or weather. The planning meeting was attended by Otto Praeger, Second Assistant Postmaster, Captain Benjamin Lipsner, Head of the Air Mail Service, and NBS Physicist Fredrick Kolster (see Figure 3). Even though the Post Office had not yet

Figure 3. Notes from the Airplane Radio Journal of Laurens E. Whittemore

From "Airplane Radio Journal of Laurens E. Whittemore." Notes from August 12-17, 1918, p. 1. Dillinger, Files, RG 167, Box 26. National Institute of Standards and Technology, National Archives, Suitland, MD.

begun night flying, it still had to contend with daytime weather conditions. A landing system was required to guide an airmail plane to its destination and allow the pilot to let down through the weather and land safely. Kolster lost no time in beginning his search for an acceptable aeronautical navigation aid. He began working on a system that marked the field for the pilot (Leary, 1985).

Localized Signaling System for Airplane Landing

What Kolster envisioned as a localized landing system, later came to be known as a marker beacon. It was a simple concept. As the pilot approached the field a radio signal marked the landing area. The flight procedure required the pilot to maneuver the airplane so the signal remained in the headset. The signal, broadcast from an antenna buried in the ground, circumscribed the airfield or landing area. The resultant signal could be heard only when the aircraft was over the landing area and would fade rapidly as the aircraft flew away from it. Kolster's design required the pilot to maneuver the airplane so the signal remained in the headsets while the pilot made an instrument decent to the airfield (Airplane, 1918; Localized Signaling, 1920).

Kolster conferred with a colleague, Dr. Fredrick Grover, choosing a signaling system based on principles of magnetic induction offered the best solution. Theoretically, an alternator energizing an antenna at 500 Hz would produce a localized signal that could be received by an airplane in close proximity to it. Kolster began experiments by constructing a 25-foot loop using several turns of wire and powered with a 500 Hz alternator. He was able to induce a signal in a receiver several hundred yards away believing that it would be "practical for one mile signalling [sic] with sufficient power at [the] transmitter" (Cochrane, 1976, p. 196; Airplane, 1918, pp. 6-7). Numerous modifications and trials continued through November when an actual flight test was planned. The simulated airfield was the roof of the newly constructed NBS Radio Building. Kolster coiled six turns of copper wire around its roof and energized it with the alternator. The aircraft, a JN-4 (Jenny) borrowed from the Post Office, had attached to its wing a loop antenna tuned to resonate at 500 Hz. The pilot listened for the signal, amplified by a three-stage amplifier, through a headset. The test flight flown on Armistice Day, November 11, 1918, proved successful. The signal marked the simulated airfield up to an altitude of 3,000 feet (Cochrane, 1976; Airplane, 1918).

In January, work on the signaling device was moved to the airfield in College Park, Maryland, for further experiments. Both the Navy and War department had watched the experiments with interest. Further tests using various configurations based on induction were not as successful and the

project members began experimenting with higher (radio) frequencies. In May, J. A. Willoughby, a member of the team, suggested a system employing two antennas energized in opposite directions (see Figure 4). The configuration produced a signal analogous to an inverted cone with the maximum signal at 30 degrees from vertical. But unexpectedly the localized landing system went into early oblivion (Snyder & Bragaw, 1986). The localized landing system was shelved, and work on a direction finder took precedence. In a January 1921 report, the Radio Laboratory

Figure 4. Notes from the Airplane Radio Journal of Laurens E. Whittemore

From "Airplane Radio Journal of Laurens E. Whittemore." Notes from August 12-17, 1918, p. 12. Dillinger Files, RG 167, Box 26. National Institute of Standards and Technology, National Archives, Suitland, MD.

expressed believe that the landing signal system could be improved, but that "it seems advisable to concentrate upon the direction finder work for the present" (Radio laboratory, 1921). The Post Office was very much interested in a direction finding system and funding was found for its development.

The Direction Finder—Historical Development

Wireless direction finding was the original term describing one of two techniques for determining an aircraft's or a ship's position. The first is an active system that requires radio operators on the ground to either calculate the airplane's location and pass the information back to the aircrew or transmit the bearings to the airplane and let the crew do the calculations. The second technique is passive. The crew determines its position by receiving signals broadcast from navigational aids. The U.S. and Europe experimented with both systems during WWI, with Europe adopting the active direction finding methodology and the U.S. ultimately choosing the passive.

Wireless direction-finding experiments began with Marconi in 1900. A year later, Lee de Forest had applied for an antenna patent that facilitated direction finding. These early experimenters discovered if an antenna, built in the shape of an L, was inverted, the longer, horizontal portion was more sensitive to signals being radiated in the opposite direction. In 1905, Marconi patented a direction-finding system built on this concept. But a more practical approach, and one upon which aeronautical navigation in the U.S. would be built, was developed in 1906 by two Italian radio pioneers, Ettore Belline and Alessandro Tosi. By 1907 the Belline-Tosi (BT) antenna had become widely accepted for use in both transmitting and receiving and their system would soon form the basis for electronic navigation in the U.S. The BT antenna will be discussed later in greater detail (Fishbein, 1995; Keen, 1927; 1938; Snyder & Bragaw, 1986).

German Navy Zeppelins, using a Telefunken Compass, were one of the first to apply direction finding in aerial navigation. The approach was passive and made use of a rotating beacon. The ground station employed a single antenna supporting thirty-two antennas radiating from the center. An omni-directional start signal was transmitted from the center antenna followed by a signal from each of the antennas at one-second intervals. The signal began and ended at true north. The radio operator on board the airship heard the start signal and began timing with a stopwatch. When the signal was at its greatest volume in the headset, the watch was stopped. The stopwatch had the degrees of the compass on its face and the point where it was stopped represented the bearing from the station. Tuning to another station and following the same procedure, the operator could triangulate the

airship's position (see Figure 5; Keen, 1938; Report No. 6, 1925).

In the U.S., Kolster began direction finding experiments in 1916 by placing a transmitter near the Navesink light station at Atlantic Highlands, New Jersey. Installing a loop antenna aboard the lighthouse tender *Tulip*, he found that the ship could determine the relative bearing to the transmitter. His technique showed promise, but further experimentation and application of Kolster's procedure would have to wait until after the war (Report No. 6, 1925; Snyder & Bragaw, 1986).

The Navy initially approached the problem of direction finding by employing active techniques. They built a series of direction-finder stations on the Atlantic Coast. A vessel would transmit a request that a bearing be taken by land-based stations. Two or more stations would relay the bearings to the ship, enabling the crew to calculate the ship's position. Unfortunately there were serious drawbacks with this approach. First, each land-based transmitter required 24-hour manning by trained personnel. Second, it was
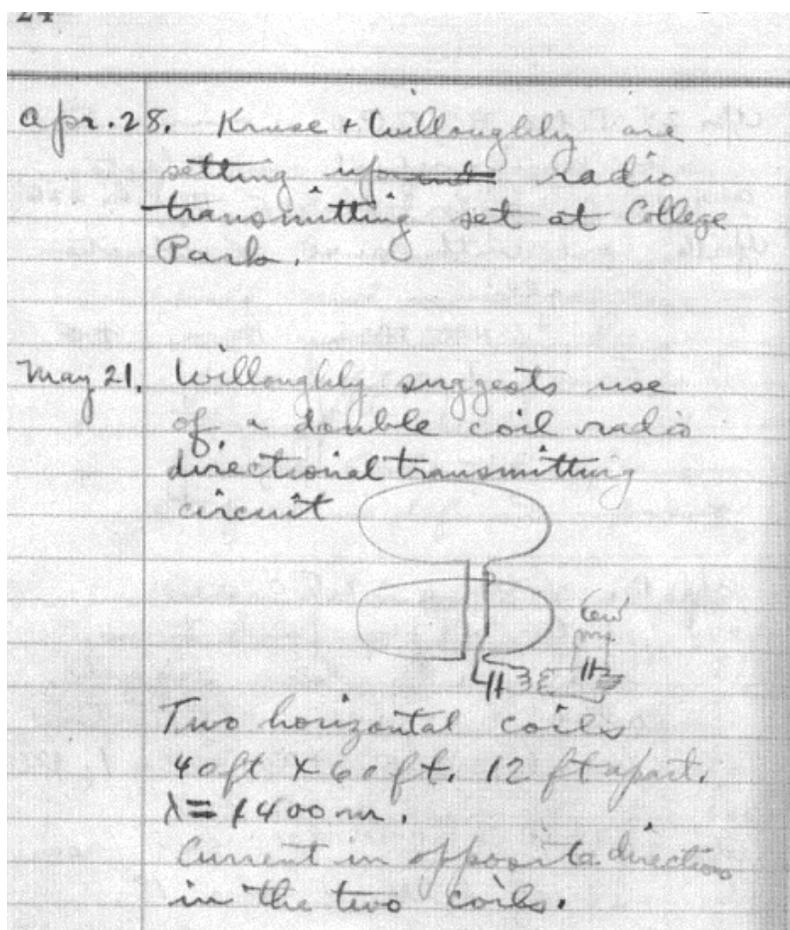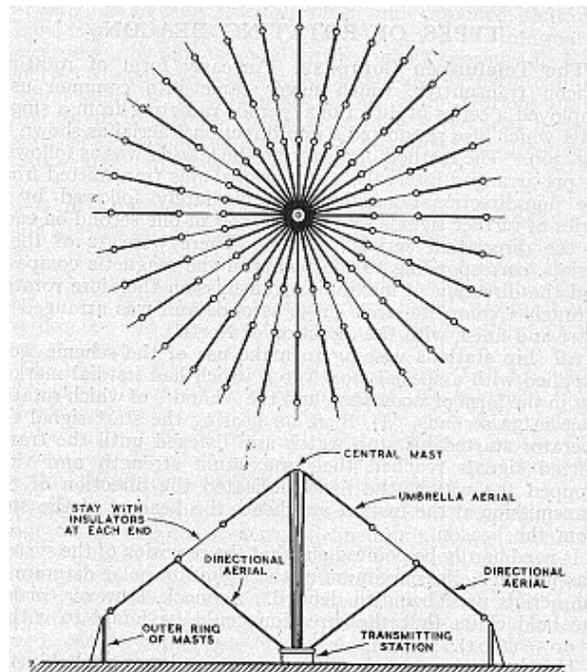

Figure 5. Notes from the Airplane Radio Journal of Laurens E. Whittemore

From "Airplane Radio Journal of Laurens E. Whittemore." Notes from August 12-17, 1918, pp. 6-7. Dillinger Files, RG 167, Box 26. National Institute of Standards and Technology, National Archives, Suitland, MD.

a slow process. Only one ship could be accommodated at a time. The third disadvantage, and most damning for the military, was the fact that while the friendly stations were taking bearings, so was the enemy. Kolster recognized these shortcomings early on and opted for a passive system, one that would allow the calculation of position to be done on-board the vessel without the need to transmit from the ship. In contrast, European nations adopted the active system for aircraft (see Figure 6). Aircraft in flight would transmit and wait for two or three ground stations to telephone bearing information to a master station. The master station calculated the aircraft's position and transmitted the information back to the airplane. The U.S. chose Kolster's methodology (Memorandum in the use, 1926; Report No. 6, 1925; Snyder & Bragaw, 1986).
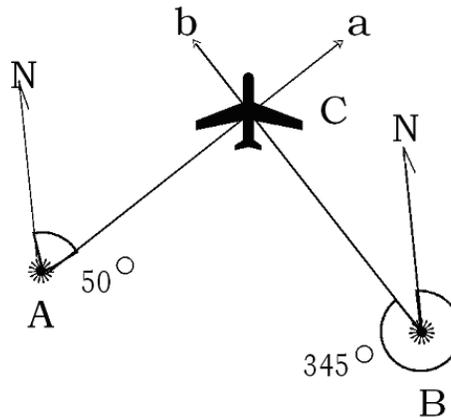
Figure 6. Active Direction Finding

Note: Stations A and B plot bearings (lines a and b) to an airplane that has transmitted a position request. The position (C) is calculated by one of the stations and relayed back to the pilot.

The first radio direction finder built by the NBS was simply a few turns of wire around a small four feet by four feet frame that could be rotated and connected to a receiver. If the antenna were rotated to a position in line with the incoming electrical wave, it would produce the strongest electrical action in the coil. The point at which the antenna was not excited by the signal would occur when the antenna was rotated to a position that was perpendicular to the incoming wave. Thus, the radio direction finder was able to determine the absolute direction of the transmitted wave and boasted accuracy within one degree. But, the device indicated two possible directions of the transmission. Either direction could be located along the line of the transmitted wave. The antenna could not differentiate between a signal originating directly behind of it from a signal originating directly in

front of it. The effect, called ambiguity, was a problem that would eventually be solved by the radio compass, an important component in the aeronautical communication and navigation system (Memorandum on the use, 1926)

By war's end, conferees representing the NBS, Navy and Bureau of Lighthouses reached a consensus to develop a direction finding system based on Kolster's methodology. The advantages of Kolster's system were obvious. A shore station could broadcast continuously with little on-site supervision required. The station would not require 24-hour staffing as did Navy stations, and broadcasts from vessels would not be required to determine, or give away, a position. Continuous improvements in the technology gave birth to a remarkable and extremely satisfactory navigation system for ships. Kolster's radio direction finder, or fog signaling, was of interest to other nations. Responding to a request from the Second Secretary of the Japanese Embassy, Hisoru Fujii, Kolster described the operation and supplied sketches and photographs of the system and offered further assistance (Kolster to Fujii, 1918; Snyder & Bragaw, 1986).

Aeronautical Applications of Kolster's Direction Finding System

In the U.S. direction finding evolved to mean flying towards a beacon or *homing*. The European system was called ground-based direction finding and this technique did find use in the U.S. as an emergency aid for lost pilots. In order to home, pilots, using radio receivers and headsets, turn their aircraft until the signal disappears. At this point the antenna is perpendicular to the transmission and is at the null or minimum signal point (see Figure 7). As previously mentioned, ambiguity is problematic. A single-coil antenna such as the one Kolster employed offers two solutions as does any single-loop antenna. For instance, if the signal is strongest at a ninety-degree angle to the aircraft, the pilot does not know whether to turn right ninety degrees or left ninety degrees. Either choice will produce the same result as far as the antenna is concerned (Kolster to Fujii, 1918; Snyder & Bragaw, 1986).

Maximum Signal   Null   Radio Station
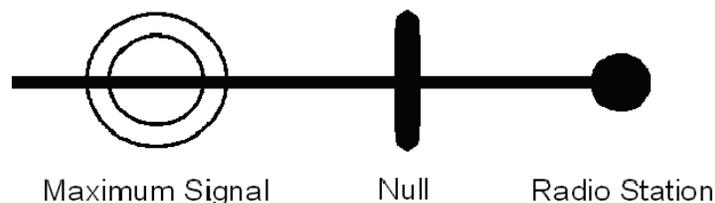
Figure 7. Maximum and Null Antenna Positions

Early Post Office test flights using direction finding were done in a borrowed Navy Curtiss R4L biplane. Two coils, A and B, were attached to the airplane and wired to an amplifier. The A coil was wound around the airplane's landing gear strut parallel to the longitudinal axis of the aircraft while the B coil was wound at a 90 degree angle. The pilot was able to switch between each coil. The A coil, providing the strongest signal, was used to locate the signal source and fly towards it. Once the airplane was in close proximity to the beacon, the B coil was used for more precise navigation. The B coil produced a null or minimum signal strength when the aircraft was pointing directly at the station since it was perpendicular to the incoming electrical wave.

A series of flight tests in the summer of 1920 produced mixed results. The Post Office used radio stations at College Park, Philadelphia and Newark to test the direction finding system. Signals were broadcast from the three stations in five-minute intervals to avoid interference. Aerial Mail pilot Wesley Smith described one successful flight on May 20 stating he relied solely on the radio compass to locate the station at Philadelphia. "I paid no attention to my magnetic compass and only watched the country below me for available emergency landing fields," Smith wrote in a report to Praeger (Report of operation, 1920). Flying until he was able to receive equal signals on both the A and B coils, he looked down and saw the radio towers. He recommended the equipment be adopted in all Post Office aircraft, believing that had it been installed a few weeks earlier he would not have crashed in the Orange Mountains (Report of operation). Other pilots liked it. Claire Vance saw its value in getting the aircraft close to the field, but not practical for descent in instrument weather. Randolf Page thought it was a great tool for teaching new pilots the routes—in clear weather (Post Office survey forms, 1920).

There were problems with the equipment, and the problems would require substantial modifications. When the airplane was flown in or around inclement weather, the static and noise completely drowned out the navigation signal. Additionally, the headphones were extremely uncomfortable, prompting a comment from Harry Hucking: "Radio helmet hard on head [with] continuous use" (Post Office survey forms, 1920). Weather information in telegraphy code was also sent to aircraft in flight and proved to be useful to the pilots. A far more useful application, some pilots believed, would have been radiotelephony.

Other problems proved to be more serious. Aircraft ignition was a source of electrical noise and attempts to shield the receiver from its effects proved difficult. These obstacles led the NBS and Post Office to begin experimenting with an alternative system using a rotatable coil and a trailing wire. Although the experimental flights appeared promising, by

1921 a political turn of events made further development of the direction finder doubtful. Post Office support of radio navigation ended. Otto Praeger, Second Assistant Postmaster General, became more interested in the development of the transcontinental airway. Appropriations were soon cut with the election of Harding, who was not a supporter of Air Mail Service. The NBS continued to inform the Post Office of current radio research of interest to the Air Mail Service, but as far as Post Office projects were concerned the Bureau found it "impossible…to engage actively in the investigation of these problems on account of the lack of funds" (Bureau, 1922; Leary, 1995, pp. 99-100; Progress Report, January 15, 1921; Smith, 1931)

CONTINUED RESEARCH

As direction-finding experiments funded by the Post Office were ending, the Army continued to sponsor research. The following four joint Army-NBS projects (identified by NBS project codes) describe significant undertakings that began to shape the form of the aeronautical telecommunications system would take (Present program, 1922).

Project E-21a—Radio Direction Finding Research

The Army and NBS had been experimenting with direction finders and localized landing systems at McCook Field in Dayton, Ohio. Direction-finding work would continue, but at a slower pace. The NBS, with Army funding and collaboration, continued aeronautical telecommunications research.

Research in direction finding not only included its use as an airborne navigation aid, but as a terrestrially based direction finder as well. In other words, the Army not only wanted a direction finder in its aircraft for navigation purposes, but also had an interest in determining a bearing to an airplane in flight from a ground station. Two types of antenna systems for these airborne and terrestrially based methodologies were studied: a single-coil direction finder and crossed-coil equi-signal direction finder (Present program, 1922).

The single-coil direction finder was built on Kolster's concept of a single rotatable coil. The null position was used to obtain a bearing to a transmission source, but in electrically noisy aircraft, the procedure proved difficult to use. The antenna, however, would find use as a terrestrially based direction finder.

The Robinson system, a form of equi-signal direction finding, employed two antennas but crossed at a ninety-degree angle—a smaller, main coil and a larger auxiliary coil. The placement of the antennas provided a minimum

signal when the airplane was homing to the beacon. This differed from the single coil, which produced a null. Having a minimum signal was preferable to the null and helped mitigate the effects of ignition noise (Keen, 1938).

Antenna tests conducted by the Army in the fall of 1921 produced remarkable results, Lt. Vaughn wrote to Whittemore at the NBS. Vaughn had concluded these preliminary tests had ruled out the use of the single coil method of direction finding for aircraft and added, "Our radio force was severely cut into during a recent 'economy' wave with the result that we are rather short-handed at present time" (Vaughn to Whittemore, 1921). The economy wave would affect the NBS as well and through 1925 the NBS would continued to follow, and when funding permitted, participate in the Army's direction finding experiments.

In a 1924 The Radio Laboratory report, experiments with direction finding for the Air Service reported that an equi-signal crossed coil system did in fact reduce the effect of electrical noise produced by engine ignition. The report included the work carried on with the single coil system and, when applied as a terrestrially based direction finder and a nearly vertical trailing wire antenna on the airplane, the system worked well (Memorandum for the director, 1924).

Collaboration with the Navy and Coast Guard produced improvement in antennas, operating frequencies and power requirements. By the summer of 1925 a high frequency direction finder had been developed with the cooperation of the Coast Guard. Such direction finders, operating at frequencies above 2000 kHz meant reliable direction determinations can be made. The Army Signal Corps had also experimented with high frequencies ranging from 3000 kHz to 7500 kHz. The Army reported that, "Such apparatus probably has a future in aircraft work because of the great distances covered by the high frequencies with small power and because of the smaller antenna needed" (Notes, 1925). The Navy also participated in direction finding research developing a cross coil equi-signal device that was made substantially automatic in action (Memorandum on conference, 1922; Memorandum for the director, 1924; Notes, 1925; Stratton, 1922).

