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THE JOURNAL

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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- Space Transportation Safety, Communication, and the Future
- Other areas of air and space transportation research, policy, theory, case study, practice, and issues

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Dr. Brent Bowen is Director and Distinguished Professor, Aviation Institute, School of Public Administration, University of Nebraska at Omaha, and the University's Director of Aviation and Transportation Policy and Research. Bowen attained his doctorate in Higher Education and Aviation from Oklahoma State University and a Master of Business Administration degree from Oklahoma City University. His Federal Aviation Administration certifications include Airline Transport Pilot, Certified Flight Instructor (Gold Seal), Advanced Instrument Ground Instructor, Aviation Safety Counselor, and Aerospace Education Counselor. Dr. Bowen's research on the development of the national Airline Quality Rating is regularly featured in numerous national and international media, as well as refereed academic publications. Dr. Bowen has in excess of 250 publications, papers, and program appearances to his credit. His research interests focus on aviation applications of public productivity enhancement and marketing in the areas of service quality evaluation, forecasting, and student recruitment/retention in collegiate aviation programs. He is also well published in areas related to effective teaching and has pioneered new pedagogical techniques. Dr. Bowen has been recognized with awards of achievement and commendation from the American Marketing Association, American Institute of Aeronautics and Astronautics, Federal Aviation Administration, Embry-Riddle Aeronautical University, W. Frank Barton School of Business, Travel and Transportation Research Association, World Aerospace Education Association, and others.

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Sorenson Best Paper Award Recipient
**CROSS-CULTURAL PERSPECTIVES OF SERVICE
QUALITY AND RISK IN AIR TRANSPORTATION**

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University of Colorado at Denver
and
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ABSTRACT

This study compares U.S. and Korean customers in terms of their perceptions of airline service quality based on SERVPERF and industry-based measures, as well as their perceptions of risks involved in the airline choice. SERVPERF is a set of multi-dimensional measures of customer evaluations of service quality. The results indicate that (a) U.S. passengers are generally more satisfied with their airline service than Korean customers on most of the SERVPERF dimensions; (b) Koreans are generally more satisfied with the bumping procedures whereas U.S. participants feel more satisfied with the airline's baggage handling, operations/safety, and connections; and (c) U.S. participants perceive higher levels of performance and financial risks whereas Koreans feel greater social risk in choosing an airline. This study also examines the SERVPERF, industry-based measures, and perceived risk in predicting customer satisfaction with, and intention to repatronize the airline. The results suggest that U.S. customers consider service reliability, in-flight comfort, and connections as the key factors determining satisfaction with airline service whereas Korean passengers generally regard reliability, assurance, and risk factors as predictors of satisfaction. The determining factors of customer intention to repatronize the airline are reliability and empathy for U.S., and reliability and overall risk for Korean customers. The study demonstrates the applicability of SERVPERF as a cross-cultural tool and indicates the importance of perceived risk in cross-cultural studies.

INTRODUCTION

Over the past two decades, the service industries in the U.S. and elsewhere in the world have grown at a phenomenal rate. In 1980, service industries worldwide were valued at \$350 billion, accounting for 20 percent of all world trade; by 1992, that figure had nearly tripled to \$1,000 billion. The service sector now accounts for 58 percent of worldwide gross national product (Bateson & Hoffman, 1999). Consequently, services are attracting increasing attention from academicians and practitioners alike. The proliferation of services not only provides business opportunities, but also poses high levels of competitive threats for service marketers. In fact, many researchers and marketers have focused their attention on customer evaluations of services in an effort to find ways to improve service quality (see Fisk, Brown, & Bitner, 1993 for a review of the literature).

However, despite the considerable amount of research under the rubric of service quality that has accumulated over the years, few studies to date have examined customer perceptions of service quality in an international or a cross-cultural setting. This issue is of paramount concern to international service marketers because the perceived service quality often reflects customers' levels of satisfaction with and intention to repatronize the services. If service quality perceptions are standardized across cultures, firms may choose to control costs by standardizing operations and marketing strategies. Assessment of quality in service industries, unlike traditional physical product industries, is not a function of statistical measures of quality including physical defects or managerial judgement.