Project E-24—Transmission of Directed Radio Waves From the Ground

In 1921, researchers began experimenting with a terrestrially based directive transmission navigational aid, one that produced a specific course and from which airways could be constructed. Navigating on a specific course, both to or from a station, eliminated the problem of drift found in homing, and could be used to define airways between airports or specific points on the ground. By March, Dellinger reported the results of an experiment based on crossing two coil antennas. Based on the earlier work

of Scheller and Bellini-Tosi, credited to NBS scientist Percival Lowell and developed by Francis Dunmore and Francis Engel of the Radio Laboratory, the concept was to transmit signals alternately on the same frequency from two crossed-coil aerials set at an angle of 135 degrees. The letter "R" was broadcast in Morse code on one antenna and the letter "L" on the other. The bisector of the 135-degree angle produced an area of equal signal strength and an aerial highway route (Progress Report, March 24, 1921). To remain on course, the pilot had to balance the intensity of the "R" and "L" in the headset. If the letter "L" became louder, the pilot would correct back to the right, and, likewise if "R" became louder the pilot would correct to the left (Snyder & Bragaw, 1986; Progress Report, March 24, 1921).

Tests were promising. Two, eight-foot, eight-turn, coils had been constructed and broadcasts were made at 300 kHz (1,000 meters). "The results when receiving at a distance of 3 miles were so encouraging as to warrant a more extensive investigation" (Snyder & Bragaw, 1986, p. 151; Progress Report, March 24, 1921). Results appeared in NBS's *Scientific Papers of the Bureau of Standards* (Engel & Dunmore, 1924). The report explained aircraft using a directive beacon did not have to contend with the effects of wind drift as when navigating towards a nondirectional radio beacon. The Army was greatly interested and was sending its representative Lt. R.E. Vaughan to discuss the findings (Engel & Dunmore, 1924; McIntosh to Stratton, 1921).

The antenna system had been modeled after Scheller's patented antenna system. Scheller's course-setter employed an interlocking A and N signal to produce a course line. The resultant interlocking signal meant that not only would the Morse code representations of the two letters be heard equally on the course, but when heard equally, would form a continuous tone in the pilot's headset. This is accomplished by transmitting the letter A on one antenna and N on the other. The Morse code for A is dot-dash while N is represented by a dash-dot. When the two are equal in intensity they produce continuous dashes, or an interlocked, signal (Keen, 1938; Report No. 6, 1925).

Further tests of cross-coil antennas were conducted on board the lighthouse tender *Maple* in the summer. The NBS placed a 2 kW quenched spark transmitter and two 150 feet by 50 feet antennas crossed at an angle of 143.5 degrees on the Bureau grounds. A receiving set was brought aboard the *Maple* and observations were made as the vessel traveled from Maryland Point to Colonial Beach Wharf. For this test the Morse code letters A and T were used (see Figures 8 and 9). As the ship made its way down the coast the researchers plotted a zone of equal intensity where small changes of intensity were difficult to discriminate. At thirty-one miles the zone had a width of one and one-fourth miles and the tests "established

Equi-Signal Course

Antennas Crossed at 143.5 deg

Equi-Signal Course

A

T

T

A

Equi-Signal Course

Equi-Signal Course
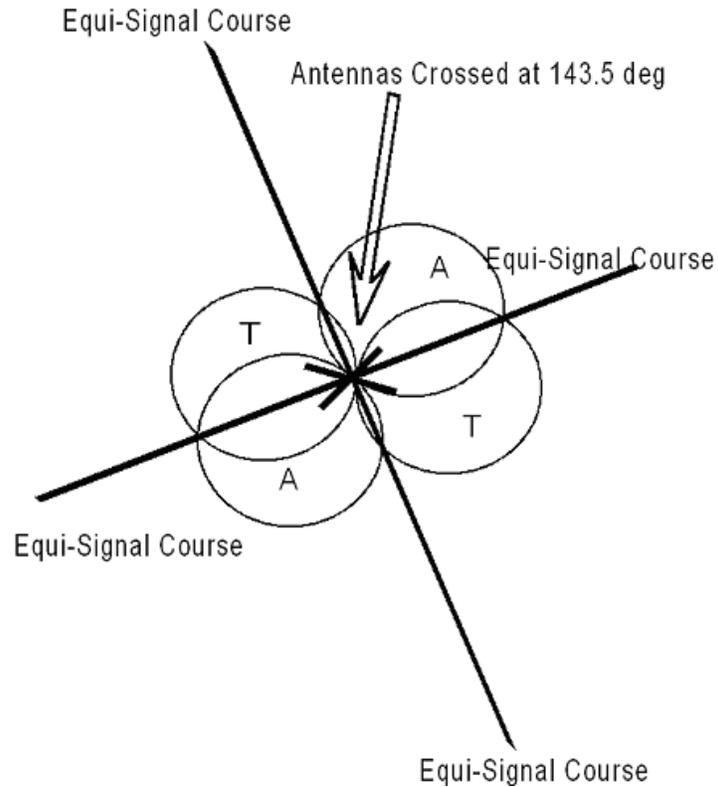
Figure 8. Crossed Coil Antenna System

without a doubt the existence of such a line or sector of equal signals"
(Report on Equi-Signal, 1921).

Flight tests were made using a 250-foot trailing antenna and a 6-stage
amplifier on a de Haviland aircraft. As long as the aircraft was on course the
A and T broadcasts were equal, however, if the airplane tuned ninety
degrees to the course line, either the A or T would predominate. This had
not been the experience on the Maple where there was an equi-signal zone.
In flight the zone had been eliminated. The cause, the researchers believed,
was the trailing antenna. The slipstream did not allow the antenna to remain
perfectly vertical, a problem that would be mitigated by attaching a weight
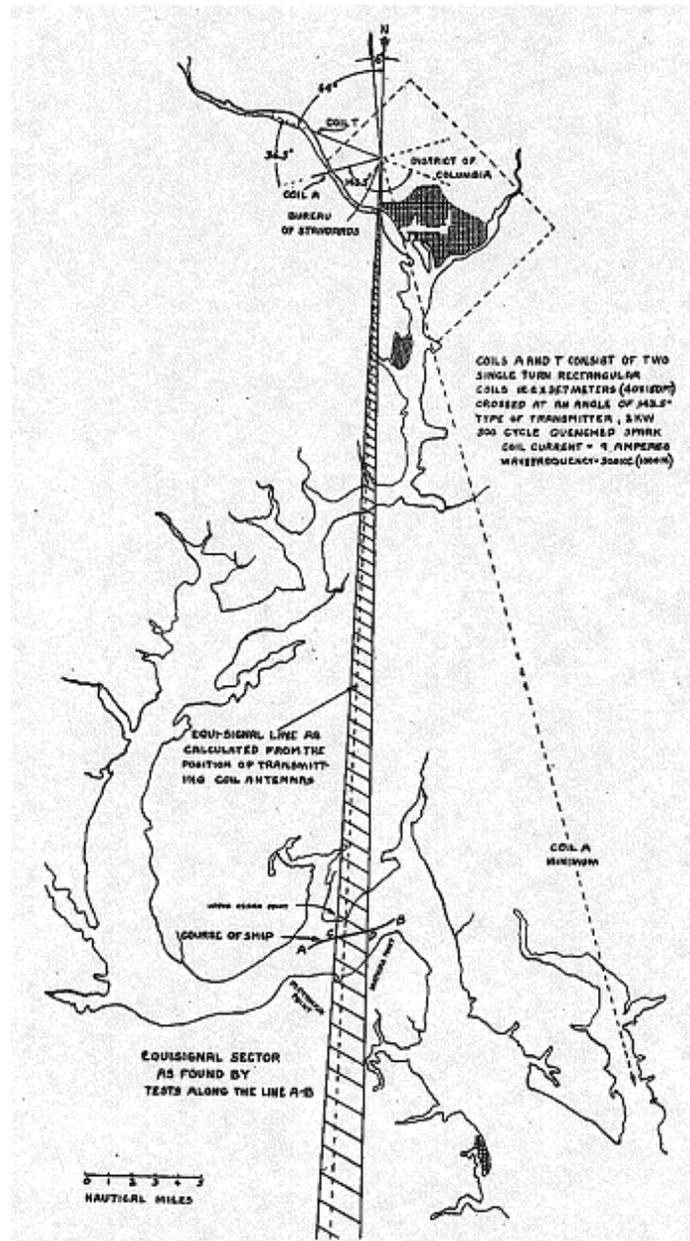
Figure 9. A Directive Type of Radio Beacon and Its Application to Navigation

From "A Directive Type of Radio Beacon and Its Application to Navigation, by F.H. Engel and F.W. Dunmore, 1924, Scientific Papers of the Bureau of Standards 19, p. 290.

to the end of the cable. The optimal solution lay in a shorter antenna, but its shorter length would degrade signal reception.

Some of the staff believed a cockpit indicator being investigated by the NBS offered a better solution. A visual system was superior to aural navigation. It eliminated the requirement for flight crews to constantly monitor the navigational signal. A visual indicator solved another potential problem—requiring pilots to switch between monitoring navigation signals to receive and transmit radio messages (Progress Report, June 16, 1921; Report of present status, 1921).

An extensive ground and flight test was completed in the fall of 1921. The transmitter, a 5 kW spark set, was placed in line with an automatic switching unit so the two antennas could be energized alternately. A DeHaviland 4B was modified to carry the inductively coupled tuner, VT-1 six-tube amplifier (with batteries) and the antenna reel and wire assembly. A total of four tests were flown and confirmed the signal changes had been due to the trailing wire antenna. Overall, the tests confirmed earlier findings. The system performed well at different altitudes and distances (Report on ground, 1921).

Not much progress was made during 1922. The NBS offered to help the Army modify or build a vacuum tube transmitter for use in navigation. "We shall be glad to assist in any way possible at the time of the Dayton tests in assembling the apparatus or in making adjustments" (Stratton, 1922) they wrote. Other work involved experiments in applying the visual course indicator to the aircraft receiver (Stratton, 1922).

By 1923 the NBS ceased further cooperative research due to a lack of funding. The Army, however, continued to study and perfect the directive navigational aid and experiment with vacuum tube transmitters. Another improvement, an experimental antenna and radiogoniometer, would add greater utility to the system. This new approach added flexibility by electronically bending the course. The original crossed-coil antenna patterned after Scheller's concept produced courses, the bearings of which were dependant upon antenna placement. The ability to create an equi-signal course spaced at selectable angles was based on the Bellini-Tosi antenna system. The antennas could be crossed at ninety degrees and with a radiogoniometer or goniometer (see Figures 10 and 11) placed in the antenna circuit. This was an important breakthrough. If these NAVAIDS were to be used to define airways, the angle of the courses formed by their beams could not be limited to ninety degrees. Courses needed to be electronically bent to accommodate a route system (see Figure 12). The Army made one other improvement. They changed to the Morse code letters A and N thereby producing an aural interlocking course (Leary, 1995).
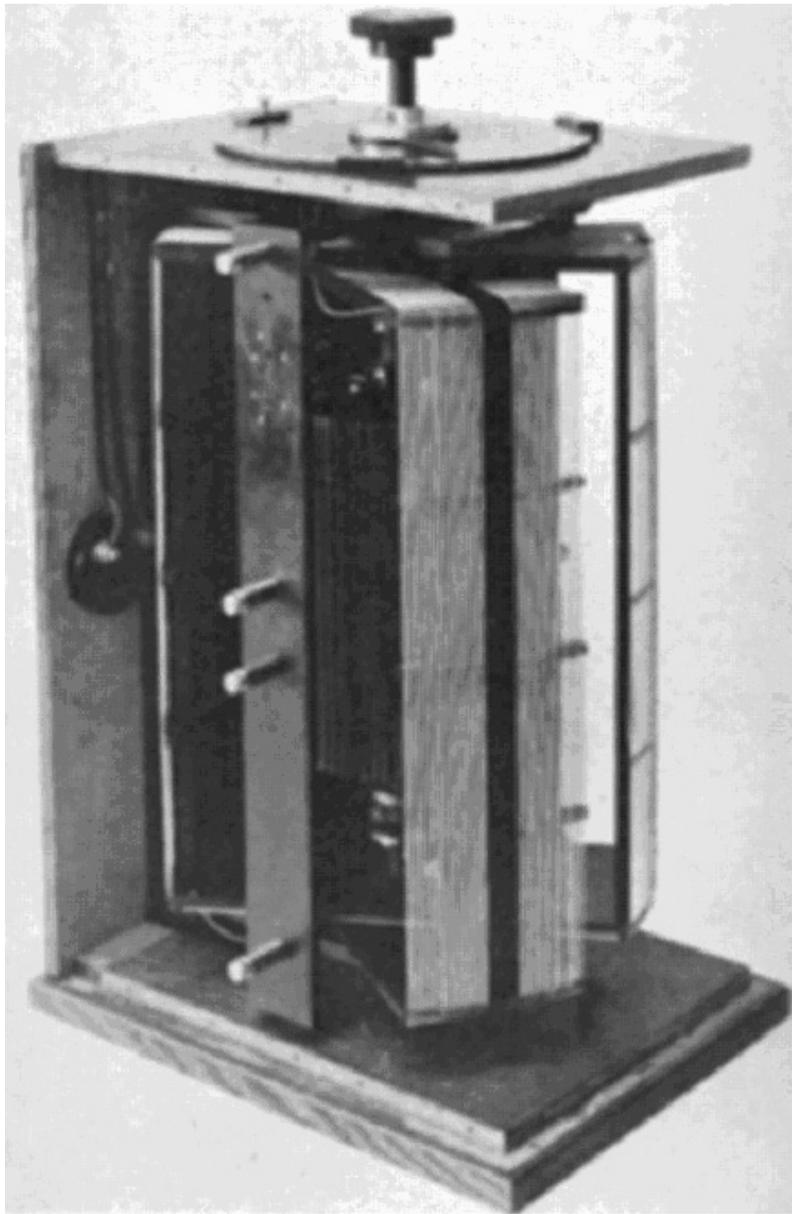
Figure 10. Goiniometer
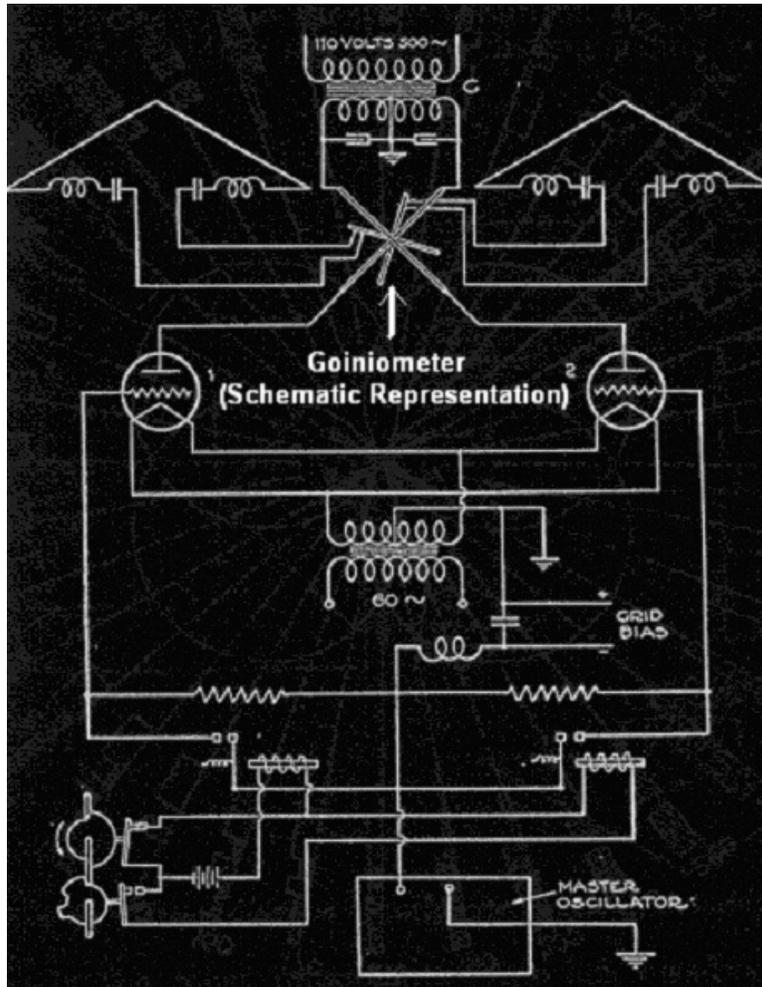
Figure 11. Schematic of Crossed-Coil Antennas with a Radiogoiniometer

Project E-22—Visual Indicator for Radio Signals

The Army had expressed an interest in devising a method for the visual display of navigational signals in 1921. Several methods for accomplishing it were suggested including a vibration apparatus, a galvnometer, a light indicator and a recording device. Further research on visual indicators, however, would wait until after the passage of the Air Commerce Act in 1926 (Memorandum for the director, 1924; Notes, 1925).
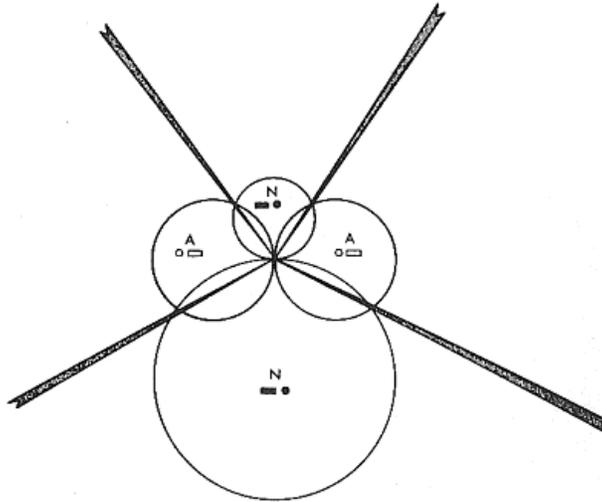
Figure 12. Goiniometer Effects

Project E-25—General Aircraft Radio Problems

The Radio Laboratory had been conducting research on many aspects of radiotelephony since 1913. Its work included establishing radio transmission formulas, the study of radio wave phenomena, vacuum tube measurements, definitions and their use in amplifiers and radio communication. They developed standards for radio, studied the characteristics of antennas and undertook projects such as Kolster's fog signaling and direction finding devices. The NBS, in a confidential report to the Bureau of Efficiency, explained that its work in radio communications was not just investigatory or theoretical but that it had developed "radio devices from a laboratory stage to a plane where they are of practical service" (Radio communication, 1921).

Many applications developed from NBS research had military origins. The radio work for other administrative departments provided a healthy portion of their funding. Funding from these departments made up almost half the Bureau's income for fiscal years 1921 and 1922, with the War Department providing the lion's share. In fiscal year 1921 Congress had allocated $30,000 for Bureau operations while the War Department had allotted $25,000. While the Bureau consulted with other departments, its radiotelephony work was closely related to the needs of the Army and the

Signal Corps (Radio communication, 1921;Work of radio, 1920).

Work carried on by the Bureau for the Army's Air Service in 1921 comprised mostly of the study of vacuum tubes, measurements of insulators used in radio construction and testing procedures for radio receivers. Consultations with Underwriters Laboratories helped define aeronautical radiotelephony development issues and commercial aviation requirements for radio installation and range. Aircraft antenna size was a problem and the Bureau worked on problems that limited use on aircraft. Additional research was done with arc transmitters and radiotelephony (Work of radio, 1920).

The winter of 1921-1922 saw an important development. Lowell and Dunmore developed a receiver powered by alternating current (AC). Up until this point, receivers had to be powered by batteries because vacuum tube filaments and plates required direct current (DC). Lowell and Dunmore constructed a power supply that produced DC power from an AC source. They were able to use common 60 Hz AC power to operate a five-stage amplifier consisting of three radio frequency stages, two audio frequency stages and a tuning circuit. Another important experiment was transmitting using shorter wavelengths. By August 1922, a transmitter was ready for flight tests. The frequency was 30000 kHz (100 meters) and required a special antenna that had been developed by the Bureau. The test flight proved successful and the frequency "was found particularly adaptable to daylight transmission" (Snyder & Bragaw, 1986).

NBS scientist August Hund was assigned the task of employing quartz crystals for accurate frequency control in both transmission and receiving. "The Bureau has devoted considerable research during the past year to the use of piezo oscillators as frequency standards" reported the NBS in 1925 (Notes, 1925). Hund and his associate's efforts resulted in crystals that controlled frequency deviations and whistling caused by beat frequencies produced in heterodyne receivers (Snyder & Bragaw, 1986; Work of radio, 1920).

The Army sponsored the following projects, listed by the NBS title, until funding became unavailable in 1924. From that point until the creation of the Aeronautics Branch in 1926, the NBS did very little research for the Army Air Service or the Signal Corps (Snyder & Bragaw, 1986, Work, 1920).

THE POLITICS OF EARLY AERONAUTICAL TELECOMMUNICATIONS RESEARCH

The lack of political interest in communication and navigation research and the technologies required to support all weather flight, paralleled the

plight of aviation between the end of WWI and the Air Commerce Act of 1926 (Komons, 1978). The Army, Navy and Post Office were all vying for limited resources, as was the NBS. With the exception of the Post Office in 1925, very little research would be conducted until 1927. There had been no aviation champion of sufficient political clout who could overcome the parochial interests of the various administrative departments and see to it that a well-conceived plan supported by proper funding was put in place. Even though the NBS often functioned as a research coordinator among various administrative departments, it also was affected by the unpredictability of political budget process. The result was an uncoordinated and inconsistent development of aeronautical technologies. The on-again/off-again approach to research slowed development in the U.S. whereas in Europe, commercial aviation was alive and well supported by radio technologies. But European nations had taken a different approach. Countries such as England, Germany and France had directly supported not only the research, but also national airlines and requisite infrastructure as well. If the U.S. were to catch up to Europe, a political champion would have to emerge, a champion able to work within the political framework of national politics and one who would command the attention of the aviation industry as well. It would be necessary to bring all the government's research resources to bear on the challenges of communication and instrument flight. Aviation found its champion in Herbert Hoover. Hoover was not aviator nor was he involved in aircraft manufacturing, the airlines or military aviation. But, as Secretary of Commerce, he had a profound influence on the development of the aeronautical telecommunications system.

During his tenure as Secretary of Commerce, Hoover made two critical aeronautical telecommunications policy decisions (Johnson, 2001). The first answered the question of funding and who would pay for the communication and navigation infrastructure. The second answered the question of what form the would system take. What were the technologies to be developed? How should they be deployed? These two questions will be considered in Part Two.

Although Hoover had been educated as an engineer, he did not directly participate in the research and development of the system. Instead, his role was political, and his administrative and fiscal policies would ultimately ensure its utility and success. By the time Hoover left the Presidency in 1935, he had, as both Secretary of Commerce and President, overseen the growth of an aviation industry supported by an aeronautical telecommunications infrastructure that had become a model for the world.

ENDNOTES

1. Captain Lindbergh attributed the origin of his nickname "Lucky" to the New York papers covering his story. After landing in New York, where he made final preparations and waited for a break in the weather, his disdain for what he termed the "tabloid" press grew daily with each inaccuracy. See Lindbergh, 1953, pp. 150-162.

2. The term *aeronautical telecommunication*" is not defined formally by the International Telecommunications Union (ITU), International Civil Aviation Organization (ICAO) or the Federal Aviation Administration (FAA). All three organizations have variations of the term when used in conjunction with other aspects of communication such as the Aeronautical Telecommunication Network (ATN) or descriptives such as "aeronautical telecommunication service." The definition used in this paper was derived from the *Oxford English Dictionary*, 2nd ed., s.v. "telecommunication," and the *American Heritage Dictionary of the English Language*, 3rd ed., s.v. "telecommunications."

3. The fleming valve is named for its inventor, John Ambrose Fleming, an Englishman who had used it as a detector in receiving sets. He was granted a patent for his invention in 1904. See Snyder and Bragraw, 1986, p, 10.

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WRITTEN COMMUNICATION PRACTICES AS IMPACTED BY A MAINTENANCE RESOURCE MANAGEMENT TRAINING INTERVENTION

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ABSTRACT

Written communication was examined in a large airline company that had implemented a Maintenance Resource Management training program. Respondent recollections of training content regarding written communication, along with trends in archival paperwork error data, were examined throughout training periods. Data from written work turnover documents were also collected from one site and analyzed to explore specific written communication practices and to examine training effects on such practices. Implications for future research geared to airline maintenance error reduction are discussed, as well as conclusions regarding program impact on error reduction.

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INTRODUCTION

The Role of Written Turnover in Aviation Maintenance

A concept of central importance to aviation safety that is covered in most Maintenance Resource Management (MRM) training programs is the practice of clear and thorough communication. A number of airline accidents caused by human factors can be traced to erosion in either verbal or written exchange of critical information (Taylor & Christensen, 1998). The role communication has been shown to play in human factors error underscores its value as a research construct. More specifically, written work turnover and other documentation represent critical aspects of high-risk organizational systems. Because the complexity of such high-risk systems has been a theorized contributor to accident rates (Perrow, 1999), the clarity and accuracy of written work turnover are critical leverage points for maintenance error reduction. Essential components of accountability, information flow and quality, and safety assurance hinge on the proper and complete use of written communication.

As written communication is so vital to safety in airline maintenance, it is no surprise that efforts have preceded the present research to increase the quality of documentation. Hutchinson (1997) examined work cards in a large repair station and found that over a twelve-month period, 40% of them contained vague, ambiguous or abbreviated phrases that missed intended standards of federal aviation regulation. A feedback system was implemented on the hangar floor whereby work-record error rates were posted daily for mechanics to see. Being shown error rates with such rapid feedback had a profound impact on documentation practices, with the 40% error rate dropping to zero in eight weeks.

Taylor and Christensen (1998) highlight the importance of written communication in airline maintenance, calling it "the bedrock of all communication in maintenance" (p. 94). Of all modes of communication operating in such a system, Taylor and Christensen see the written message at the core. They cite three critical factors in improving written communication in airline maintenance. One factor is employee participation. Involving employees in the improvement process has shown to be a positive force in reducing paperwork errors (Taylor, 1994). A second critical factor is ergonomics and forms design. Research has explored this area to maximize the clarity and usefulness of work documents in airline maintenance (Patel, Drury & Lofgren, 1994). Finally, measurement and feedback on performance is important as Hutchison (1997) has shown. Efforts to measure patterns in written communication and provide feedback to researchers, managers and mechanics about improving this skill help initiate a process geared toward safer airline maintenance departments.

The present study marks an initial attempt to measure some qualities of written communication beyond the mere absence or presence of discrepancies. It is also an effort to examine the effects of a MRM training program containing modules on improving written communication in general and written turnovers in particular. That training took place in two phases. For the large repair hangar described here (hereafter called the *subject site*) Phase I training occurred from January 2000 through April 2000, the period during which all participating employees went through the first day of training. Phase II, the second day of training, began for the subject site in June 2000 and concluded in August of 2000. Other sites in the same company (hereafter collectively called the *subject company*) had started the training, but had not yet completed it. Their interim results are compared with the subject site. Further comparison uses some results from MRM programs in two other companies, whose programs did not include modules on written communication and whose training was completed in one phase.

A Definition of Written Turnover

We are defining *turnover* in organizations employing shift work as the passing of partial or incomplete jobs from one shift to the next. More specifically, written turnover is denoted as the documentation of work performed and passed from at least one shift to another during aircraft overhaul. Written turnover in the airline industry serves two crucial purposes: (a) it leaves a paper trail of accountability for each step in a set of maintenance procedures and (b) it provides the next work shift with information vital to assuming the next stage of a task and ultimately completing the entire job. Important to conclude from this description is that the work card represents a carefully crafted centerpiece to a system of checks, re-checks, accountability and safety nets. Written turnover practices represent the critical human component to this system that ultimately determines the system's ability to reduce maintenance error.

For the subject company, written turnover was emphasized primarily in Phase I of the training, with cursory reminders occurring during Phase II. Specifically in Phase I, the *Three Cs* (clarity, completeness and correctness) were stressed as critical to written communication. Training exercises demonstrating the importance of such written communication included a task that involved following a complete set of directions, the clarity (or unclarity) of which was not apparent to participants until the very last step. A second exercise had participants write a work document entry, striving for enough clarity, completeness and correctness to enable a second, naïve participant to correctly assemble a set of objects in a particular fashion based on what was written. Additionally, considerable time was spent in

discussing and examining company turnover documents and how to fill them out properly.

Research Hypotheses

Based on the emphasis in Phase I training toward written communication and turnover, our expectation was that turnover quality and attitudes toward written communication would be most improved immediately following this period, and that errors in written documents would be diminished.

Hypothesis 1: Following training, the subject company'' respondents' intentions to write more clearly, and subsequent reports of their having written more clearly and improved their turnovers will be higher than other companies not using this training.

Hypothesis 2: Following training, paperwork errors in the subject company will show a decrease coincident with behavior change.

Hypothesis 3: Following training, the actual written turnovers would improve in length (completeness), in legibility (clarity) and in content (correctness), compared with appropriate pre-training baselines.

METHOD

Kirkpatrick (1998) identifies four levels of training evaluation criteria or outcomes, each increasing in relevance to bottom-line organizational goals. The four evaluation levels articulated by Kirkpatrick in order of increasing importance are reactions, learning, behavior and results. Reactions are simply the opinions of training participants about the training. Such data is easily measured and collected, but has a theoretically and practically weak relationship to ultimate organizational goals. The second level of evaluation, learning, carries a bit more weight toward bottom-line training objectives. An evaluator targeting this level of criteria is interested in principles, facts, and attitudes that were gained or changed as a result of training. Behavior is the third level of evaluation and represents more direct connection to work practices. An evaluator at this level is looking for actual behavior change or reports of behavior change related to job performance. The final, deepest and most critical level of evaluation criteria, according to Kirkpatrick, is results. At this level, training effects are related to organizational objectives. If an evaluator can demonstrate that this level of criteria is affected by a training initiative, then that evaluator has data that are able to make meaningful statements about the success of the program.

The data used in the present study was collected with the Kirkpatrick concepts as a model, and with primary attention to the second, third and fourth levels of evaluation criteria (learning, behavior and results). Kirkpatrick warns that evaluation of results is generally difficult to obtain. Former attempts have been made to link MRM training to bottom-line organizational results (e.g., ground damage incidents and lost time injuries) (Taylor, 2000).

The current study is an attempt to measure a behavioral process in aviation that is very closely related to fourth level evaluation criteria. An overriding organizational objective in the subject company, as well as the greater aviation industry, is the minimization of incidents and accidents. We are examining the quality of written turnover as a behavioral criterion shown by accident investigations to have direct consequence for these safety objectives (e.g., NTSB, 1992).

Subjects and Samples

The subjects (employees of the subject site) are aviation maintenance repair mechanics and quality inspectors, plus their immediate supervisors and middle managers who have completed a two phase MRM training program in a maintenance repair site belonging to a large airline. The subject site is unique in that *all* of its employees have completed both phases of this MRM training, which emphasized improving written turnovers. Initial field interviews at the subject site during and after the training period revealed that many participants especially valued its sections on written communication and turnover. Results from this subject site are compared with other heavy maintenance facilities in the same company (subject company) that had begun, but had not yet completed, the same MRM training. Survey results from the subject site and the larger subject company are compared with heavy maintenance operations in two other airlines (*comparison companies A and B*) whose MRM training did not include the topics of written communication or improving written turnovers. Survey respondents in the comparison companies include mechanics, inspectors, and management and support personnel in similar proportions to the subject company.

DATA

Assessment of Written Turnover Quality

The documents from which we assessed the quality of written turnover in the subject site consist of non-routine work cards that are included in the document packages resulting from aircraft heavy maintenance overhaul called maintenance checks. These maintenance checks are a set of preplanned maintenance inspections and procedures, which are conducted

at required intervals for aircraft of a particular model. The non-routine work results from defects or damage found during the preplanned inspections. The overhaul process studied here is called *C-check* in the industry and is a fairly extensive overhaul process. Because the set of maintenance procedures for a C-check is so large, the subject company has divided theirs into six parts that can each be performed usually in three to four days of nine to twelve eight-hour shifts.

For each non-routine job card they work on, these maintenance employees are required to sign the entries for which they accept responsibility using their own stamp issued with their employee ID number. The employee who stamps the repaired by section on the front of the card accepts responsibility for his or her section, as well as any entries on the card that have not been stamped. The checked by section of a work card is generally stamped by an inspector, meaning this individual is accepting responsibility that the completed job has been conducted properly, and that any required inspection items have been properly inspected.

Sampling Written Turnover Data

The subject site's data sample represents turnover data entries recorded by the mechanics, inspectors, supervisors and managers in this one heavy maintenance station. All turnover entries were recorded by employees that had completed both phases of the MRM training during the preceding year. Turnover data were collected and coded from completed work documents during visits to the company archives. A purposeful sample of document packages was drawn. We could not review all non-routine work cards for the subject site with the time and manpower available. We therefore sampled the documentation of approximately 10% of all C-checks performed at the subject site for a two-year period. Because no grounded or theoretical reasons could be conceived to choose one phase of the C-check over another, our sample was selected without regard for the phase of C-check other than gaining an adequate proportion of the total checks conducted in 1999 and 2000. The population consisted of 179 document packages in 1999 and 169 in 2000, a total of 348. From this, a sample of 16 packages from each of 1999 and 2000 were included in the sample, a total of 32. Phase I training began in January of 2000 and concluded in March of 2000. Phase II began in June of 2000 and concluded in August of 2000.

Figure 1 shows the distribution of the 1,386 separate turnover entries obtained from the 32-package sample. March, September, and December were selected as appropriate periods in each year to draw samples based on their proximity to 2000 training onset and conclusion. The sample chosen allows examination of changes in written turnover performance at critical points coincident with onset and termination of training. It also allows for
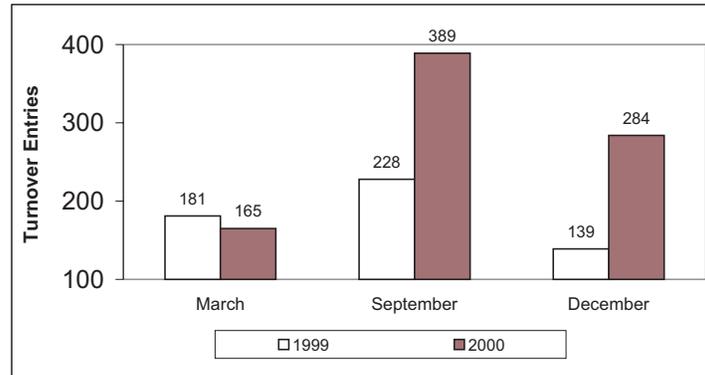
Figure 1. Total Number of Turnover Entries for Each Sampled Month in 1999 and 2000

comparisons to baseline from the same months in 1999, during which training had not yet been implemented.

Coding the Turnover Data

Turnover written in response to the initial inspection and defect description were assessed and coded by two raters. Turnover length (completeness) was recorded by counting the number of words included in the turnover, including reference numbers and abbreviations. Legibility (clarity) was recorded by assigning a rating from 1 (completely illegible) to 4 (completely legible) for each turnover entry. Content (correctness) was recorded by counting the number of times an entry included correct or incorrect information. By industry standards, information on what was done, or information on where the employee stopped or how he or she left the situation is considered correct and information on what to do next is considered incorrect. Raters were compared on turnover length, content and legibility for each time block separately using independent samples t-tests. Number of words (length) and content were stable across raters, with no significant differences between raters. However, comparison of raters on legibility yielded significant differences at almost all time blocks, reflecting the increased subjective judgment inherent in this measure.

Measuring Paperwork Discrepancies

The subject company's airline maintenance department, in which the new training on written communication had been implemented, has measured and reported total paperwork discrepancies for each station by month between 1995 and 2001. The subject company's monthly reports were made available to the researchers for use in identifying improvement

trends coinciding with the training. In order to compare the subject site with others in the subject company, the raw data contained in these reports were corrected for station size through the use of personnel headcount. Trends for these corrected data were examined for a period prior to the onset of the training and for the available months thereafter. Viewing these trends we expected to find the most impact of the MRM training on the subject site in which all employees had completed both phases; and to a lesser degree in the other maintenance stations in the subject company where not all employees had yet been trained.

Survey Measurement

Employee intentions to improve their written communication following their training, and their reports of actually doing so, were collected using post-training surveys. Survey data were collected from the subject company and from two comparison companies using the Maintenance Resource Management–Technical Operations Questionnaire (MRM/TOQ), a well-tested and validated survey instrument (Taylor, 2000). Training participants completed surveys immediately after their training. In the subject company's sites where training occurred in two phases, questionnaire data were collected after each phase. The MRM/TOQ data used to explore the effect of the training on written turnover come from responses to previously validated open-ended items that are subsequently coded into fixed categories (Taylor, 1998; 2000). Initial responses come from the immediate post-training questionnaire, in which participants were asked what was memorable about the training they had just received, and how they intended to use the training. Further responses were collected from participants several months after their training when these respondents received another MRM/TOQ in which they were asked to describe what changes they had actually made as a result of their training. Since the coding scheme included categories for both "writing more clearly," and "improving my turnovers," we expected to find such responses in greater proportion in the subject site, next most frequent in the remainder of the subject company, and the least in maintenance operations at the comparison companies where the MRM training curriculum did not include written communication as a topic.

RESULTS

Comparisons of Written Turnover Before and After MRM Training

Written Turnover Completeness

Figure 2 shows the written turnover length (or completeness) for the subject site for 1999 (the year before MRM training) and 2000 (the year in

which training occurred). As shown in Figure 2, the distribution of mean number of words in turnover arrayed across sampled months in each year are roughly parallel for this measure and higher for 2000.
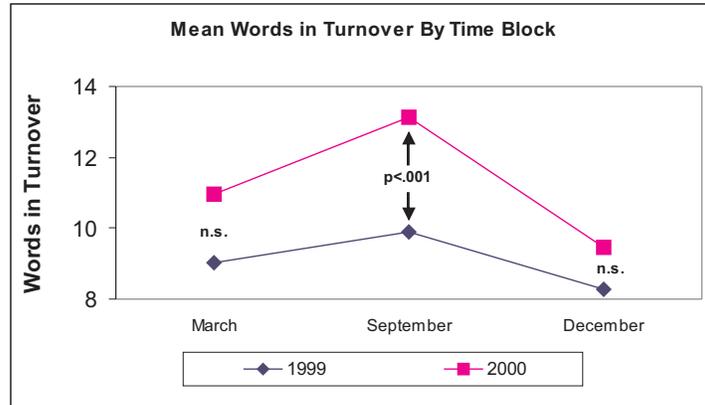
Figure 2. Turnover Length: Subject Site Comparison for Six Time Periods, 1999 and 2000

A one-way analysis of variance (ANOVA) was conducted for turnover length with time period as the factor, and it was significant (F = 8.892; df = (7, 1,808); p < .001). Tukey HSD post hoc analysis revealed the following. The increase in turnover length between December 1999 and the two periods March and September 2000 are statistically significant (p < .001), implying stepwise improvement resulting from Phase I and Phase II training. However there is a significant decrease in turnover length from September to December 2000 (p < .001), which suggests that the training effect is short lived. The post hoc analysis shows also the increase in September 2000 (the month following the completion of all training) over the same period in 1999 is significant at p < .001. Differences in turnover length remain non-significant when compared for the months of March and December in 1999 and 2000.

Written Turnover Clarity

Figure 3 shows that average legibility (clarity) scores are reasonably high. They range between a low of 3.1 and a high of 3.6 on this 4.0-point scale. The one-way ANOVA of turnover legibility (with time period as the independent variable) is also significant (F = 13.603, df = (7, 1,814), p < .001). The Tukey HSD post hoc analyses reveal somewhat similar results to those seen for turnover length. As shown in Figure 3 a sizable increase in legibility was found from December 1999 to March and
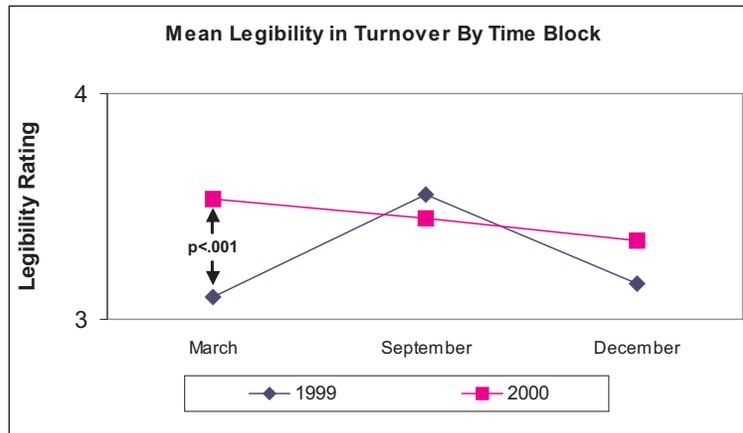
Figure 3. Turnover Legibility: Subject Site Comparison of Six Time Periods, 1999 and 2000.