Rather, it is a function of customers' expectations and perceptions about the services (Bateson & Hoffman, 1999; Lovelock, 1984; Parasuraman, Zeithaml, & Berry, 1985).

The purpose of this study was twofold: (a) to examine customer perceptions of services and risk of services provided by commercial airline companies in a cross-cultural setting; and (b) to assess the effectiveness of existing measures of service quality and risk in predicting customer satisfaction and intention to repatronize the services. Since airline services are used worldwide, they offer an excellent opportunity for this type of cross-cultural research. This study compares U.S. and Korean customers in terms of their service quality perceptions and repatronage intentions. For this purpose, the study uses the SERVPERF scale, industry-based measures, and various types of perceived risks. SERVPERF is an instrument developed by Cronin and Taylor (1992), which is now widely used in measuring customer evaluations of service quality. In an effort to incorporate the high involvement/high risk nature of airline services, the study also examines the predictive ability of perceived risks. These measures are further explained later.

SERVICE QUALITY MEASUREMENT IN THE AIRLINE INDUSTRY

An overview of the competitive situation of the airline industries in the U.S. and Korea suggests that measurement and management of service quality is the fundamental issue for the survival and growth of airline companies. This section describes those measures developed in past literature, which were used in the present study.

Service Performance Measures

While carriers experimented with service competition, similar experiments were occurring in the academic world. Parasuraman, Berry, & Zeithaml, 1991; Parasuraman, Zeithaml, & Berry, 1985, 1988) have developed a service quality measure designated SERVQUAL which states that the customer's assessment of overall service quality is determined by the degree and direction of the gap between their expectations and perceptions of actual performance levels. They have also identified five dimensions underlying overall service quality: tangibles, reliability, responsiveness, assurance, and empathy. They proposed that perceived service quality could be estimated by calculating the difference between expectations and perceptions of actual service performance. Since the SERVQUAL scale was developed, it has been widely used to measure perceived service quality in various service industries such as health care,

financial institutions, and life insurance (e.g., Crompton & Mackay, 1989; Johnson, Dotson, & Dunlap, 1988; Webster, 1989; Woodside, Frey, & Daly, 1989).

Initial publications on airline service quality appeared in 1988 (Gourdin, 1988). The first direct application of the service quality gap model was presented in 1991 (Fick & Ritchie, 1991; Gourdin & Kloppenborg, 1991). Fick and Ritchie used the SERVQUAL scale to measure perceived service quality within several service industries including the airline industry. However, they simply reported the mean scores of consumer expectation and perception of service performance measures, and failed to determine the relative impact of various SERVQUAL items on overall service quality and satisfaction. In order to find out the relative importance of individual SERVQUAL items, they could have performed further analysis of their data on the basis of multivariate statistical techniques.

The SERVQUAL scale has also been extensively used in Korea to measure the quality of services provided by retail stores (Lee & Lee, 1997), telecommunication companies (Oh, 1995), and airline companies (Kim, 1997). For instance, Kim used the scale to measure customer evaluations of airline service quality. She found that reliability, empathy, and tangibles had the most significant impact on customer perceptions of service quality. The current study extends her research framework and includes measures that are specific to the airline industry.

However, the SERVQUAL scale has been criticized in terms of its validity and reliability. It has also been pointed out that including all 44 items (22 items of service expectations and a duplicate 22 items of service performance) in one study often makes the survey task too onerous for respondents (Buttle, 1996). Thus, it has been suggested that the 22 items of perceptions of service performance would be sufficient in measuring service quality (Carman, 1990; Vandamme & Leunis, 1993). Cronin and Taylor (1992, 1994) have empirically demonstrated that the measures of service performance, or so-called SERVPERF, perform better than SERVQUAL which includes expectations as well as performance. They have shown that SERVPERF explains more of the variation in the global measure of service quality in all of the four service industries examined: banks, pest control, dry cleaning, and fast food services. Therefore, this study used SERVPERF in measuring the airline service quality (see Appendix A for the SERVPERF dimensions and measures).