September 2000 (suggesting an effect of Phase I training), which are significant at the $p < .001$ and $p < .01$ levels of confidence, respectively. The highest level of legibility occurs in March 2000, immediately after Phase I training and is significantly greater than its counterpart a year earlier. No significant changes occurred across time periods in 2000, and no other significant differences emerged for legibility.

Correctness of Turnover: Descriptive versus Prescriptive Narrative

Among the hypotheses tested in this research is the improvement in correctness as well as the completeness and clarity of written turnover documents. As previously mentioned, policy at the subject company and elsewhere in the industry discourages maintenance employees from making statements in the turnover about what the next course of action should be for the employee receiving the turnover. This is because such statements can limit the decision making of the turnover recipient, and additionally the suggested comment may be against authorized procedures. Each entry was dichotomously coded as having either included or not included what was done, how the situation or job was left, and what needed to be done next. From these data, we compared *descriptive* turnover only (stating what was done or how the job was left), and *prescriptive* turnover (adding statements about what the next mechanic should do), on turnover length and legibility.

Legibility (clarity) was not different between descriptive and prescriptive turnovers ($t = -1.95$, df = 2091, n.s.). However, for total number of words (completeness) the prescriptive turnover entries had significantly more words than the descriptive turnover entries. Levene's test was

significant for the t-test used for analysis (F = 32.70, p < .001), and the group sizes were unequal, necessitating a non-parametric analysis. The Mann-Whitney U test showed significant difference in mean ranks at z = −6.154, p < .001. The greater number of words in the prescriptive turnover is no surprise, as additional writing should be required to include direction about what should be done next. This finding reinforces a point made in the subject company's MRM training that longer turnover is not necessarily better turnover.

Unfortunately this advice did not have a measurable effect on performance. Figure 4 shows the oscillating percentages of prescriptive turnover entries across time blocks. An overall Chi Square test (X^2) of the 6 time blocks by inclusion of prescriptive turnover was significant ($X^2 = 37.77$, df = 5, p < .001). Post hoc Chi Square tests were conducted for adjacent time blocks, and significant differences were seen for several of them. A significant decrease was found from September 1999 to December 1999 ($X^2 = 8.65$, df = 1, p < .01), a significant increase was shown from March 2000 to September 2000 ($X^2 = 22.04$, df = 1, p < .001) and a decrease was revealed for the period September 2000 to December 2000 ($X^2 = 14.20$, df = 1, p < .001). Thus no clear effect of MRM training on eliminating prescriptive turnovers can be discerned from the current analysis.
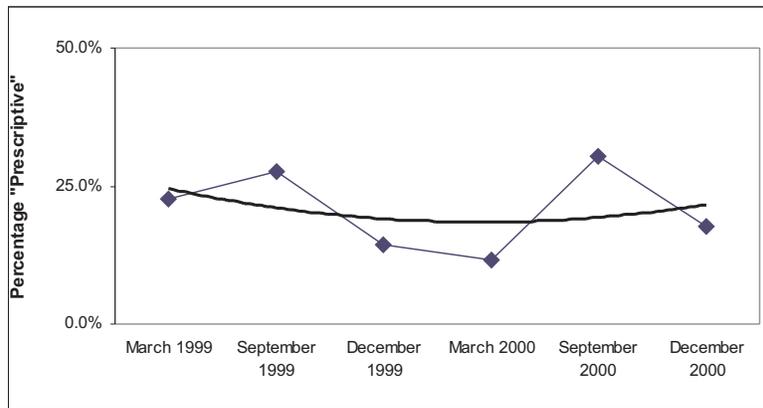
Figure 4. Turnover Content: Subject Site's Percentage of "Prescriptive" Responses for Six Time Periods, 1999 and 2000

Testing other effects on turnover correctness

Pearson's Chi-Square statistic was conducted for each of these variables in cross-tabulation with the three main job titles of mechanic, inspector and manager. Overall 2 x 3 cross-tabulations yielded significant Chi-Square statistics ($X^2 = 21.95$, df = 2, p < .001), indicating a relationship between

turnover content and job title. In 2 x 2 Chi-Square tests, mechanics were shown to be more likely than inspectors ($X^2 = 32.807$, df = 1, p < .001) and managers ($X^2 = 7.082$, df = 1, p < .01) to write a prescriptive response. Managers and inspectors did not differ from one another.

Paperwork Errors in the Subject Company

Figure 5 shows the total number of paperwork or document errors per month from January 1995 to January 2001 for the subject site and the average errors per month for all remaining base maintenance stations in the subject company. A slight positive trend is shown in number of errors across time (the trend line for the subject site is solid and the trend line for the average of the remaining stations in the subject company is dashed), with a sharp increase occurring in 2000 and 2001. Both trend lines in Figure 5 show a positive slope after 1998. This seems perplexing considering the ongoing training program in progress designed, in large part, to reduce these types of errors. However, a hiring freeze ended in the subject company at the beginning of 1998, and a number of young and less experienced mechanics began work for the subject company at the beginning of 1999.
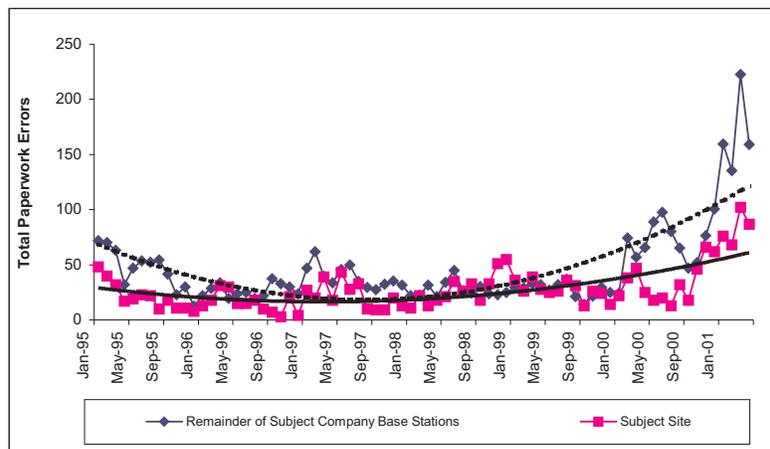
Figure 5. Paperwork Errors from January 1995 through April 2001

Head count data is shown in Figure 6. This shows a slight increase in the number of employees from 1998 to 2001 in the subject site and a stronger growth in new employees in the remainder of the company. Head count data was not available prior to 1998.

We could easily expect that a population suddenly infused with new employees would yield an error trend with an increasing slope. Any
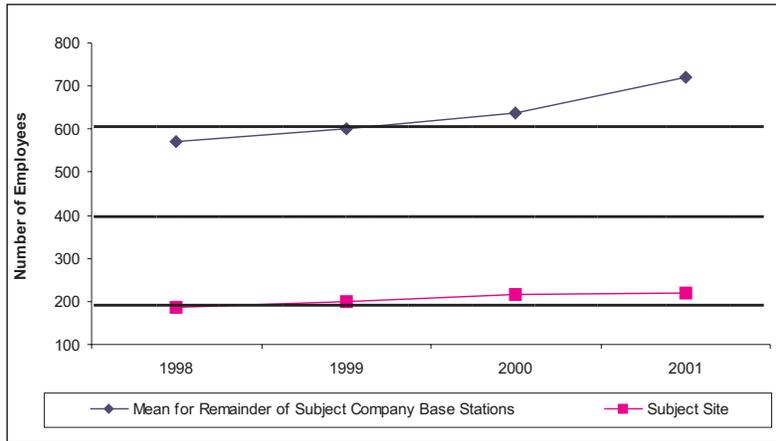
Figure 6. Head Count Data from 1998 through 2001

significant effects of MRM training are likely counterbalanced by the propensity of a new hire to commit error. To assess the possible effects of new employees hired, we adjusted errors by head count and compared the trend line slopes before and after January 1999. Figure 7 shows the year 1998 and the different trends in paperwork errors between the subject site and the remaining heavy maintenance stations in the subject company. The subject site is less affected by new hires in 1998 and shows an error rate increasing more sharply than the head count rate over time, which shows an
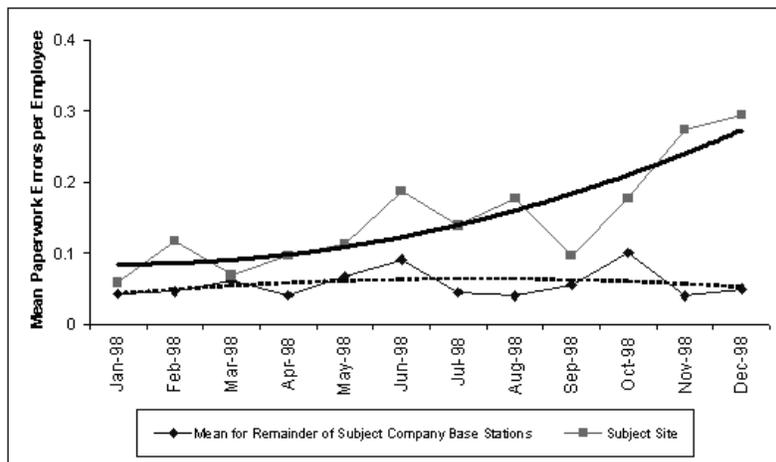
Figure 7. Paperwork Errors Adjusted for Head Count for 1998

overall increase in errors per employee during this time preceding MRM training.

For 1999 through 2001, corrected for head count, Figure 8 shows an increasing trend for both the subject site and remaining stations. This similar shift in trend for both groups lends support to the idea that new and relatively inexperienced mechanics can be largely responsible for the diminished paperwork skills and the increase in paperwork error rates in 1999-2000.
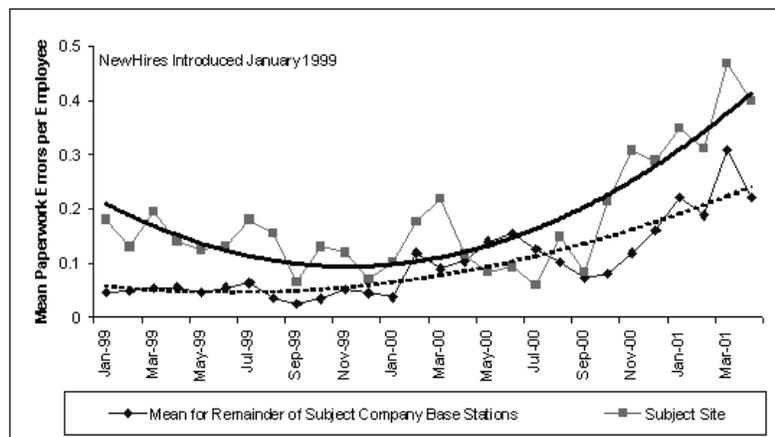
Figure 8. Paperwork Errors Adjusted for Head Count for 1999, 2000 and 2001
(During Training and after New Employee Hiring)

Field Interviews and Survey Data

Recollections and Intentions

In field interviews conducted in June 2000, shortly after Phase I training was completed, a sample of 46 maintenance employees from the subject site were asked what they remembered best about the training. "Turnover" tied for the highest response with "case studies and videos" at a 15% response rate. This apparent enthusiasm and remembrance for written turnover was encouraging, since written turnover was a primary component of Phase I training. Interviews conducted with Aviation Maintenance Technician (AMT) and foreman at the subject site in December 2000 showed that AMTs' attempts to improve written turnover had begun, but then ceased. Interview respondents generally agreed to a lack of management support or encouragement for the effort.

Following both Phase I and Phase II, the MRM/TOQ included the questions "What are good aspects of the training" and "How will you use

this training on the job." Among the general themes that are coded for each of these, three bore some relationship to the topic of written turnover. Those themes were "improve turnovers," and "write more clearly," as well as "communication" (this last theme code was used if the respondent wrote only the word "communication" and nothing else). Data from the subject site were compared with the results from remaining heavy maintenance stations in the same company; and both of those are compared with companies A and B that are engaged in similar heavy maintenance operations, but whose MRM training did not cover written communication.

Table 1 shows the degree to which respondents felt the three selected communication topics were memorable (or good) in the training they received.

The results in Table 1 reveal a difference among the six survey samples in their mention of memorable topics that is statistically significant (Chi Square = 41.62, df = 10, p < .001). These results show a substantial regard for the treatment of improving turnovers in the subject site and in the remainder of the subject company immediately following their Phase I training. Improving turnovers was not mentioned at all in the two comparison companies following their MRM training and this is to be expected insofar as their training programs did not emphasize that topic. Likewise, and for the same reason, no mention of the turnover topic was made following the Phase II training in the subject site and the remainder of the subject company. A smaller proportion in the subject sites mentioned clearer writing as a memorable aspect of their Phase I training and this

Table 1. Communication and Turnover Responses for "What were the good aspects of the training?"

What were the good aspects of the training?	"Improving turnovers"	"Writing more clearly"	"Communication"
Following Phase I, Subject Site (n = 245)	7.4%	1.6%	4.2%
Following Phase II, Subject Site (n = 263)	0	0.5%	2.1%
Phase I, Remainder of Subject Company (n = 837)	7.3%	3.4%	7.3%
Phase II, Remainder of Subject Company (n = 236)	0	0.4%	1.2%
Comparison Company A (n = 1,844)	0	0.3%	4.1%
Comparison Company B (n = 153)	0	0.6%	3.8%

X^2 = 41.62, df = 10, p < .001

appears as a very small percentage following Phase II training as well as for the two comparison companies. There appears to be little difference in the general "communication" topic among the six samples except that it seems to diminish in the subject site and remainder of the subject company after Phase II training as specific references to communication are reduced in that training.

Table 2 shows respondents' expectations—as a result of their training—to improve their turnovers, to write more clearly, or to just communicate.

Table 2. Communication and Turnover Responses for "How will you use this training on the job?"

How will you use this training on the job?	"Improving turnovers"	"Writing more clearly"	"Communication"
Following Phase I, Subject Site (n = 245)	6.6%	8.1%	4.1%
Following Phase II Subject Site (n = 263)	1.1%	0.6%	3.0%
Phase I, Remainder of Subject Company (n = 837)	15.6%	8.7%	6.1%
Phase II, Remainder of Subject Company (n = 236)	0.1%	0.8%	3.5%
Comparison Company A (n = 1,844)	0	0.1%	7.2%
Comparison Company B (n = 153)	1.3%	0	7.8%

X^2 = 46.76, df = 10, p < .001

Results shown in Table 2 show that participants in the subject site and in the remaining heavy maintenance stations in the subject company more frequently expressed intentions to improve turnover and write more clearly than in the other two companies. The Chi Square test for difference among the six survey samples over the three response categories is statistically significant (Chi Square = 46.76, df = 10, p < .001). These respondents also most frequently expressed intentions to improve turnovers and write more clearly after Phase I than after Phase II. This reduction of intentions following Phase II training is not a surprising finding considering these topics were not emphasized in Phase II content. The two comparison companies show minimal intentions to practice either improved turnovers or clearer writing. Intentions to improve general communication show little difference among the six samples.

Reports of Actual Behavior

Table 3 displays data collected from the subject company's MRM/TOQ following Phase II, and shows the degree to which respondents say they *did* improve their turnovers, they *did* write more clearly, or they *did* communicate better in general as a result of their training. These results are compared, in Table 3, with data collected from respondents in the two comparison companies in a follow-up MRM/TOQ survey administered two months after their training.

Table 3. Communication and Turnover Responses for "What changes have you made on the job?"

What changes have you made on the job?	*Phase II, Subject Site (n=180)*	*Phase II, Remainder Subject of Company (n=259)*	*Comparison Company A (n=585)*	*Comparison Company B (n=150)*
Wrote more clearly	0.6%	2.3%	0	0
Better turnovers	1.1%	1.9%	0	1.3%
Communication	2.7%	1.9%	1.6%	6.0%

$X^2 = 10.66$, df=6, n.s.

These reports of behavioral change several months after the initial training are suggestive, but cannot be said to statistically support the prediction of respondents' actual change in written turnovers resulting from the training. Although Table 3 data do show a slight trend in the subject company respondents' reports of writing more clearly and improving their turnovers, the Chi Square test does not show a significant difference among the several samples.

DISCUSSION

MRM Training Effects on Turnover Practices

The most direct evidence we have presented here, the analyses of written turnover length and legibility, does yield findings showing benefit of MRM training. For our subject site, which received the maximum effect of the training; turnover completeness (length) increased over 1999 baseline levels in March 2000, after Phase I, and again in September 2000 following Phase II. The second direct, but partial support for our hypotheses lies in the clarity (legibility) results. Legibility increased over baseline after Phase I, but returned to 1999 levels after Phase II. Possibly, legibility is a habit quickly and readily improved, but also more likely to degenerate than writing more complete descriptions.

This failure to fully support our hypothesis might be explained by participant reaction to the second training module, in which the written communications skills were not sufficiently reinforced. In the second training phase, participants get a reminder of Phase I content, and may hear the implicit message that management is committed to the values and ideas advocated in the training. Field observation following Phase I and again after Phase II revealed little management support for improving written turnover in the subject site. Our results, as illustrated in Figures 2 and 3, do show improvement in written turnover from before the training in December 1999 to after the first phase in March 2000 and again for at least one of the measures from March to September 2000. Making a change such as this to improve written turnover, requires support and encouragement from others. It is evident that encouragement was not strong or continuous in the subject site.

The analysis of job titles and turnover content showed mechanics to be the most thorough in their entries, being more likely than managers or inspectors to include all three types of content recorded. These findings are consistent with job roles. Because mechanics are performing a bulk of the actual work, occupational demands may motivate them to write longer and more comprehensive turnover. Consistent with this explanation are the positive sentiment and the stronger intent to improve turnover shown after Phase I than after Phase II revealed in the survey data (see tables 1 and 2).

Participants may have made an initial effort to write more legibly after the first training because it was not too demanding and difficult. Probably because little commitment at the subject site was dedicated to this change, and little reinforcement was received by mechanics, the efforts waned in the absence of reminders or internal incentives. Anecdotal reports from field visits suggest that local management did little to reinforce the content of the Phase I training and that this had dampening effects on mechanics' motivation to apply the training further.

Paperwork errors data provided additional means by which to assess MRM training effects, but they were not conclusive. The employment of a substantial number of new maintenance personnel into the subject company at the beginning of 1999 was shown to confound the data and thus make difficult the detection of any training impact on paperwork error rates. Under these circumstances special technical training in the proper use of forms would be of benefit for the new hires as well as for the more experienced mechanics who were providing them on-the-job guidance and advice. Without such technical training the effect of this diminished basic skill may outweigh any error-reducing effects the MRM training may have provided. That less-experienced workforce is likely responsible for some if not much of the increase in errors following 1998. Similar data were not available from the comparison companies because they had not collected similar or comparable paperwork errors.

Myriad explanations are possible for the somewhat inconsistent results regarding turnover entries, general paperwork errors, and participant expectations following the training. Ultimately, we are faced with little knowledge about the way these specific variables work in organizational research. To our knowledge, there have been no previous studies of written turnover or paperwork errors in airlines or any other industries to date with the exception of the studies and cases referred to in the introduction.

Generalization of Results

Specific Communication Training Changes Attitudes and Behavior

We have found that specific training in improving written communication included in the curriculum of the first part of a two-part human factors training program produces measurable and favorable results. The training program we examined was completed for 263 employees in one maintenance site. In two other of the company's maintenance sites over 800 AMTs and managers completed the first part of the training. Of these latter groups little more than one-quarter had completed the second part of the training at the time of our study. On the basis of the high sampling ratio these two samples represent, and their consistent results following the first part of the training the change effect can be generalized. Phase I training did lead to improvement in measures from Kirkpatrick's Level 2 (learning) and Level 3 (behavior) categories. Resultant changes in written turnover quality (the learned behavior, measured only in the subject site), were short lived and were not sustained long enough to have an effect on subsequent overall paperwork quality or on aircraft safety (Level 4, results).

Two-part Training Does Not Sustain Learned Behavior and Motivation If It Is Not Designed to Do So

We found that changes in perceptions and in intentions followed Phase I, where communication was emphasized, but diminished following Phase II where it was not emphasized. These results are consistent for the subject site and the rest of the subject company–especially when contrasted with the two comparison companies. Our ability to generalize this finding is quite good because those AMTs and managers who attended Phase II training were all of the employees (n = 263) for the subject site, and were a sizable number (n = 236) and proportion (28%) of base maintenance employees for the remainder of the company. The latter proportion can be considered a random sample of the 800 plus AMTs and managers who attended Phase I training.

We reported that interviews from the subject site revealed only a small amount of local management encouragement and support for improved communication during and after the training. The data on turnover quality, also collected at the subject site, provided evidence that the quality of the

written turnovers improved and then diminished in the subject site following Phase I and Phase II, respectively. We did not collect similar data for the rest of the subject company and cannot, therefore, generalize that a similar oscillation in turnover quality would occur everywhere two-part training of this type is used. Lack of management support provides explanation for the oscillation in turnover quality just noted, but corroborating interviews were not conducted in the rest of the subject company so generalization to the rest of the company cannot be made. Local conditions and results in the subject site cannot be generalized to explain causal effects for the positive change in attitude and intention recorded in the subject company, following Phase I, and the diminution of those changes following Phase II. However, the localized dampening effect of poor management support for improving communication in the subject site could help explain its lower intentions and subsequent reported behavior changes in comparison with the total subject company.

The performance data we collected (average paperwork errors per maintenance employee) do not show a subsequent or long term effect of the training. If anything, the effect of adding inexperienced AMTs is seen to increase errors. Lack of local management support for improving written communication in the subject site, revealed in interviews with AMTs and foremen, is also consistent with the accelerating rate of total paperwork errors in that location from the beginning of the year 2000. That accelerating rate of paperwork errors seems more consistent with the lack of local management support for improving written communication than with the simple addition of new AMTs.

CONCLUSIONS

MRM Training Works–Communication Was Improved

In this paper we have reported that a specific training curriculum, with focus on better writing and communication skills, and on documenting turnover, can make a positive difference in aviation maintenance. Results in a single site were shown to generalize to the larger company. Such training increased trainees understanding of written communication, improved trainee attitudes toward communication, and changed their behaviors in that direction as well. Our results also show that a non-specific MRM curriculum will have little impact on improving targeted communication behaviors.

Improved Communication Was Not Sustained

It is clear from these results that specific training is effective in changing behavior, but the impact on the organizational bottom line—on error reduction and aircraft safety—is illusive. Our results also show that there are several obstacles to improving the bottom line of turnover documents.

The first obstacle is that when employees are ignorant or uninformed of paperwork details and processes, they will make paperwork errors. A successful maintenance operation needs to provide a thorough grounding for its new AMT employees in understanding the company's forms and documents. The company's technical training department should provide this basic and thorough grounding in use of forms and documents soon after an employee is hired.

The second obstacle is a lack of management support and encouragement for improved communication processes and techniques. When such techniques are part of a larger human factors (MRM) program to reduce human error there is the added risk of undermining AMT confidence in the overall MRM effort. Local management may hold the perception that encouraging AMTs to use good written communication practices will act against meeting production demands. When those fears become known to employees (as they surely will eventually) the latter will quickly become cynical of such training in particular and of MRM programs in general. Management must provide support and encouragement for AMTs to take the time to provide written descriptive narrative in a complete and legible form. If managers are ambiguous about (or inconsistent in) providing AMTs the time to complete turnover forms clearly and legibly, this inconsistency will be seen as confusion (or, worse yet, duplicity) to those subordinates.

The third obstacle to address in successfully reducing human error is the individualistic occupational culture of the North American aircraft mechanic (Taylor, 1999). The strong, silent type has many virtues, but in a complex world of modern aviation technology maintenance technicians need to communicate more than has been formerly expected by the industry. This normal tendency of AMTs to communicate less rather than more is only enhanced when their managers are reluctant or hesitant to support what MRM programs encourage.

Management Must Take A Clear and Active Role in Change

The conclusion that local management must be consistent and forceful in its support of company MRM training programs is reinforced by previously reported results regarding obstacles to successful organizational change in the airline industry (Taylor, 1998; Taylor & Christensen, 1998; Patankar & Taylor, 2000). In every instance studied over the past dozen years the one key variable in successful MRM programs is unwavering management support at all levels. It is time for aviation maintenance management to take a clear and active role in promoting and supporting the human factors and error reduction programs they impose on their employees.

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AN EMPIRICAL INVESTIGATION OF FINANCIAL AND OPERATIONAL EFFICIENCY OF PRIVATE VERSUS PUBLIC AIRPORTS

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ABSTRACT

The primary purpose of this paper is to compare efficiency of privatized and government owned airports. Although in the U.S. almost all of the airports used by commercial air carriers are owned and operated by the public sector, the trend towards airport privatization, especially in Western Europe, Asia, and Latin America, has stimulated new thinking in this regard both from the U.S. government, as well as businesses. As the privatization trend in the airport industry continues, airport managers are facing an increased pressure to find more cost-efficient ways of running their airports. Implementing improvement standards will become a necessity. Moreover, there is an increasing economic pressure on local governments to privatize

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airports. One important finding of this study is that government owned airports had better operating efficiency in terms of passengers per runway area, movements per gate, and movements per runway. On the other hand, privatized airports have higher financial efficiencies (revenue per passenger and revenue per landing).

HISTORY, TRENDS, AND ANALYSIS

Airport privatization means the infusion of capital by private sectors to gain partial or total control over an airport's activities and facilities. Many airports have been privatized worldwide since the trend of privatization was introduced. In 1987, the British government initiated the sale of its commercial airports under the Thatcher government. The government-owned British Airport Authority (BAA) was offered to the public for $2.5 billion. Currently, the BAA operates seven major airports in the UK and has generated profits ever since it was privatized. The company is listed on the London Stock Exchange and has a market capitalization exceeding $8 billion (Biederman, 1999).

Attracted by the positive results from the UK model, the trend of airport privatization occurred in other countries. Austrias Vienna Airport was listed on the Vienna Stock Exchange in 1992. Also, two Danish Airports were incorporated as Copenhagen Airports Ltd. and listed on the Copenhagen Stock Exchange in 1994. The private sector holds slightly less than 50 percent of the shares in either example (Poole, 2000a). However, the privatization of BAA has not been without its critics. These critics charge that the government converted a public asset into a regulated private monopoly that requires regular review and negotiation over the airport's charges to the airline. Privatization will not necessarily ensure that citizens get better service at lower cost than from the government (Vasigh, 2001). Service and cost are the result of the relationship between the regulatory controls, choice of markets to serve, market power, and productivity.

Another European airport being publicly traded is Italy's Aeroporti di Roma. Recently, the Italian Leonardo consortium won the bidding process to become the major shareholder of the airport (Airports International, 2000).

The Amsterdam Schipol Airport is preparing for an initial public offering of shares at the Amsterdam Stock Exchange. The Dutch government, the majority shareholder, is expected to decide shortly on this matter while the other shareholders, the cities of Amsterdam and Rotterdam, already agreed to sell their respective stakes (Airport World News, 2000). Schipol's strategic alliance with the German Flughafen Frankfurt/Main AG (FAG) is another example of an incorporated entity. Currently, all shares are still owned by the state and federal government. However, a share offer at the stock exchange is planned until the end of the decade (see Table A1). The FAG will be part of the consortium operating the new Berlin-Brandenburg Airport in Germany's capital, which will be

the first fully privatized airport in Germany after its expected completion in 2007.

In Toronto, Pearson's Third International Terminal, Trilliorn, was built by a private contractor. This is the first example of a privatized airport facility in North America. Canada's commercial airports are leased to non-private groups that operate independent of government in setting rates and financing expansion programs. In the U.S., while airline service itself has been freed of economic regulation and allowed to become a dynamic industry in 1978, the majority of U.S. airports have remained under government control. The first airport available for private investment was the Indianapolis International Airport, the nation's 44th largest airport in terms of total enplaned passengers (FAA, 1996). In October of 1995, the BAA took over the management of Indianapolis International Airport (Schwartz, 2000) promising to raise non-airline revenues by $32 million within the ten-year period of the contract. The goal was to achieve a 25 percent reduction on landing fees by increasing revenues and lowering costs while at the same time improving service quality. The contract was renegotiated in 1998 and extended until 2008, the longest term allowable under Indiana law. Costs per passenger were reduced from $6.70 to $3.70 and have increased very little since then. In spite of the rather moderate passenger growth rate of 3.5 percent, non-airline revenue income per passenger, minus expenses, more than doubled between 1994 and the end of 1999. Table A2 lists private participation in operation and management of North American commercial airports.

In contrast to Europe, Australia and a few Latin American countries privatization efforts of U.S. commercial airports had been limited to contract management. This approach avoids more aggressive forms of privatization such as long-term lease agreements or the selling of shares to private investors. Westchester Airport in New York State is another example of the use of a management contract as privatization method. After the airport was facing severe losses, the county government decided in 1977 to bid on a basis of five-year contracts. Under contract management, the airport has become solidly profitable showing net incomes of up to $3 million per year. Also, the Burbank-Glendale-Pasadena Airport Authority bid its management contract to Airport Group International (AGI) who has operated the airport since 1978.

In the Pacific Region, Australia has privatized the three busiest airports—Brisbane, Perth and Melbourne. The scheme was originally announced in 1994 and initiated in July 1997 as the Federal Airport Cooperation offered the sale of long-term leases (For, 1997). Each of these airports has considerable monopoly power and was subject to price regulation. These airports were sold for AU $3.337 billion (Cook, 1997). The majority of ownership of bidding companies had to be Australian. The Australia Pacific Airport Cooperation (APAC) won the bid for Melbourne in which the BAA holds a 25.1 percent stake. Brisbane, the fastest growing

airport, went to Brisbane Airport Corporation Ltd., in which Amsterdam Schipol Airport owns a 15 percent stake. Recently, the FAG has acquired an equity investment. Brisbane is the first overseas airport where FAG and its alliance partner, Schipol Group, work actively together (Going down under, 2000). The Airstralia Development Group, in which AGI, successor of the Lockheed Air Terminal Group, owns 16 percent, acquired Perth Airport. The Sydney Kingsford Smith International Airport was expected to be the most interesting target for privatization. Its privatization has been delayed due to a political dispute arising over an issue of noise problems. A further fifteen airports are to follow the privatization process once the process of privatizing the first three airports is completed successfully.

On the Asian continent, Malaysia was the first country to begin the process of airport privatization. Its Malaysian Airports Bhd (MAB) was offered to retail investors emitting 88 million shares at a price of RM 2.5. The second offering, directed to institutional investors, raised RM 275 million (Deals of the Year, 2000). The Airport Company operating all of Malaysias 37 airports plans to sell down further shares in the near future. Other privatization efforts are under way in various Asian countries. In Korea, the government-owned airport authority is in charge of privatization of the newly constructed Inchon Airport (Biederman, 1999). In addition, the Omani government is evaluating the privatization of two major airports. The Credit Swisse First Boston (CSFB) has been appointed as its financial advisor to manage the process and determine the best methodology to implement this process (Omani Government, 1999).

Latin America is no exception. The Mexican government plans to sell its fast growing Cancun Airport on the New York Stock Exchange. It is expected to general over $400 million in revenue. Grupo Aeroportuario del Sureste SA (Asur), who has been operating the airport as well as eight smaller Mexican airports since early 1998, is expected to retain 15 percent of the 85 percent being offered to the public, as well as operating control. The Asur consortium itself is composed of Copenhagen Airport A/S of Denmark, Groupe GTM SA of France, Spains Grupo Ferrovial and the construction concern Grupo Tribasa SA (Investors, 2000). In Chile, the Santiago International Arturio Benitez Airport was privatized by a 15-year management concession. Management was handed over as of January 1999 to an international consortium composed of Vancouver Airport Services, a construction group from Spain, and two Chilean companies. Argentina awarded a 30-year operating license to a consortium led by U.S. based Ogden Aviation Group for 33 of Argentines airports (Ogden Corporation News, 1999). The consortium pays about $5.13 billion over the contracts life and assumed responsibilities in February 1998. The contract mandated necessary investments in the renovation of the airports. However, the take-over was delayed by three months. The new consortium, as well as the prior airport operator, the Argentine Air Force, which is still in charge of Air Traffic Control (ATC), increased user charges as part of a cross

subsidization policy of the 28 airports that remain unprofitable. The airlines estimate a raise in their operating cost by 271 percent (Turbulent Dialog, 1999). In Table A3, we present a summary of recent airport privatization transaction statistics.

Airport Privatization Techniques

Five methods of privatization are contracting out, contract management, long-term lease, build-operate-transfer and full divesture and sale of shares.

Contracting Out. This method is the traditional tool to privatize state owned enterprises (SOEs) and to relinquish public control. It involves contracting out for the provision of selected services such as restaurants, parking, security services, cargo, baggage handling, and fueling services. Under this scheme governments retain the right to establish business policies and manage the airport.

Contract Management

The second tool for airport privatization involves the private sector in management contracts. The state retains the ownership and investment responsibilities. Only management and operations are handed over to the private sector. This privatization technique has been applied at the airports managed by the American division of the BAA, which are Indianapolis International Airport and Pittsburgh International Airport.

Long-term Lease

Under this method, the state can turn over operations and management, as well as investment responsibilities, to the private sector. Recent examples of this are the three Australian airports of Brisbane, Melbourne and Perth, Steward International Airport in the U.S., and airports in Argentina. This sector may also be in charge of financing the construction of the airport but has to return the object after the end of an agreed amount of time. The main objective for a government is to increase funding while at the same time transferring operational responsibilities.

Build-Operate-Transfer

BOT; or its variation of Build-Own-Operate-Transfer BOOT are commonly used technique for this option. This facilitates large new investments but still maintains government ownership and control. BOT projects to develop new airports have been underway in a few countries, the largest of which is Athens $2 billion project. BOT transactions are relatively complex and various financial and technical specifications are needed in order to be successful. The lack of private ownership might impose difficulties in raising and investing large amounts of capital from the private sector.

Full Divestiture and Sale of Shares

The fourth option is transferring the ownership of the airport along with management and investment responsibilities. A common model for this type of privatization is Build-Own-Operate (BOO), where the private sector is responsible for current investments and financing the instruction of the airport. This can be achieved by permitting full or partial divestiture. Commonly used means for implementing this option are buyouts, public offering of shares, and flotation of stock via capital markets. This approach sanctions the government to generate additional revenues for itself while transferring operational responsibilities to the private sector. The sale of ownership limits possibilities of future state or government intervention. The most known example of this privatization option is selling BAA shares to the private sector. Also, the privatization of Vienna International Airport, Copenhagen, and Vancouver's Pearson International Airport all illustrate the use of this technique. However, this technique requires the existence of well-developed capital markets. Needless to say, in most developing countries this tool may not be used because of their thin capital market.

The FAA Airport Privatization Pilot Program

U.S. Congress enacted legislation creating the Airport Privatization Pilot Program in October of 1996. The Pilot Program provides an opportunity to test the potential benefits of privatization to increase funding for airports, lower operating costs and improve airport management and customer service. This program was established to experiment with the effects of privatization among U.S. airports by exempting five airports from the anti-diversion provisions implemented in the Airport and Airway Improvement Act of 1982 (Utt, 1999). The program eliminates the no-profit rule for the new owner or lessee, and it eliminates the grant-payback requirement. The application process must be initiated by either submitting a preliminary or a final application. In the former application process, the public sponsors should identify objectives of the privatization, a description of the process, a timetable for finding a private operator, and financial statements. In the application, airports anticipating privatization under the pilot program have to specify terms and conditions of the lease or sale agreement with a private entity (FAA News, 2000).

A major barrier for the participation in the FAA Pilot Program is the requirement that a city or state must obtain the approval of airlines representing 65 percent of the landed weight at the airport. In the case of many major hub airports, 65 percent of the landed weight represents a single airline. Thus, the dominant carrier is awarded veto power over privatization efforts. The difficulty in finding necessary majority consensus among airlines serving an airport under the FAA Pilot Program is a likely reason why so few airports have so far applied for participation (Utt, 1999).

On March 22, 2000, the FAA approved the privatization of Stewart International Airport (SIA). Stewart's application process had to overcome a number of obstacles. Its major airlines could not reach an agreement with New York State on the use of lease-revenue proceeds for general governmental purposes and rejected an application proposal already made in 1998. The airport currently has scheduled passenger service, but has experienced up to 25 percent decline in passengers (Airport World News, 2000). National Express PLC, a UK-based company that owns two regional airports in England, was awarded a 99-year lease contract from the Department of Transportation (DOT). Thus, SIA became the first U.S. airport to be fully privatized and the first participant in the FAA project (Reason Public Policy Institute, 2002). National Express, a formerly public company privatized under the Thatcher government, is planning to launch a redesign in conjunction with a local real estate development company in order to market the airport to airlines and related businesses. To date, Stewart Airport is the only privatization to be finalized.

The second airport to apply for participation in the Pilot Project was Niagara Falls International Airport (NFIA). Its final application to participate in the program was submitted to the FAA in June 2000. On January 30, 2001, Niagara Frontier Transportation Authority (NFTA), which has been operating the airport under a joint agreement with the U.S. military, reached a 99-year, longterm, lease agreement with Cintra Concesiones de Infraestructuras de Transporte, S.A. (NFTA, 2001). In 2001, Niagara International operated at a loss of $1 million a year.

However, the FAA ultimately rejected the privatization of NFIA as a result of the projected economic impacts of the events of September 11, 2001. Revised projections completed by the investors indicated that the airport would not have been profitable for many years. As a result, funds available for improvements to the airport were substantially reduced or eliminated. As such, one of the goals of airport privatization could not have been met thereby necessitating the FAA's decision (Rimmer, 2002). According to the NFTA, Cintra Niagara would have been responsible for covering all operating costs and had agreed to invest a minimum guaranteed commitment of $10.1 million in the NFIA, which could only have been spent on marketing, promotion, master planning and capital improvements. Additional amounts were expected to be spent over the term of the contract (NFTA, 2001).

A further applicant to fill a slot among the five pilot airports is Brown Field Airport in California, located about 25 miles south of San Diego. The airport had formerly been a World War II training site and handles a small amount of general aviation air traffic (Schwarz, 2000). Under the pilot privatization program, Brown Airfield is supposed to be developed into a world-class cargo port named San Diego Air Commerce Center (SANDACC). SANDACC, together with a local developer and the Diversified Asset Management Group (DAMG), which was founded in

1994, will focus on worldwide airport investment opportunities. Over a 10-year horizon, New York-based DAMG plans to invest $1 billion into the project. According to estimates of the company, the all cargo airport is supposed to employ nearly 12,000 people and generate more than $750 million in economic benefits to the San Diego area (Gersten, 1999). In a memorandum of understanding with the City of San Diego, members of the Brown Field Aviation Park project team (such as DAMG) agreed to operate the airport under a 50-year lease contract with full payments due upon the sale of bonds to finance the project (World Trade, 1999).

The fourth airport to apply for privatization under the pilot program is Rafael Hernandez Airport in Puerto Rico. A preliminary application was filed on December 20, 1999 (Airport Privatization, 2000). The Puerto Rico Port Authority has recently selected a team including Frankfurt Airport, Raytheon, and a local firm to win the bid for a long-term lease agreement. FAA approval is still pending and expected to be granted by the end of the year (Poole, 2000b).

New Orleans Lakefront Airport captured the last of the five available slots to apply for participation in the FAA Pilot Privatization Program. About 93 percent of the air traffic at Lakefront Airport is general aviation, yet the facility is also able to accommodate aircraft up to a size of a Boeing 757. The privatization effort was initiated in February 2000 as the Orleans Levee Board, owner and operator of the airport, retained the services of Infrastructure Management Group (IMG) to manage the privatization process. For 2001, the airport expects to face a current deficit of $340,000 and operating costs exceeding two million dollars. By privatizing the airport, the board hopes to turn the airport into profitability (Stuart, 2001). Currently, the proposals of two companies—TBI Airport Management and American Airports Corporation—have been under review by the FAA. TBIs parent company (TBI PLC) acquired Airport Group International in 1999 and operates airports in various countries. American Airport Corporation, a subsidiary of American Golf Corporation, manages and operates several general aviation airports in the U.S. The lease contract would run for 50 years and is assumed to generate revenues of between $3 million and $10 million over the first 10 years.

DATA AND METHODOLOGY

We compiled detailed information on fifteen airports, both public and private, published in several different reports. These specific airports were chosen based upon their similarity in hub size. Financial data for BAA airports are obtained from the financial report published by the airport. These particular airports were chosen because they reflect the most prominent privatized airports in England. They are Heathrow (LHR), Gatwick (LGW), Stanstead (STN), Glasgow (GLA), Edinburgh (EDI), Aberdeen (ABZ) and Southampton (SOU). Similar data for the U.S. was

taken from the Compliance Activity Tracking System (CATS), which are provided by the FAA. These particular airports were chosen because they represent the top eight of the top thirty largest airports in the U.S. They are Atlanta Hartsfield (ATL), Chicago O'Hare International (ORD), Dallas/Fort Worth International (DFW), Denver International (DEN), Detroit Metro Wayne (DTW), Los Angeles International (LAX), Newark International (EWR) and San Francisco International (SFO).