Industry-based Measures

While SERVPERF has proven applicable and useful in measuring the airline service quality, it has certain limitations. One of the limitations concerns the generic nature of the scale (Ostrowski, O'Brien, & Gordon,

1993). Although the scale is so generic that it can be applied in measuring perceived quality of various services, it fails to capture industry-specific dimensions underlying the quality perceptions. Therefore, the current study incorporates those industry-based measures in determining airline service quality.

The initial tools of service quality measurement in the airline industry were really economic-based, pre-deregulatory tools that had been developed by the Civil Aeronautics Board (Douglas & Miller, 1974; Jordan, 1970). Service quality assessments from the perspective of the airline consumer first appeared in the doctoral dissertation work by Kearney (1986). It examined service quality from the perspective of industry-based economic and marketing measures (see also Kloppenborg & Gourdin, 1992, for these industry-based measures).

Gourdin and Kloppenborg (1991) used an intriguing approach to sampling consumers in addition to industry and government transportation officials to develop a set of criteria for expected quality. They found significant statistical differences between passengers and management on a number of essential variables, most of which are industry-based service quality measures mentioned above.

Several teams of researchers compiled the industry-based measures of airline service quality and compared them with SERVQUAL in terms of their ability to predict customer satisfaction and intention to repatronize (Cunningham & Brand, 1989; Lee, Cunningham, & Wadsworth, 1993; Young, Cunningham & Lee, 1994a, 1994b; Young, Cunningham, Lee & Wadsworth, 1992). They found that SERVQUAL measures were as strong as the industry derived measures in predicting perceived quality and were the only significant predictors of intention to repatronize. The present study includes and uses the industry-based measures that they put together (see Appendix B for the industry-based dimensions and their measures).

Risk Perceptions

Another factor that pertains to the customer evaluation of the airline service quality is perceived risk in selecting an airline. Perceived risk has been widely dealt with in past literature since it accompanies all purchases to varying degrees and influences buying behavior (Bettman, 1973; Cox, 1967; Chaudhuri, 1997; Cunningham, 1967; Dowling & Staelin, 1994; Mitchell, 1999). Past research suggests that consumers generally feel a higher level of risk when purchasing a service than when buying a manufactured product since services are basically intangible and difficult to test before purchase (Murray, 1991; Zeithaml, 1981). A study by Sweeney, Soutar, and Johnson (1999) revealed that perceived risk plays a mediating role in the perceived service quality and value for money

relationship in a retail setting.

Since most of the travel experiences rely on intangible services, it is expected that travelers' perceptions of risk are likely to be high, and such perceptions would influence their evaluations of the travel services (Moutinho, 1987; Sonmez & Graefe, 1998). Although researchers have not yet examined or measured perceived risk in the context of airline selections, the existing evidence implies its potentially significant influence on evaluations of airline service quality (Roehl & Fesenmaier, 1992).

Another interesting issue that warrants a close investigation is the potential differences in consumer risk perceptions across cultures. In the product domain, a piece of evidence suggests that American and Mexican consumers differ in terms of the level of perceived risk involved in making purchases; on average, Mexicans perceive a lower level of risk in brand selection, compared to Americans (Hoover, Green, & Saegert, 1978). Another study indicates that Americans and Germans are more risk-averse than Chinese in reacting to financial investment options (Weber & Hsee, 1998). Thus, it is proposed that perceived risk can be used to analyze consumer behavior patterns in different cultures (Verhage, Yavas, & Green, 1991). Such cross-cultural differences should have strong implications for international airlines and are examined in this study.

Past literature suggests that perceived risk is a multi-dimensional construct (Kaplan, Szybillo, & Jacoby, 1974; Roselius, 1971). Therefore, in this study, overall perceived risk was measured as well as perceptions of five risk dimensions: financial, performance, physical, psychological, and social risks (Murray & Schlacter, 1990; Roehl & Fesenmaier, 1992). The purpose of including such measures of individual dimensions was to examine cross-cultural differences on each risk dimension and to determine each one's relative impact on overall service quality and intention to repatronize.