In addition, operational data for BAA are provided by Civil Aviation Authority (CAA) of the United Kingdom and data for the U.S. were obtained from the Aviation and Aerospace Almanac of the corresponding year. Financial data include operating costs, profits, and revenues. Operational data consists of a number of annual movements and passenger and cargo statistics. Data used in this analysis include: airport gates (G; American Association of Airport Executives, 1994-2000), number of annual enplaned passengers (PAX), Purchase price of airport (PP), purchase price per enplaned passenger per year (PPAX), runway capacity (RWY; AirNav, 2002). The results of assessing airport operations are an important benchmarking tool, which can be applied for many different purposes such as external and internal comparison and airport valuation modeling.

There are several methods for measuring airport performance; however, four common methods are ratio analysis, regression analysis, data envelopment analysis (DEA) and total factor productivity (TFP). The empirical study for this research is based on the first two.

Ratio Analysis

This technique is one of the first mechanisms that can be used in the airport industry for measuring airport performance.

Regression Analysis

This approach basically measures the relationship between several exogenous variables and their impacts on airport productivity, efficiency, and profitability. One of the problems associated with regression analysis is that several factors, such as capital assets, are hard to measure.

Data Envelopment Analysis (DEA)

An alternative method available for situations in which outputs are not easily defined is the DEA. This procedure applies linear programming in which multiple inputs and multiple outputs are converted into a scalar measure of relative productive efficiency. In a DEA analysis we assume there are a finite number of airports to be evaluated. In the production process, an airport uses several different inputs to produce its outputs (Martine & Roman, 2001). Additional advantages of DEA are its ability to benchmark members of the efficient set used to effect these evaluations and

identify these sources of inefficiency, and its ability to identify sources of inefficiency in each input and output (Cooper, Seiford & Tone, 2002).

Total Factor Productivity (TFP)

This method measures productivity of all inputs involved in the production process, which allows for measuring cost-efficiency and cost-effectiveness (difference being in the selection of the measure of output). It is also possible to examine economies of scale and density as well as investigate the impact of variations of input and output prices on an airport's performance (Gillen & Lall, 1997). TFP allows us to distinguish productivity differences in airports that arise from economies of scale as opposed to those differences resulting from managerial performance.

EMPIRICAL RESULTS

The achievement of efficiency depends on the framework of competition and regulation in which the privatized airport operates. Privatization enhances economic efficiency if it sharpens corporate incentive to cut costs and improve productivity (Vasigh & Haririan, 1996). This research investigates if there is any superiority of private ownership over public airports.

The purpose of this study is to compare efficiency of privatized and government owned airports. The British airports, owned by BAA, are used as a sample of the privatized airports. The sample includes three London airports: LHR, LGW, and STN, as well as GLA, EDI, ABZ, and SOU. The sample of the non-privatized airports consist of the U.S. airports ATL, ORD, DFW, DEN, DTW, LAX, EWR, and SFO. The sample airports are compared in two areas of efficiency—operating and financial. Some of the limitations of this comparison are economics of scope, pricing strategy, framework of regulation, and business objectives which all vary considerably among private and state-owned airports. Monopoly power could create economies or diseconomies of scope (Bailey & Friedlaen, 1982).

Operating efficiency is assessed with ratios that reflect combinations of inputs and outputs. The number of gates and the area of runways (in square meters) at each airport are used as measures of input. The number of gates for the BAA airports was estimated using the number of aircraft stands in each airport. Number of passenger throughput and number of the aircraft movements are used as measures of output. Operating efficiency ratios, that is, passengers per gate, passengers per runway area, movements per gate and movements per runway area, are presented in Table 1. Table 1 presents the means of the ratios for all airports in each sampleprivatized and non-privatized. The last column provides t-statistics of the difference. Mean ratios for two types of ownership are tested to see whether there is any difference in operating efficiency. In this comparison t-test is used. T-

statistics of the difference for the means with critical value are compared at 98 percent confidence interval. For all ratios in question, except passengers per gate, there is a statistically significant difference in ratios for government and privately owned airports. Hence, government owned airports had better operating efficiency in passengers per runway area (see Figure 3), movements per gate, and movements per runway (see Figure 2).

Financial efficiency is studied through the comparison of the mean ratios of revenue per gate, revenue per runway (figure 4), cost per runway (figure 6), and cost per gate. This comparison is for two independent and unrelated samples of state owned enterprise airports and private ones. The t-statistics for the first three ratios suggest that there is a statistically significant difference between two types of enterprises at the 98 percent confidence interval. For these three ratios, public enterprises had better financial efficiency than their private counterparts (see Table 2).

Another method to assess efficiency used in the research is the multivariable regression. There are four regression functions derivedone for operational and three for financial efficiency. The operations efficiency function considers passengers per runway ratio as a dependent variable and operational revenue, cost and ownership as independent variables. Ownership is a dummy variable, which indicates if the airport is private or state owned. The first financial efficiency function uses a revenue/cost ratio (see Figure 1) as the dependent variable. Number of passengers, aircraft movements (operations), gates, area of runways, and ownership are used as independent variables. The second function for financial efficiency includes revenue per passenger ratio (see Figure 5) as a dependent variable and number of aircraft movements, gates, runways, and ownership as independent variables. In the third financial efficiency function, cost per runway is the dependent variable, and operating revenue, number of passengers, and ownership are independent variables. For privatized airports, cost per runway is lower than that for public airports. The number of passengers per runway is also higher for public airports as compared to privatized airports (based on our samples). The results of the multivariable regression are shown in Table 3. The last column provides adjusted R^2.

Table 1. Univariate Test of Operational Efficiency of Government versus Private Airports

Ratio	Government Owned Airports	Privately Owned Airports	T-Statistics of Difference
Number of annual enplaned passengers/ Airport Gates	218,869	163,776	-1.68
Number of annual enplaned passengers/Runway Capacity	36.22	16.88	-3.39
Movements/Gate	6,053	3,538	-75.91
Movements/Runway	0.985976057	0.254008829	-6.95

Table 2. Univariate Test of Financial Efficiency of Government versus Private Airports

Ratio	Government Owned Airports	Privately Owned Airports	T-Statistics of Difference
Revenue/Gate	2,955,101	2,006,063	-3.60
Revenue/Runway	462	189	-11.30
Cost/Gate	1,473,646	1,242,548	-1.51
Cost/Runway	233	117	-5.74

	1996	1997	1998
US	3.08	3.70	3.83
UK	1.39	1.40	1.50

Figure 1: Revenue-Cost Ratios: U.S. , U.K. Airports Comparison

	1996	1997	1998
US	0.97	0.99	1.00
UK	0.21	0.22	0.23

Figure 2: Landing per Runway: U.S. , U.K. Airports Comparison
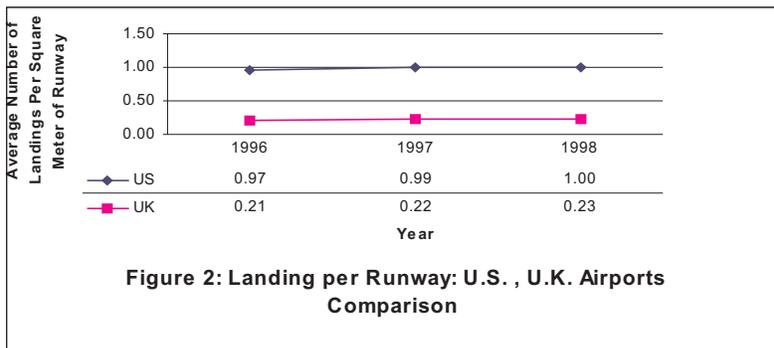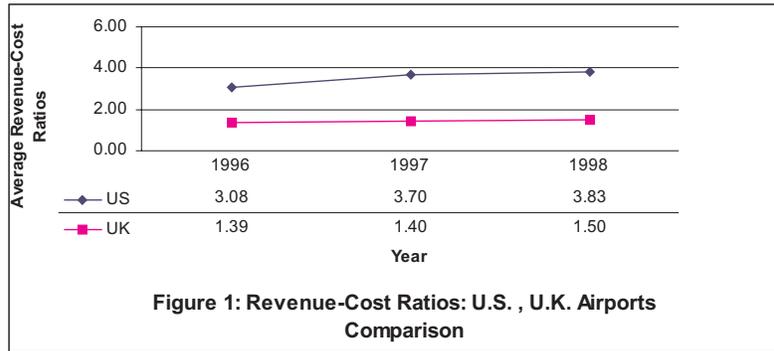
Table 3. Multivariable Regression of Government versus Private Airports

Dependent Variable	Independent Variables								Adjusted R^2
	Intercept	Passengers	Operations	Gates	Runways	Ownership*	Revenue	Cost	
Revenue/Cost	3.50	4.09^*10^{-8}	-2.73^*10^{-6}	0.0025^{**}	-1.40^*10^{-6}	-1.40	-	-	0.21
Revenue/Passengers	27.81	-	-2.82^*10^{-5}	0.070	3.43^*10^{-6**}	-14.06	-	-	0.34
Passenger/Runway	24.07	-	-	-	-	-13.88	-3.49^*10^{-9**}	6.97^*10^{-8}	0.32
Cost/Runway	22.12	1.60^*10^{-6}	-	-	-	-17.48	-7.27^*10^{-8}	-	0.71

*Dummy Variable (1 = Private, 0 = State owned) **Independent variable has t-statistics below 1.7

Avg. number of Passengers per Square Meter of Runway	1996	1997	1998
US	34.94	36.53	37.94
UK	13.31	14.35	15.55

Figure 3: Passenger per Runway: U.S. , U.K. Airports Comparison

Average Revenue Per Landing	1996	1997	1998
US	529.33	529.69	585.94
UK	1162.28	1198.57	1094.63

Figure 4: Revenue Per Landing: U.S. , U.K. Airports Comparison

Average Revenue Per Passenger	1996	1997	1998
US	15.18	14.75	15.50
UK	20.65	19.84	16.40

Figure 5: Revenue Per Passenger: U.S. , U.K. Airports Comparison

CONCLUSION

Our study demonstrates that cost per landing and cost per passengers of BAA airports are higher than the sample of U.S. airports. The empirical results regarding operational efficiency reflect the statistically different ratios for government versus privatized airports. Countries that have privatized airports generally impose some form of price regulation or landing fees. The UK has allowed a form of market-based pricing by permitting airports to charge airlines higher landing fees during peak traffic times. Hence, privatization is not successful for insuring that citizens get the services they require from government at lower cost. Revenue per passenger and revenue per landing for privatized airports of UK is higher than the sample of non-privatized airports. The Reason Foundation, a privatization advocate, points to labor productivity growth at airports in the UK as evidence of private airports ability to operate more efficiently. However, private airports' monopoly power could also be a source of increase in revenue and profit. Profitability is the result of the relationship between the regulatory controls, choice of market to serve, market power, and productivity.

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APPENDIX

Table A1. Airport Privatization Transactions Anticipated in 2001

Airport	Purchaser	Percentage	Date
Amsterdam Schipol Airport	Public Flotation	75.8%	Oct 2001
Frankfurt Airport (Fraport AG)	Public Flotation	Pending	Mid 2001
Airport Authority of Thailand	Pending	Pending	End 2001

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Table A2. Private Involvement in Airport Management

Contract Type Company	Management Contract	Lease Contract/Ownership
Lockheed Air Terminal/ Airport Group International/ TBI Plc.[1]	Albany, NY Burbank, CA Atlanta (International Concourse) Toronto (Terminal 3) (Canada)	Belfast (Ireland) Cardiff (UK) Stockholm-Skavsta (Sweden) Orlando Sanford (USA) Santa Cruz (Bolivia) Cochabamba (Bolivia) La Paz (Bolivia) **Minority Holdings:** Perth (Australia) 16% Northern Territory 20% Hobart 30% London-Luton (25%)
American Port Services[2]	White Plains/Westchester, NY Branson Airport, MI Republic, NY Tweed New Haven Regional, CN Teterboro, NJ Atlantic City, NJ	
National Express[3]		Stewart Intl., NY East Midlands Airport (UK) Bournemouth (UK)
	Indianapolis Intl., IN	London Heathrow (UK)
BAA, Plc.[4]	Harrisburg, PA Mauritius, Partly (retail/catering) Boston Logan, MA Newark NJ Pittsburgh, PA (also consulting)5	London Gatwick (UK) Stanstead (UK) Glasgow (UK) Edinburgh (UK) Aberdeen (UK) South Hampton (UK) Melbourne (Australia) Launceston Airport (Australia) (as part of the APAC consortium, 15.1% share). Naples, Italy

Table A3. Airport Privatization Transactions, Cost and Activities (1997-2001)

Country	Airport	Purchaser	Percentage Purchased	Sales Date	Number of annual enplaned passengers (in millions)	Purchase Price (million US$)
Australia	Adelaide	Manchester	100	March 1998	1.8	238
	Brisbane	Schipol	100	July 1997	5.1	1,100
	Canberra	Local Consortium	100	March 1998	0.9	44
	Coolangata	Manchester	100	March 1998	1.0	70
	Hobart	AGI (TGI PLC)	100	March 1998	0.5	24
	Launceston	BAA	100	March 1998	0.3	11
	Melbourne	BAA	100	July 1997	6.7	1,100
	Perth	AGI (TGI PLC)	100	Juy 1997	2.2	495
Argentina[6]		Ogden/SEA Milan	100	February 1998	7.8	1,400
Bolivia[7]	La Paz	AGI (TGI PLC)	N/A	March 1997	1.2	N/A
	Santa Cruz					
	Cochabamba					
Germany	Dusseldorf	Hochteif/ Aer Rianta	50	January 1998	7.5	208
	Hamburg International	Hochteif/ Aer Rianta	36	October 2000	9.5	256
Greece[8]	Athens Intl. Airport S.A.	Hochteif/ Aer R. /Fraport	45	March 2001	N/A	1,833
Italy	Naples	BAA	70	August 1997	1.5	32
	Rome	Public Flotation	45	July 1997	11.9	344
Mexico[9]		Copenhagen	15	November 1998	4.7	116
Malaysia Airports Holdings[10]		Public Offering	28	November 1999	32.7	130
New Zealand	Auckland	Public Flotation	52	July 1998	3.4	232
	Wellington	Infratil	66	August 1998	1.6	49
Peru	Lima Jorge Chavez Intl.	Fraport/Bechtel/ Cosapi	43	February 2001	2.2	6.4
South Africa		Aeroporti di Roma	20	March 1998	8.1	165
UK	Birmingham	Aer Rianta	40	March 1997	2.7	58
USA[11]	Stewart International	National Express	100	September 2000	0.3	35

[1] TBI Plc. acquired Airport Group International (AGI) in September 1999 for a price of L190 million.

[2] In March 1997, American Port Services (APS) bought the majority of Johnson Controls airport and fleet maintenance. In 1998, Associated British Ports, Plc., purchased ASP.

[3] Information provided on company homepage (www.nationalexpressgroup.co.uk) as of Dec 6, 2000.

[4] Based on information publicly provided on BAA homepage (www.BAA.co.uk) as of December 6, 2000.

[5] BAA has been awarded a contract for Pittsburgh Airport, to review the current cargo business and international passenger routes and to develop strategic plans to maximize the full potential of the airport.

[6] 30-year concession for 33 airports. The purchase price is based upon the present value of guaranteed annual rent payments of $171.1 million.

[7] La Paz, Santa Cruz, and Cochabamba were offered for a 25-year concession with annual payments to be made. AGI bid 20.8% of gross revenues.

[8] 30 year concession under a BOT scheme.

[9] 50-year concession for nine airports in the southeast. (including Cancun).

[10] MAHB has a 30 year management contract for 36 of Malaysia's airports, as well as a 50-year lease agreement for Kuala Lumpur International Airport.

[11] 99-year lease contract under the FAA pilot privatization program.

WHO SOARS IN OPEN SKIES?
A REVIEW OF THE IMPACTS OF ANTI-TRUST IMMUNITY, AND INTERNATIONAL MARKET DEREGULATION ON GLOBAL ALLIANCES, CONSUMERS, AND POLICY MAKERS

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ABSTRACT

The past decade has seen a proliferation of global airline alliances. A significant shift in two government economic policies, international market deregulation (open skies) and the granting of anti-trust immunity to alliances has made these unions a reality. These policy shifts have affected the tripartite relationship between government, airlines, and consumers. This article reviews the analysis by the U.S. Department of Transportation (2000a), Brueckner (2001) and Oum (2001), and builds a link between open skies policy and findings of lower fares, higher revenues, higher profits, and service improvements. The article suggests that U.S. policy makers advanced the open skies agenda through foreign coalition building and multilateral agreements.

INTRODUCTION

The intersection of public policy and business is, arguably, nowhere greater than in international air transport. Since the late 1970s, it has been U.S. Department of Transportation (DOT) policy to pursue increasingly liberal agreements with foreign aviation partners. Such agreements are typified by open skies accords, which allow for the economically liberalized transport of passengers and cargo between the U.S., its partner countries and beyond. These agreements extricate traditional restrictions on frequency, capacity and gateways for airlines of the participating nations. The U.S. has signed 56 such agreements, constituting more than half of all U.S. bilateral aviation agreements (DOT, 2001). In the DOT's 1995 *Statement of United States International Air Transportation Policy* the commitment to open skies was reiterated and international alliances

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were endorsed as a means to achieve the goal of expanded international aviation. The DOT's Office of Aviation and International Affairs has recognized that modern airlines require "…a higher quality and quantity of supporting route authority than they have sought in the past" (DOT, 1995). The past decade has seen a proliferation of global airline alliances, largely motivated by increasing demand for worldwide service (GAO, 1995). Alliances take a variety of forms. The most common are isolated codeshare agreements and broad-based strategic alliances. The former have existed for many years and involve the creation of *on-line travel* by partner airlines selling a single ticket over a route where both airlines' aircraft are used. Each airline sets it own fares and, depending on the institutional arrangement, the carriers may share costs. Broad-based strategic alliances have experienced a recent surge in popularity. These alliances offer on-line service from and to many or all of their member airlines' destinations. For the carriers involved, these relationships may include schedule planning, revenue and cost sharing, and joint marketing efforts. The schedule and fare planning features of strategic alliances are available only to those alliances that receive immunity from antitrust laws. This immunity is granted by the DOT.

A convergence of two DOT policies, international market deregulation and the granting of antitrust immunity to strategic alliances, has made these unions a reality. The first section of this document provides a historical context for current policy. The second section provides an explanation of why airlines have formed alliances. Assessments of the impact of policy on airlines, consumers and public policy are offered in the third, fourth and fifth sections.

The implications of current trends on these constituents are important to understanding the holistic impact of current policy. For consumers, improved service and lower fares are of top priority. Shareholders covet improved earnings and higher share prices. U.S. public policy makers are committed to fostering a competitive marketplace where consumers receive good value and business thrives.

THE HISTORY OF INTERNATIONAL AIR TRANSPORTATION REGULATION

Introduction

Not long after the Wright brothers took flight in 1903, it became apparent that the world community would need parameters to guide this new mode of transport. The first multinational meeting on international air transport regulation convened under the aegis of French government in Paris in 1910. Scheduled international service between Paris and London commenced in 1919, and it became increasingly apparent that government

regulation of international air transport would be a complex mix of foreign and economic policies.

Chicago: Open Skies Round One and the Agreements

The interceding two decades saw significant advances in aviation technology and production. These developments made aviation an increasingly relevant component of foreign and economic relations. On November 1, 1944, representatives of 53 allied or neutral states gathered in Chicago to explore, as the U.S. government described it, "The principle to be followed in setting up a permanent international aeronautical body and a multilateral convention dealing with the field of air transport, air navigation, and aviation technical subjects." (De Murias, 1989, p. 45)

The U.S. called for the adoption of multilateral open skies. Free competition in civil international air transport was to be the hallmark of such an agreement. The chief American representative, Adolf Berle, called for what he coined an *open sky* charter (Sochor, 1991). Berle feared that any quota or limitations on civil aviation would lead to cartels that could oppress the rights of passengers and shippers to purchase service in a competitive marketplace.

Most nations believed Berle's proposal would allow Americans to command international aviation because of their dominant position. In response to this criticism, Berle offered to supply thousands of surplus warplanes to nations struggling to develop civil aviation (De Murias, 1989). *The Times* newspaper of London accused Berle and the U.S. of using a big stick in an effort to force acceptance of its position.