RESEARCH METHOD

Questionnaire Design

The survey questionnaire consisted of three sections. Questions in the first section asked respondents to evaluate the quality of services provided by the airline company that they had used most recently. Perceived service quality or overall satisfaction was measured through the question, "Overall, I am very satisfied with the airline," on a 7-point Likert scale ranging from "strongly disagree" to "strongly agree." Behavioral intention to repatronize the airline was measured through the question, "I will definitely use the airline again the next time I fly" on the same scale. Perceived quality of individual service aspects was also measured by the SERVPERF items

using the same 7-point scales. The items of SERVPERF (Cronin & Taylor, 1992, 1994) based on the revised version of SERVQUAL (Parasuraman, *et al.*, 1991) were reconstructed to be suitable to measure airline services.

The second section included industry-based measures described earlier. The last section of the questionnaire dealt with behavioral and demographic characteristics of respondents. Specifically, this section involved questions on (a) frequency of air travel; (b) perception of risk involved in air travel; and (c) demographics (e.g., sex, age, income).

In developing the questionnaire and collecting data, this study followed the guidelines for conducting international marketing research, as developed and proposed by Douglas and Craig (1983) and Malhotra, Agarwal, and Peterson (1996). To ensure the equivalence of the research instrument used in two different countries, this study adapted the specific procedure suggested in the literature (Brislin, 1970; Brislin, Lonner, & Thorndike, 1973; Triandis, 1976) and used in Calantone, Schmidt, and Song (1996), which involved double translation with de-centering. Specifically, four bilinguals, who were fluent in English and Korean, participated in the process. They earned their undergraduate degrees from major U.S. universities and were enrolled in a graduate program at a major Korean university at the time this study was conducted. Two of them prepared a Korean translation of the English version of the questionnaire. Problems and ambiguities in the process of translation were discussed with one of the authors. Subsequently, this questionnaire was reverse translated into English by the other two bilinguals who did not see the original English version. Then, based on the comparison between the original and the reverse translated English versions, adjustments were made to the Korean questionnaire. It was believed that the equivalence of the two versions of the questionnaire, English and Korean, was ensured throughout the procedure.

Sampling and Data Collection

Data from both the U.S. and Korea were collected in surveys of business professionals attending evening MBA courses. In the U.S., before the main study was conducted, a pilot test was performed on a small scale in order to make sure that the questions were read and understood as intended. The questionnaire was then administered to a random sample taken from a student population of an evening MBA program at a major metropolitan university. A total of 105 respondents participated in the survey, yielding 105 usable responses. The same procedure was performed in Korea in an effort to ensure the comparability of data collected in the two different countries. A total of 145 respondents participated in the survey, yielding 143 usable responses.

Both the Korean and U.S. MBA students were full-time working professionals who, in many cases, traveled as part of their responsibilities. As such, they are broadly representative of typical airline customers. A pilot test showed that most of the students were regular users and many of them were heavy users of air travel services.

ANALYSIS AND RESULTS

Sample Characteristics

The data was coded and tabulated in preparation for analysis. Because the data was obtained from student samples, descriptive analyses were performed to analyze the make-up of the samples. Table 1 shows the demographic profile of the respondents. The Korean samples tended to be

Table 1. Sample Characteristics of Respondents

<i>Variable</i>	<i>Overall (n = 248)</i>	<i>U.S. (n = 105)</i>	<i>Korea (n = 143)</i>
	<i>percent</i>		
Sex			
Male	69	52	80
Female	31	48	20
Age			
Under 30	32	40	26
30-39	55	45	63
Over 39	13	15	11
Marital Status			
Single	32	37	29
Married	62	51	70
Other	6	12	1
Ethnic Background			
White	34	83	0
Asian	62	8	99
Other	4	9	1
Income			
Under \$30K	18	19	18
\$30K-\$40K	20	17	22
\$40K-\$50K	20	18	21
\$50K-\$60K	17	12	19
\$60K-\$70K	10	15	7
Over \$70K	15	9	13
	<i>number</i>		
Total Airline Trips (Last Year)	6.49	5.50	7.21
Business Trips (Last Year)	4.36	3.32	5.13

more male, younger, more often married, and more homogeneous in terms of race and ethnic background.