The Rise and Fall of the International Air Transport Association

Nine months after the close of the Chicago Convention, an act of Canadian Parliament incorporated the International Air Transport Association (IATA). The Association existed as a unique trade association in that it was established and supported by governments to accomplish a task, which under bilateral agreements was the function of governments. Taneja (1988) cites three reasons why the U.S. initially approved of IATA's activities. Since the U.S. had minimal power to establish international rates, it would not be in that country's interests to have foreign nations unilaterally establish rates for U.S. carriers. The organization offered a high degree of transparency and the right of refusal, so it could not be deemed a price fixing cartel. Finally, it allowed European carriers to keep fares at a level that guaranteed the development of their flag carriers.

In 1955, IATA received permanent antitrust immunity from the U.S. government. Throughout the 1960s and 1970s the organization authority continued to be recognized by a variety of foreign governments and commissions. On June 9, 1978, as domestic deregulation was taking hold,

the Civil Aeronautics Board (CAB) issued a show cause order as to why IATA should continue to receive antitrust immunity. As a result of the order immunity was continued for tariff coordination and conferences, but under a set of significantly more liberal conditions. At this point IATA was reorganized into a tiered organization, one tier acting as a trade association, the other tier in charge of tariff coordination. As explained later in this article, tariff coordination has played a significantly smaller role in the organization over the past two decades.

Postwar Bilateral Agreements and the American Upper Hand

In 1946, the U.S. and U.K met in Bermuda to sign a bilateral aviation agreement. The gravity of the Bermuda Agreement, as it was known, was not to be underestimated, for it served as the model for all other bilateral agreements until its renegotiation in 1976. The Bermuda Agreement's provisions specifically outlined which routes and cities airlines could operate over and between. The British favored fare and tariff determination by nations, but as a conciliation to the Americans, the British allowed for the determination of fares and tariffs by IATA and to allow carriers to determine the frequency and capacity of their flights. The Bermuda Agreement also granted fifth freedom rights to both nations, allowing them to carry passengers from the U.K. or the U.S. to a third nation.

Bermuda II and Open Skies Round Two

In 1976, Great Britain announced the termination of the Bermuda Agreement. Britain's primary objection to the agreement was that U.S. carriers were able to transport a disproportionate share of traffic across the North Atlantic. The possibility of U.S.-U.K. routes being paralyzed pressured the U.S. to adopt the Bermuda II Agreement in 1977. Under Bermuda II, multiple carrier designations were virtually eliminated, capacity controls were put in place, and U.S. fifth freedom rights were sacrificed.

The Carter administration, frustrated by Bermuda II and commencing deregulation of the domestic market, returned to Berle's goal of an open skies policy. In early 1978, the DOT released "Policy for the Conduct of International Air Transport." The document was all but a renunciation of Bermuda II, declaring, "[America will seek] trade competitive opportunities, rather than restrictions and pursue our interest in expanded air transportation and reduced prices" (Toh, 1998). By the middle of the year CAB took the provocative step of issuing a show cause order to IATA. The order required IATA to defend the premise that its structure of international tariffs remained in the public interest and should continue to receive antitrust immunity. Congress passed and Carter signed the

International Air Transportation Competition Act (IATCA) the following year (Public Law 96-192).

The act was a far-reaching policy declaration. As shown in the *Goals for International Aviation Policy* section, the act calls for a "negotiating policy which emphasizes the greatest degree of competition that is compatible with a well-functioning international air transport system" (Public Law 96-192[s>1300], 1979). The act goes on specifically to direct the State and Transportation Departments to negotiate agreements and consult to the *maximum extent practicable* with the Commerce and Defense departments, as well as all other key players in the formulation of both broad policy goals and individual negotiations.

The Carter Administration witnessed limited reform during its single term. In 1977, when Carter took office, Pan Am and TWA were the only U.S. airlines to operate transatlantic service. Upon its departure in January 1981, Delta and Northwest had initiated passenger service on the North Atlantic route.

CURRENT REGULATION AND IMPLEMENTATION OF ANTITRUST IMMUNITY

The Open Skies Era: Open Skies Round Three

Since 1980, the DOT has aggressively pursued open skies agreements. The first such agreement was with the Netherlands in 1992. Today, the U.S. is engaged in 56 bilateral open skies agreements. At the 2000 Asia-Pacific Economic Cooperation (APEC) summit a one-of-a-kind multilateral open skies accord was signed by the U.S., Chile, Singapore, New Zealand, and Brunei (Office of the Press Secretary, 2000). Not all negotiations have met open skies objectives. Negotiations with the U.S.'s largest international aviation partner, the U.K., have failed to bring about open skies, as have negotiations with the largest Pacific partner, Japan. Other major trading partners with which the DOT has yet to reach open skies accords include China, Australia, Brazil, and Russia. DOT takes a carrot-and-stick approach to encouraging agreement. Incentives (carrots) are offered to countries willing to sign open skies agreements, particularly antitrust immunity of international alliances. At the same time, as a punishment (sticks), antitrust immunity for international alliances has been conditional on the signing of an open skies agreement. In the case of the Northwest/KLM Royal Dutch Airlines (NW/KLM) alliance, open skies originated prior to the development of the alliance. The 1996 agreement with Germany made clear to German authorities that if Lufthansa desired antitrust immunity for its existing alliance with United, an open skies accord was a prerequisite. Grants of antitrust immunity are phenomenally valuable to carriers, because it is not only a guarantee an absence of

government interference, but immunity also prevents private antitrust actions.

The Granting of Antitrust Immunity

Immunity is not granted simply for abiding by antitrust laws. To pursue and maintain the public interest, immunity is approved only after a competitive analysis is conducted and caveats to the immunity are prescribed.

Approval is granted based on an alliance's enhancing or negligible effect on competition and public benefits it could provide. To determine public benefits, the DOT performs an analysis of a proposed alliance's competitive effect. For instance, the competitive analysis of a proposed 1999 alliance between NW and Malaysian Airlines (MH) examined three markets: a) U.S., b) Far East-U.S. city pairs and c) Malaysia and direct U.S-Malaysia city pairs. The proposed alliance was not found to diminish competition in the U.S.-Far East market. The proposed alliance would control about a 19% market share, 4% less than the STAR Alliance's[1] share of this market (DOT, 2000b). The alliance partners are currently the only airlines of each nation to serve the U.S.-Malaysia market; despite this, the DOT found that their alliance would not enable either partner to engage in supra-competitive pricing. Since neither carrier provides non-stop service, it was felt that third-country airlines offering on-line connections would provide sufficient competition. The DOT is required by law to determine the effect on the public interest of all coordination agreements. The DOT perceives the public interest to promote open skies agreements and greater competition.

The most significant restrictions require that both carriers withdraw from any IATA tariff conference activities that affect or discuss any proposed through fares, rates or charges applicable between the U.S. and any country designating a carrier that has been or is subsequently granted antitrust immunity to participate in similar alliances (DOT, 2000b). This means a foreign carrier can no longer (if it already does) participate in IATA pricing agreements between the U.S. and any international points. The requirement is mandated to assure that the competition immunity it is expected to create is not undermined by price coordination. This policy serves to further weaken IATA's rate and tariff role worldwide.

An examination of airline competition studies ownership interests in computer reservations systems (CRS). When an alliance agreement includes carriers that own shares in competing CRS, immunity is not afforded to this sphere of marketing, as it is likely to reduce competition. Consistent with other immunity agreements, foreign carriers are required to provide extensive origin and destination (O/D) data for all passenger itineraries that contain a U.S. point on an ongoing basis. U.S. carriers

already provide this data to DOT; all O/D information is treated in confidence by DOT. This information allows department officials to track the effects of alliances on market share and competition.

EVOLUTION OF ALLIANCES

As a mature industry with heavy capital investments and slim profit margins, both the domestic and international airline industries are ripe for consolidation. The spate of mergers, acquisitions and bankruptcies that followed domestic deregulation has evolved into a period of rationalization where the remaining large U.S. carriers have sought to strengthen their position by attempting to acquire (in full or part) competing firms, the most recent being the ill-fated United-US Airways partnership and the purchase of TWA by American Airlines. However, with regulators reluctant to approve mergers or acquisitions among domestic carriers, alliances have proven an attractive alternative for carriers like Continental, Northwest and America West. The alliances allow the carriers to please customers, satisfy stockholders and keep government regulators at bay.

Internationally, the airline industry is perhaps the only global industry to remain with exclusively national companies. Regulators do not even have the option to approve international mergers, because national ownership requirements prevent foreigners or foreign corporations from owning airlines based in another country. Current U.S. law is typical of most industrialized nations, limiting foreign ownership of airlines to a 25% stake. The tremendous international consolidation of pharmaceutical, telecommunication and maritime firms could serve as a model for airlines in the absence of such ownership requirements. However, since the removal of such restrictions is unlikely, airlines opt for alliances as a means of partially realizing the potential mergers offer.

The attraction for major U.S. airlines to enter such relationships is to access markets they could not afford to serve alone. Motivated by increasing international tourism and the globalization of business, the principle growth opportunity for U.S. airlines is in the international sector. Total passenger traffic between the U.S. and foreign destinations increased by 248% from 1980 through 2000; and from 39.5 million in 1980 to 137.3 million in 2000. IATA predicts 226 million passengers will fly in 2010.

U.S. airlines have enjoyed a growing share of the international market. In 1980, U.S. carriers carried 49% of the traffic between the U.S. and foreign destinations; by 1993 the figure had grown to 53%. Since 1993 the percentage of passengers carried by U.S. carriers has decreased slightly to 51%, likely precipitated by the carriage of passengers on codeshare flights. In the year 2000, only 8 of the top 50 U.S.-foreign markets experienced a reduction in passengers. Total growth in the top 50 markets was 7% from

1999 to 2000 (DOT, n.d.). Revenue share information is not available, but the U.S. share of revenues may actually be higher than the passenger carried share. It is important to note that domestic market growth pales in comparison to the growth possibilities in the international sector. The major U.S. carriers have aggressively pursued these international opportunities by founding alliance networks. Generally, such alliances do not create overlap and simply serve to extend a carrier's reach without negatively affecting competition.

Types of Alliances

The international alliance movement has evolved in the past decade to more than codesharing on a few flights with limited airlines to broad-based strategic alliances. Codesharing simply allows partner airlines to list flights operated by the other as its own. Strategic alliances allow partners to maximize their geographic scope, level of operating and marketing integration, and revenues. The first strategic global alliance was between NW and KLM . This broad-based alliance involved the full integration of each carrier's networks, market planning/pricing, promotion, administrative activities and other activities. The alliance touches such a variety of corporate functions that some industry experts have labeled it a de facto merger. For instance, KLM no longer has reservation offices in the U.S.; all reservation services are handled by NW, and vice versa in Europe. Oum (2001) finds that strategic alliances led to productivity gains on the average of 5%. The carriers almost immediately saw the fruits of their arrangement. In the first three years of their agreement, they experienced a 3.5% point jump in market share from 7.0% to 11.5% (GAO, 1995). By 1999, their market share of Atlantic flights has decreased to 9.0%; however, with their newest partners Alitalia and Continental, they control approximately 17.0% of the market. The increase in market share led to significant increases in revenues for both carriers, $100 million for KLM and between $125 and $175 million for NW (GAO, 1995). The revenue sharing formula is based on an agreed prorated formula accounting for the miles each airline flies on alliance routes. The alliance's effect on profits is unclear; that said, Oum found that strategic alliances improved partner airlines profitability by 1.4%.

Since the creation of the NW/KLM alliance, others have followed suit. Today, the top three U.S. carriers—United, Delta, and American—are all involved in global strategic alliances. In 1997, United was a founding member of the world's largest airline alliance, the STAR alliance. The OneWorld alliance was founded in 1998, with American Airlines as a charter member. Delta left the Atlantic Excellence alliance with Swiss Air and Sabena in early 1999 to create a global alliance called SkyTeam with Air France, Korean Air, and Aeromexico later that same year. These three

carriers have taken a relatively uniform approach to alliance development, with each alliance being founded by an American, European and Asian carrier. Each has grown since it founding and summary statistics for each carrier are shown in table 1.

Table 1. 1999 Major Alliance Statistics

Alliance	Launch Date	# of Members	Passengers (ml)	Group Revenues (bn)	Global Market Share (pax)
Wings	1989	2	71.6	$16.8	4.6%
STAR	1997	13	292.7	$69.6	18.8%
oneworld	1998	8	199.3	$50.0	12.8%
SkyTeam	1999	4	175	$5.4	11.2%

Source: O'Toole, Kevin. (2000, July) The Global Groupings. *Airline Business*. 50-51

A Non-Global Approach

For carriers not participating in strategic alliances, there are a number of alliance alternatives. After the demise of its equity alliance with British Airways, US Airways has chosen a regional alliance approach. Essentially, US Airways applies the commuter model to its international service. The carrier operates all transatlantic service on its own aircraft and connects to Deutche BA flights in Frankfurt and Munich. These Deutche BA flights serve regional centers in Germany on behalf of US Airways.

TWA adopted a hybrid approach in its alliances with Royal Jordanian and Kuwait Airways, offering service across the Atlantic to Amsterdam, Amman and Kuwait City with onward connections to regional business and cultural centers. TWA was traditionally the leading U.S. carrier to the Middle East and these alliances affirmed their position in the region.

Alliance Membership: A Means to an End

Alliances serve as a strategic means to achieve increased profitability (Oum & Yu, 1998). The dynamic nature of international air transportation means that in the absence of significant equity sharing membership may shift as fluidly as contracts allow. The 1990s were a period of frequent formation and dilution of alliances. This trend appears to have moderated with the turn of the millennium, but the growing pressure of a slowing global economy may spur a close examination of the bottom line benefits of alliances. With the understanding established in this section, the effects of alliance membership are discussed in the following sections. A detailed examination and summary of current research on the effects on consumers

immediately follows this section. Finally, a discussion of implications for public policy is presented.

THE EFFECT ON CONSUMERS

The proliferation of immunized alliances and expansion of open skies agreements has important implications for consumers. The implications are best divided into two categories: service and fares. Service considers markets offered (city pairs), flight frequency and the host of difficult-to-quantify conveniences that alliances provide. Fares are understood in the simpler context of changes in fares as a result of these trends.

Literature Review

In June 2000 (revised March 2001), University of Illinois professor Jan K. Brueckner published an assessment focusing on the effect codesharing, alliance formation and antitrust immunity has on fares. The assessment was titled "International Airfares in the Age of Alliances: The Effects of Codesharing and Antitrust Immunity." Brueckner's report used DOT data to show successively increasing decreases in fares with implementation of codesharing, alliance creation and antitrust immunity. A report by the DOT's Office of Aviation and International affairs, issued in October 2000, takes a more holistic look at the effect of alliances and open skies agreements on U.S.-European travel. The report found significant improvements in service and reductions in fares.

Among other formal assessments are three published by the DOT (1995, 2000b, 2001), one by the U.S. General Accounting Office (1995) , a half dozen or so academic articles, and a Canadian Transport Act Review report by Oum (2001) that summarizes the results of an extensive econometric study performed in 1999. The reports issued by DOT concern the Canadian open skies agreement and developments in the transatlantic market. All of the DOT reports praise the advances made in open skies agreements and antitrust immunity and find benefits for industry and consumers. The GAO report was released in 1995, and, though generally supportive, expresses concerns about the anticompetitive effects international alliances may have on the domestic industry. The academic articles approach the issue from a variety of economic and legal perspectives and, in general, are supportive of current trends.

Fares

Before a discussion of specific assessments, it is important to understand how international fares are constructed. The simplest fares are those on a single carrier; as discussed in the regulation section, in most circumstances the carrier is free to establish a fare it believes to be

economically viable. Fares for interline travel (travel involving multiple carriers) are heavily dependent on cooperation between the carriers. The level of cooperation is, of course, limited by antitrust laws. The traditional pricing structure relies on fares generated by IATA's fare conferences. The carriers meet under the auspices of IATA and establish interline fares for a multiplicity of international city-pairs. Total revenue is divided by the airlines providing the service on a distance-based prorate basis. With the decreasing importance and relevance of IATA's fare making authority, airlines have developed their own interline pricing scheme, called a *special prorate agreement*. The agreements have each carrier specify the revenue it requires to carry a passenger on its portion of the route; the ticketing carrier then charges the combined fare and divides the revenues accordingly. This arrangement serves as the foundation for most codesharing agreements. The final pricing option, cooperative pricing, is open exclusively to carriers that have been granted antitrust immunity. Cooperative pricing, as the name indicates, allows the carriers to share proprietary information and establish a joint fare for given city pairs. Alliances implementing cooperative pricing negotiate revenue and cost-sharing policies to meet the needs of the participating carriers.

Implications of Fare Structures

Each fare structure arrangement carries certain micro-economic implications; non-cooperative pricing does not maximize joint profit and leads to higher fares. By contrast, cooperative arrangements internalize negative externalities of a two-carrier trip and lead to lower fares (Brueckner, 2001). The IATA multilateral fare conference structure accentuates the diseconomies of the non-cooperative models. IATA unanimity rules allow each carrier a right of refusal on proposed fares, so fares are driven up to accommodate the costs of inefficient firms. The bilateral structure of special prorate agreements leads to fares lower than those formulated by IATA, but still possesses the negative externalities of non-cooperative arrangements. The establishment of joint fares, protected by immunity from antitrust prosecution, allows carriers to maximize joint profits, ultimately providing the lowest possible fare to consumers. While immunity arrangements could lead to collusive practices, they are granted because it is believed such activity will not occur.

Brueckner's Assessment

Brueckner's (2001) analysis concentrates on the effect codesharing and antitrust immunity have on international interline passenger fares. Utilizing DOT passenger O/T data, the paper discretely measures the effect of codesharing and antitrust immunity and then reconciles the effect when the policies are implemented in conjunction. The study's data is taken from the

third quarter of the 1999 Passenger Origin and Destination Survey. The survey represents a 10% sample of all airline tickets where at least one route segment is flown on a U.S. carrier. The data includes O/T airport, fares and number of passengers observed paying a given fare. Most importantly, the data shows both the ticketing and operating carrier, allowing for examination of codeshared operations. The original data set contained in excess of 750,000 records with at least one non-U.S. airport; however, after controlling for relevant data, the final analysis set contained 54,687 observations of itineraries in 17,518 city-pair markets. Brueckner studied a carrier variable, examining the 74 most frequently appearing carriers, the effect of alliances (using the four predominate alliances in 1999[2]) and the effect of immunity (among the carriers who enjoyed immunity in the third quarter of 1999[3]).

Findings. The study provides a number of interesting findings in regards to the behavior of alliance and immunized carriers. The percentage of codeshare operations among non-alliance, alliance, and alliance with immunity carriers is predictable. Only 23% of non-alliance itineraries involved codesharing. Codeshare itineraries for alliance carries without immunity were not substantially higher (28%). Immunized alliances carried the majority of their itineraries on codeshare operations (63%). The empirical fare findings are of particular interest to consumers. Brueckner finds that: a) fares are 8-17% lower on codeshare itineraries versus non-codeshare itineraries; b) fares are 13-21% lower on carriers with antitrust immunity versus those without; c) fares are 17-30% lower on immunized codeshare itineraries (codesharing and immunity are substitutes, in that the combined effect is less then the sum of the parts); and d) fares are 4% lower on alliance carriers versus non-alliance carriers.

Oum's Assessment

Oum (2001) analyzes the effect of alliances on productivity, price and profitability. He uses data from 1986 to 1995 from a panel of 22 international airlines. He does not delineate between immunized and non-immunized alliances and the data set draws largely on figures prior to widespread international deregulation of the industry. The econometric analysis distinguishes between strategic and tactical alliances. The differences in alliance scope drive three major findings:

1. Strategic alliances enable partner airlines to achieve an average of 5.0% gain in total factor productivity and 1.4% increase in profitability while being able to lower their prices to consumers an average of 5.5%.

2. Improved productivity during the post-alliance period is an important source of increased profitability for partner airlines as well as a means to enhancing a carrier' ability to reduce prices.

3. Tactical alliances do not have statistically significant effects on partner airlines' productivity, pricing or profitability.

The Open Skies Connection

Codesharing and antitrust immunity are the most significant reducers of international airline passengers' fares. Table 2 illustrates the connection between the existence of open skies agreements, the granting of antitrust immunity to alliances, and levels of codesharing between alliance carriers. The top six alliances in terms of itineraries traveled are all immunized and involve foreign carriers whose nations have signed open skies agreements with the U.S. Discounting the Continental-Alitalia and United-Ansett pairings, the top six alliances in terms of percentage of codeshare itineraries comprise the same characteristics as the alliances with corresponding volume data.