Although there were differences between the two samples in terms of some demographic characteristics, there were similarities in other characteristics. Specifically, the incomes were similar for the two groups. The samples were relatively affluent by U.S. and Korean standards; 54% of the U.S. and 60% of the Korean sample had annual incomes greater than \$40,000. More importantly, investigation of the respondents' travel behavior revealed that individuals in both samples were extensive users of airline services. On average, the U.S. sample individual made 5.50 airline trips (of which, 3.32 were business trips) and the Korean counterpart made 7.21 trips (5.13 business trips) in the last 12 months. Based on the results, we believe that the respondents represent a group of people who travel by air sufficiently often to be familiar with airline services. Thus, these individuals must have formed opinions and perceptions about airline services and quality based on their actual air travel experiences.

Measure Validation

The next step of the analysis dealt with how well the SERVPERF measures exhibited reliability when used in an airline services setting in the U.S. and Korea. Individual measures were subjected to reliability analysis in accordance with their predicted dimensions. Based on the analysis using coefficient alpha (Cronbach, 1951), all dimensions showed acceptable reliability; the alpha values of all the constructs were either close to or greater than .7, the threshold Nunnally (1978) recommended for basic research (see Appendix A for Cronbach's alphas of the dimensions). Therefore, index measures of the five dimensions of SERVPERF were constructed by taking the mean of the set of measures for that dimension. These indices were used in the regression analysis, which will be explained later.

In their previous studies, the authors had no a priori dimensions for the industry-derived measures. Therefore, the measures were subjected to a factor analysis to investigate underlying dimensions. From the factor analysis results, five dimensions were identified and described as (a) baggage handling; (b) bumping procedures; (c) operations and safety; (d) in-flight comfort; and (e) connections. The measures were also subjected to reliability analysis using Cronbach's coefficient alpha. As expected, all dimensions also showed acceptable reliability (see Appendix B). Thus, the simple mean ratings on the measures were used again in the subsequent regression analysis.

SERVPERF Measures

The U.S. and Korean respondents were asked to evaluate the quality of services provided by the airline that they had flown on most recently utilizing the overall measures and various SERVPERF scale items. The results are summarized in Table 2.

Table 2. SERVPERF Measures: Results of the t-Tests

<i>Variable^a</i>	<i>U.S.</i>	<i>Korea</i>	<i>t-value</i>	<i>p-value</i>
	<i>mean</i>			
<i>Overall</i>				
I am very satisfied with the airline.	4.94	3.96	6.12	.001
I will definitely use the airline again.	5.09	4.48	3.11	.01
<i>Tangibles</i>				
The airline has up-to-date equipment.	4.45	4.25	1.22	.23
The airline's physical facilities are visually appealing.	4.50	4.17	2.03	.04
Employees are well dressed and neat.	5.50	5.13	2.60	.01
Physical facilities are kept up.	4.69	4.27	2.83	.01
<i>Reliability</i>				
The airline keeps promises.	4.32	4.20	.69	.49
The airline is sympathetic and reassuring.	4.05	4.23	-1.01	.31
The airline is dependable.	4.90	4.51	2.43	.02
The airline keeps time.	4.71	4.68	.15	.88
The airline keeps its records accurately.	4.85	4.35	3.12	.01
<i>Responsiveness</i>				
The airline tells the customers exactly when the services will be performed.	4.43	4.20	1.16	.25
You receive prompt service from the airline.	4.25	4.01	1.32	.19
Employees are always willing to help customers.	4.36	3.81	2.92	.01
Employees respond to customer requests promptly.	4.27	3.76	2.63	.01
<i>Assurance</i>				
You can trust employees.	4.84	4.38	3.08	.01
You feel safe in your transaction with employees.	4.89	4.25	3.87	.001
Employees are polite.	5.13	4.56	3.31	.001
Employees get adequate support.	4.24	4.21	.20	.84
<i>Empathy</i>				
The airline gives you individual attention.	4.22	3.62	3.17	.01
Employees give you personal attention.	4.42	3.40	5.46	.001
Employees know what your needs are.	4.49	3.91	3.16	.01
The airline has your best interest at heart.	4.38	3.68	3.79	.001
The airline has convenient operating hours.	4.39	3.19	6.60	.001

^a Measured on a 7-point Likert scale where 1 = "strongly disagree" and 7 = "strongly agree"