DOT's (2000a) study, "International Aviation Developments (Second Report): Transatlantic Deregulation: The Alliance Network Effect" confirms this connection. The study found fare reductions in excess of 20%

Table 2. Compiled by Author using DOT Data

Carriers	OSA Foreign Flag Nation	Immunity	#Intineraries	Codeshare Itin.
Northwest-KLM	Yes	Yes	7,671	60.3%
United-Lufthansa	Yes	Yes	4,771	37.7%
United-Air Canada	Yes	Yes	3,575	67.0%
American-Canadian	Yes	Yes	2,591	93.4%
Delta-Swissair	Yes	Yes	1,683	77.2%
Delta-Sabena	Yes	Yes	1,511	86.9%
American-British Air	NO	NO	1,412	0.0%
United-SAS	Yes	Yes	642	34.9%
American-Qantas	NO	NO	458	57.4%
United-Air New Zealand	Yes	NO	390	36.2%
Delta-Austrian	Yes	Yes	379	81.8%
Continental-Alitalia	NO	NO	369	74.0%
United-Ansett Australia	NO	NO	334	73.1%
United-Varig	NO	NO	253	28.5%
American-Cathay Pacific	NO	NO	203	0.0%
United-Thai	NO	NO	151	6.0%

between countries with which the U.S. shares open skies agreements. The most dramatic fare reductions are for service from interior U.S. points to airports beyond European hubs and from U.S. gateways to points beyond European hubs, 24% and 25%, respectively.
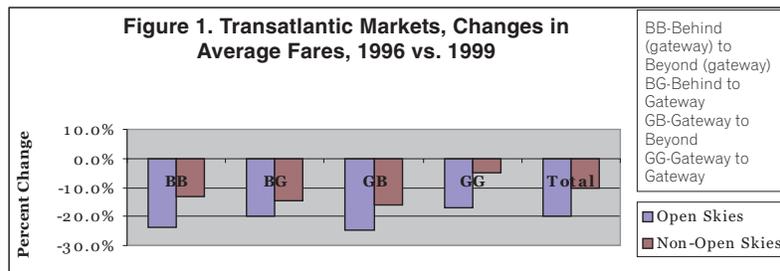
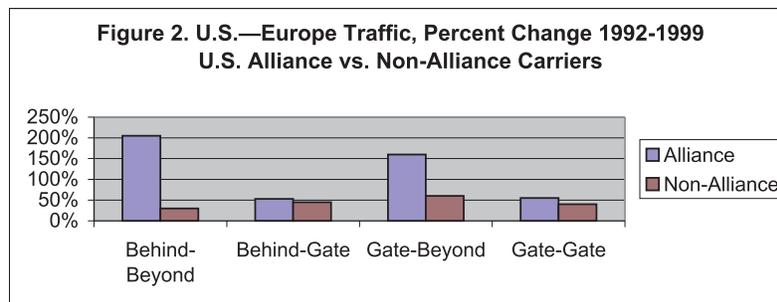Source: Reproduction of U.S. DOT Chart from International Aviation Developments.

Figure 1 demonstrates that open skies agreements have also affected nations not participating in the schemes, as open skies alliance traffic competes via hubs onto non-open skies states. As can be expected, the influence is least in the gateway-to-gateway market, as consumers are accustomed to non-stop service. Brueckner's (2001) findings combined with this information, present a strong case for the pursuit of open skies agreements and the granting of antitrust immunity to global alliances.

Service

DOT's report also illuminates the positive effects on service open skies agreements and international alliances are having in North-Atlantic travel (DOT, 2000a). The proliferation of open skies bilateral agreements with European partners has created a more service-competitive transatlantic structure. These agreements, in combination with grants of antitrust immunity to alliances, have provided carriers the operating flexibility necessary to improve and expand services. Improved services have included both coordinating schedules for connecting flights from behind and beyond points and an increase in capacity from gateway-to-gateway markets. This growth has not been limited to alliance carriers. The open skies agreements have allowed U.S. carriers, particularly Continental Airlines, to provide head-to-head competition to the larger alliance carriers. In the past five years, Continental has developed its Newark, New Jersey, hub to serve 17 European destinations, challenging alliance hubs in four European cities.
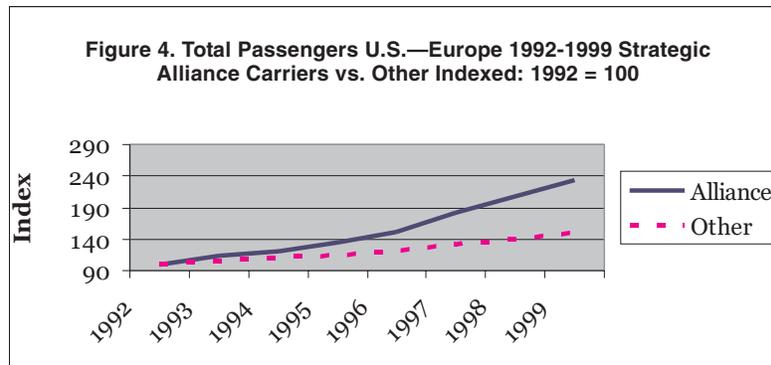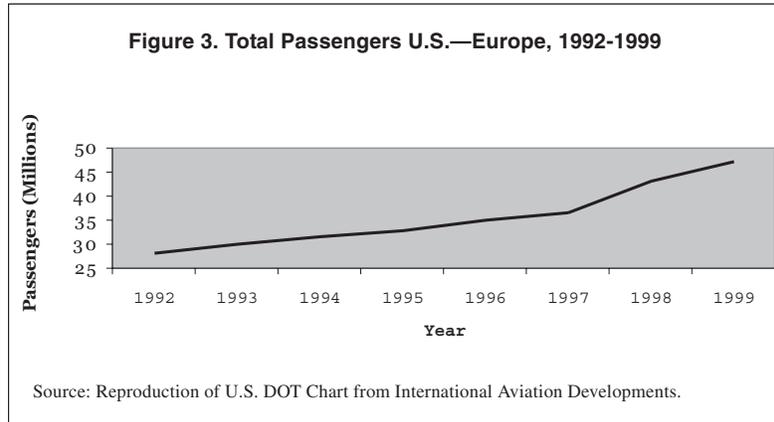
Case Study: The North-Atlantic Market

Passenger growth in the North-Atlantic market has been significant, nearly doubling between 1992 and 1999. In 1992, the U.S. signed its first open skies agreement with the Netherlands. Between 1992 and 1999, 15 agreements were signed with European trading partners (DOT, 2000a). While the strong economic conditions of the period undoubtedly claim some credit for passenger growth, the deregulated environment created by open skies and the increased frequencies provided by alliance carriers are primarily responsible for the growth. The good economy fails to explain the incongruent growth experienced in interior markets; Figure 2 details that this growth is indisputably attributable to the introduction of alliances, behind-beyond and gateway-beyond growth are overwhelmingly driven by alliances.

Source: Reproduction of U.S. DOT Chart from International Aviation Developments.

Figure 3 demonstrates the dramatic increases in transatlantic traffic. Figure 4 illustrates how the increase in passenger volume can largely be attributed to the creation of alliances under the open skies and immunity policies. Further, Figure 4 exhibits that growth is promoted by alliances. The consummation of alliance agreements by United and Delta in 1995 marked the first considerable uptick in growth. The growth accelerated rapidly with the granting of antitrust immunity in 1996. The non-alliance traffic growth post-1996 is particularly significant; because it affirms that alliance growth is not caused by travel diverted from non-alliance airlines, but in fact represents new traffic. The growth in traffic by non-alliance carriers post-1996 is largely related to Continental's expansion and testimony to the competitive vigor deregulation has brought to the market place.

Figure 3. Total Passengers U.S.—Europe, 1992-1999

Source: Reproduction of U.S. DOT Chart from International Aviation Developments.

Figure 4. Total Passengers U.S.—Europe 1992-1999 Strategic Alliance Carriers vs. Other Indexed: 1992 = 100

Source: Reproduction of U.S. DOT Chart from International Aviation Developments.

The Impact of Service Expansion

The service expansions promoted by alliances have been of tremendous benefit to historically underserved cities. The power of linking large multinational networks, such as those of NW and KLM or United and Lufthansa, allows convenient affordably priced service to be available between interior points in North America and interior points in Europe. The predominance of alliances has created competitive service from many interior cities. For instance, all four major alliances publish fares and offer double-connection service between Austin, Texas, and Prague, Czech Republic. While the number of passengers carried on such a route may be few, the collective effect of thousands of new city pair markets should not be underestimated. The DOT found the greatest percentage growth in traffic has occurred in such markets. One study (DOT, 2000a) found that

Birmingham, Alabama, experienced a 39% increase in traffic to major European cities; to smaller European cities, traffic more than doubled. Figure 5 illustrates that most expansive growth has occurred in these non-gateway markets.

Figure 5. U.S.—Europe Traffic, U.S. Alliance Carrier Traffic by Market Sector, Percent Change from 1992
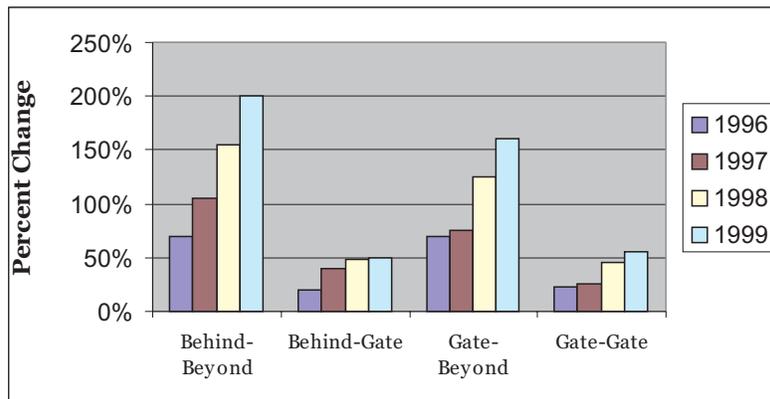
Source: Reproduction of U.S. DOT Chart from International Aviation Developments.

International aviation policy can have discernable effects on local economies. Alabama is in a better position than ever to compete with surrounding states with major international gateways, such as Georgia, for the U.S. operations of multi-national corporations. The local effects expand beyond the U.S. to our partners in open skies agreements. The growth in traffic to interior European destinations has encouraged the development of European hubs, largely as result of U.S. generated traffic. The growth is both in terms of destinations served from hubs, as well as new banks of flights to existing destinations. This growth here and abroad creates jobs and strengthens local economies.

THE EFFECT ON PUBLIC POLICY

Introduction

In the past year the government's attention to the airline industry has focused on security. Prior to the attacks on the World Trade Center and Pentagon in September 2001, the domestic airline industry was under scrutiny from a variety of U.S. public policy makers. The government agencies and bodies involved in oversight included the DOT, the Federal

Aviation Administration (FAA), the DOT's Office of the Inspector General, the Justice Department's Anti-Trust Division, Congress, and the State Attorneys General. All of these organizations express a commitment to fostering a competitive marketplace, where consumers receive good value and business thrives. As the industry recovers and reorganizes it is likely this attention will return.

The priorities of public policy makers are meaningfully different from those of consumers or shareholders. The focus of public policy is to ensure that a functioning pro-competitive market exists. The government provides the infrastructure required for the industry to operate (e.g., airports and Air Traffic Control) and safety regulations and oversight to inspire consumer confidence. In the past, economic regulation was also a responsibility. Domestic and international deregulations have largely eliminated this task. However, public policy leaders remain accountable for the concrete and steel essentials, as well as, the maintenance of economic components of a competitive market.

The important international successes, addressed in earlier sections, occurred while the public's attention focused on domestic customer service failures and anticompetitive threats. Today, the mass media's attention focuses on security and the sustainability of the industry. The consumer and business benefits of open skies and immunized alliances require that the momentum of past success in these areas must continue to be cultivated. Rodney Slater, former secretary of transportation in the Clinton administration told the WINGS Club weeks before his departure from the post, "I strongly believe that in the 21st century, aviation will be the engine of growth for the world that the Eisenhower Interstate Highway system was for America during the latter half of the 20th century" (Slater, 2001).

A collection of important international markets with which the U.S. does not share an open skies agreement exists; the list includes Japan, U.K., Spain, China, Brazil, and Russia. The work of the Bush administration in the early 1990s to develop open skies agreements, and the efforts of the Clinton administration in spreading the policy to nearly every corner of the globe, left the present administration with the task of signing these final deals and moving the nations airline industry and international aviation relationships into the era of globalization.

Each of the remaining nations presents special challenges. The U.K. and Japan as the U.S.'s largest aviation trading partners cannot be ignored, despite the unique challenges they bring to the negotiating table. I propose a two-pronged approach to building pressure for these and other nations to sign open skies agreements: internal pressure and noninvolvement in multilateral agreements. Internal pressure must be developed by working with business and political interest within each nation to convince them to sign these agreements, in collaboration with the perceived and quantifiable

effects of noninvolvement in surrounding multilateral agreements. The remainder of the section explores how this policy can be implemented.

Foreign Coalition Building

Pressure from the airline of a foreign nation is typically crucial to winning open skies concessions from a restrictive government. This proved true in reaching an accord with Germany, where Lufthansa's desire for antitrust immunity led the German authorities to agree to open skies. This approach may be taken a step further by not only convincing carriers to place pressure on their government's regulators, but by building energy from the entire business community for open skies. The State Department's role as lead negotiator on aviation agreements will be of benefit in the pursuit of such a strategy. A convincing case must be presented to opinion leaders in nations with whom we do not have agreements by U.S. embassies, the DOT Office of Aviation and International Affairs, the Department of Commerce and business associations.

Implementation

The DOT, in conjunction with the State Department and the Commerce Department, should organize an effort to persuade the business communities of foreign partners to influence their governments to agree to open skies. Secretary Slater provided significant leadership in this arena, touring Europe, Africa and Asia to secure agreements. Including the foreign trade expertise of the Commerce Department to the overall negotiating strategy is crucial to the success of this approach. Media efforts, trade missions and commercial links will be the tools used to build interior pressure for open skies. Media efforts, such as opinion pieces placed in the national business press of target nations, can play a key role in influencing target audiences. In addition to media efforts, multi-national corporations with offices in target countries may be called upon to join efforts to persuade foreign partners. The role of these companies will be to lobby other businesses to support open skies. Multinational business leaders may not feel comfortable lobbying foreign governments on such a tangential issue; however, building support in the wider business community is a realistic task for multinationals. The Commerce Department will be a good resource in developing contacts with these companies, considering the department's current support of U.S. business overseas. U.S. embassies overseas will organize lobbying efforts targeted at local political leaders. The support of local and regional airports and aviation authorities will bring authority and legitimacy to the cause.

Who Will Implement?

The DOT and the State Department, in consultation with the Commerce Department, will handle target nation selection. After a nation is selected, the Commerce and State Departments will take the lead in initiating and developing support within the business and political communities. DOT will focus on lobbying the aviation community, namely the transport ministry, as well as, airline and airport executives. These efforts, more than the multilateral strategy, are likely to require a commitment of additional resources to DOT and the Commerce Department.

Opposition

The airlines that oppose these agreements are typically government-owned inefficient operations that fear they can not compete with the highly efficient American carriers. The recent movement toward broad-based strategic alliances and the desire to attain antitrust immunity for such alliances is certainly a source of leverage. The U.S. has not yet pro-actively marketed anti-trust immunity to the international community. Bringing in the holdout nations may require taking a proactive stance.

Multilateral Approach

In November 2000, at the Asia-Pacific Economic Cooperation (APEC) summit, then Secretary Slater signed the first-ever multilateral aviation agreement. The agreement between the U.S., Brunei, Singapore, New Zealand and Chile should serve as the launch of a new global strategy. The ability of multilateral agreements to place pressure on regional neighbors should not be underestimated. The APEC negotiations were observed by Australia and Japan, an occurrence that does not typically take place in bilateral negotiations.

In the 1970s and 1980s, the U.S. attempted to persuade recalcitrant nations to adopt its position through what, at the time, was labeled by industry observers as *divide and conquer* (De Murias, 1989). In this strategy, liberal agreements were negotiated with neighboring nations to advance U.S. goals with third countries. Overall, the strategy found limited success. However, with nearly global acceptance of the principles of open skies, the pressure provided by multilaterals may make the difference in negotiations with nations reluctant to ratify open skies accords.

Implementation

We have successfully reached bilateral open skies agreements with nearly every country in Europe, and the European Union has adopted internal deregulation. The multilateral signed in Brunei is open to signage by any other nation. The nations the U.S. currently has open skies

agreements with, particularly European nations, should be encouraged to join this agreement. Another option is to pursue a single multilateral agreement between our existing European open skies partners and us. This single agreement could be joined by non-signatory European nations as they decide to participate.

As with the APEC agreement, a key feature of any new multilateral agreement should be expanded access to equity financing. The agreement liberalizes the traditional ownership requirement, thus enhancing foreign carriers' access to outside investment. The greatest success of this policy will probably not be found in the UK, as the issues preventing an agreement there are so complex. A main point of contention would no doubt continue to be landing rights at London's Heathrow airport. However, negotiating as a single multilateral unit, the U.S. position may be strengthened. A multilateral agreement could, however, successfully encourage Spain to fully liberalize their agreements with the U.S.

Domestic Resistance

The flight attendants' unions provide the strongest domestic resistance to multilateral agreements. They are concerned with the equity provisions in the agreement that could allow U.S. airlines to purchase foreign carriers and operate them on the international routes to the U.S., replacing flights worked by U.S. flight attendants. This issue could be difficult, as the flight attendants are likely to receive the full support of the U.S. labor community.

The equity provisions are critical to the success of multilaterals, but labor resistance could derail signatures. To respond to these concerns, the DOT could monitor the U.S. ownership of foreign carriers and could require them to report ownership in excess of 25%. The percentage is based on the maximum allowed percentage of foreign ownership of a U.S. carrier. Unions have expressed the desire for such monitoring (Coleman, 2000). Further, it should be stressed to the labor community that the airline industry, unlike the shipping industry, is not likely to adopt a flag of convenience strategy.

International Resistance

This approach may prove a difficult sell to the international community. The European Union appears to be the perfect body to participate in a multilateral agreement. In fact, the U.K. and Ireland are the only E.U. members to publicly oppose the creation of a Transatlantic Common Aviation Area. However, for the foreseeable future, the opposition of the U.K. and Ireland precludes the development of such a multilateral. The Scandinavian nations may be good start for a U.S.-Europe multilateral, as we have open skies agreements with each nation and they represent a combination of E.U. and non-E.U. member states.

The role of unions is important in European politics. The typically contentious airline labor unions support our initiatives as they create union jobs. The International Association of Airline Pilots, to which most pilots unions belong, supports deregulation and open skies. The concerns of U.S. flight attendants' unions should be less with a European multilateral, as carriers of each nation do not stand to benefit from moving operations between the two continents.

CONCLUSION

Open Skies, At Last? Immunity, Forever?

Nearly a century ago, when Adolf Berle first mused of open skies, it seemed that there might never be an international political climate to support his philosophy. In a number of important ways, it appears that just such a climate has formed and the clouds of regulation are drifting away. Though aviation clauses are conspicuously absent from the World Trade Organization and open skies among the North American Free Trade Agreement partners remains limited by ownership and cabotage restrictions, the past two decades have seen a steady movement toward international deregulation.

Airline industry globalization within this deregulated paradigm has created positive synergies for industry and the flying public. Industry benefits from greater passengers volumes and higher yields. The creation of competing global networks expands service and drives down prices for consumers.

Foreign ownership restrictions are the principal obstacle to truly open skies. For now, it appears the world is absent the political will to make international mergers a reality. Potential mergers between E.U.-based carriers can be likened more to the consolidation of the U.S. market than to true international mergers. The political reality makes the role of antitrust immunity in the new international regulatory environment important. Given existing ownership limits, immunity from civil and criminal antitrust regulation provides the most competitive industry paradigm.

ENDNOTES

1. The STAR Alliance is a partnership of U.S. and Asian airlines, including United Airlines, All Nippon (ANA), Singapore Airlines, and Thai Airlines.

2. The four alliances at the time were: a) WINGS consisting of Northwest, KLM, Alitalia and Continental; b) STAR consisting of United, Lufthansa, SAS, Air Canada, Varig, Thai Airways, Ansett Australia and Air New Zealand; c) ONEWORLD consisting of American, British Airways, Canadian, Qantas and Cathay Pacific; and ATLANTIC EXCELLENCE consisting of Delta, Swiss Air, Sabena and Austrian Airlines. Atlantic Excellence dissolved in late 1999.

3. The partnerships with immunity are Northwest/KLM, United Airlines/Lufthansa, United Airlines/SAS, United Airlines/Air Canada, American Airlines/Canadian Airlines, and all Atlantic Excellence partnerships.

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