Individuals in the U.S. sample highly agreed with many of the statements of the measures. Some of the most highly rated factors were "Employees are well dressed and neat" (mean = 5.50), "The airline is dependable" (mean = 4.90), "I feel safe in my transaction with employees" (mean = 4.89), and "Employees are polite" (mean = 5.13). The Korean sample also rated the airline highly on such statements as "Employees are well dressed and neat" (mean = 5.13), "The airline is dependable" (mean = 4.51), "The airline provides services at the time it promises to do so" (mean = 4.68), and "Employees are polite" (mean = 4.56). However, on many of the measures, including the overall satisfaction/behavioral intention measures, the average ratings of the U.S. sample were significantly higher than those of the Korean sample (see Table 2 for the results of the *t*-tests). In particular, there was an interesting contrast between the samples on the empathy dimension. For the five statements measuring this service dimension, the U.S. sample evaluated their airlines more favorably than the Koreans. For instance, the U.S. sample's level of agreement with the statement, "Employees give you personal attention" (mean = 4.42) was significantly higher than that of the Korean sample's (mean = 3.40, $t = 5.46$, $p < .001$).

Industry-based Measures

The respondents were also asked to evaluate the airline service quality on the industry-based measures. The results are summarized in Table 3.

U.S. participants also tended to rate the airline service relatively high on those measures. For example, they rated highly the "airline safety" (mean = 5.48), "service differentiation between each class" (mean = 5.15), and the "right equipment for trips" (mean = 5.10). In addition, U.S. participants scored very high on the "amenities important to the comfort of passengers" (mean = 5.02). On the other hand, they rated other factors relatively low. For example, U.S. travelers stated that seating on U.S. airlines was not quite comfortable in terms of agreement with the "right layout of seats" (mean = 3.19), "wide seats" (mean = 3.30), and "enough room in the aisles" (mean = 3.30). From a negative perspective, they also stated that U.S. carriers placed too many seats inside an aircraft. The Korean sample offered some different perspectives especially regarding in-flight comfort. For example, they stated that their airline seats had good pitch (mean = 4.24), the layout of seats was just right (mean = 3.28), and food/beverage service was good (mean = 4.02).

Perhaps the most interesting results were produced from the *t*-tests (see Table 3). Some of the factors that were highly significant offer insight into the different perspectives of the U.S. and Korean samples. For example, Koreans, compared to U.S. participants, were relatively satisfied with

Table 3. Airline Industry-based Measures: Results of the *t*-Tests

<i>Variable^a</i>	<i>U.S.</i>	<i>Korea</i>	<i>t-value</i>	<i>p-value</i>
	<i>Mean</i>			
<i>Baggage Handling</i>				
Baggage handling is prompt and efficient.	4.88	4.01	4.45	.001
Airline inline agreements work well for the customer.	4.69	3.78	5.06	.001
Airline check-in is efficient.	4.78	4.13	3.56	.001
<i>Bumping Procedures</i>				
Airline bumping procedures are fair/convenient.	3.88	4.88	-5.14	.001
Bumping procedures provide adequate compensation.	4.28	3.14	6.07	.001
Information provided by airline at airport is adequate.	3.38	4.30	-4.97	.001
<i>Operations and Safety</i>				
Ticket and reservation procedures are adequate.	4.89	4.62	1.57	.12
Airline is safe.	5.48	4.36	6.76	.001
Airline selects the right equipment for trips.	5.10	4.47	4.20	.001
Amenities are important to the passengers.	5.02	3.90	6.08	.001
Airline distinguishes between classes through service.	5.15	5.41	-1.49	.14
<i>In-flight Comfort</i>				
Airline seats have good pitch.	3.75	4.24	-2.42	.02
Airline seats are wide enough.	3.30	2.08	2.33	.02
There is enough room in the isles.	3.30	3.08	1.04	.30
The layout of seats in aircraft is just right.	3.19	3.28	-.42	.68
Airline food and beverage service is good.	3.69	4.02	-1.74	.08
<i>Connections</i>				
Airline offers sufficient flight frequency.	4.82	4.06	4.31	.001
Airline offers flights at right times of the day and night.	4.72	3.77	5.75	.001
Airline correctly coordinates connections.	4.47	3.84	3.75	.001
Airline offers sufficient non-stop flights.	4.57	4.17	2.15	.03
Airline offers sufficient connecting flights.	4.61	4.01	3.60	.001

^a Measured on a 7-point Likert scale where 1 = "strongly disagree" and 7 = "strongly agree"

bumping procedures (means = 4.88 and 3.88, respectively, $t = -5.14$, $p < .001$) as well as the information provided by the airline at the airport (means = 4.30 and 3.38, respectively, $t = -4.97$, $p < .001$). On the other hand, U.S. participants were generally satisfied with their airline's baggage handling, safety/operations, and connections.

Risk Perceptions

As indicated in Table 4, respondents from both the U.S. and Korean samples evaluated the overall, financial, performance, physical, psychological, and social risks associated with choosing an airline.

Table 4. Risk Perceptions: Results of the *t*-Tests

<i>Variable^a</i>	<i>U.S.</i>	<i>Korea</i>	<i>t-value</i>	<i>p-value</i>
	<i>Mean</i>			
Overall Risk	4.20	3.75	2.55	.01
Financial Risk	4.28	3.57	3.59	.001
Performance Risk	5.13	4.23	5.07	.001
Physical Risk	3.98	4.09	-.51	.61
Psychological Risk	4.11	4.32	-1.00	.32
Social Risk	2.34	2.79	-2.34	.02

^a Measured on a 7-point Likert scale where 1 = "no risk" and 7 = "high risk"

The U.S. respondents indicated that the primary sources of risks in choosing an airline were performance, financial, and psychological risks. The means for these types of risks were 5.13, 4.28, and 4.11, respectively. Respondents from the U.S. sample did not state that there was much social risk involved in choosing an airline. On the other hand, Korean respondents indicated that the highest sources of risk associated with choosing an airline were psychological, performance, and physical with means of 4.32, 4.23, and 4.09, respectively. Both of the samples indicated that there was minimal social risk in picking an airline (means = 2.34 for the U.S. sample and 2.79 for the Korean sample).

When the responses of the U.S. sample were compared to those of the Korean sample, there were highly significant differences in performance and financial risk with *t*-values of 5.07 and 3.59 and significant levels of $p < .001$. There was also a difference in the evaluation of overall risk with a *t*-value of 2.55 and significance of $p < .01$. Surprisingly, Koreans, compared to U.S. participants, stated that there was a greater level of social risk in choosing an airline ($t = -2.34$, $p < .02$). Physical and psychological risks were not significantly different, although Koreans indicated that there were higher physical and psychological risks.

Regression Analysis

A set of stepwise regression analyses was performed for each sample to determine differential effects of SERVPERF, industry-based measures and risk variables on customer satisfaction with airline services. The results are summarized in Table 5.

Table 5. Impact of SERVPERF, Industry Indices, and Risk Factors On Customer Satisfaction: Results of the Stepwise Regression Analysis

Variable	U.S.		Korean	
	Standardized Coefficient	t-value	Standardized Coefficient	t-value
<i>SERVPERF Measure</i>				
Tangibles	—	—	—	—
Reliability	.36	4.34***	.56	7.48***
Responsiveness	—	—	—	—
Assurance	—	—	.18	2.41*
Empathy	—	—	—	—
<i>Industry-based Measure</i>				
Baggage Handling	—	—	—	—
Bumping Procedure	—	—	—	—
Operations and Safety	—	—	—	—
In-flight Comfort	.22	2.65**	—	—
Connections	.37	4.54***	—	—
<i>Perceived Risk</i>				
Overall Risk	—	—	—	—
Financial Risk	—	—	—	—
Performance Risk	—	—	-.14	-1.83
Physical Risk	—	—	.21	3.45***
Psychological Risk	—	—	-.15	-2.08*
Social Risk	—	—	—	—
		$R^2 = .54, F = 33.71***$		
		$R^2 = .63, F = 44.52***$		

* $p < .05$, ** $p < .01$, *** $p < .001$

The overall regression models were highly significant ($R^2 = .54$, $F = 33.71$, $p < .001$ for the U.S. sample; $R^2 = .63$, $F = 44.52$, $p < .001$ for the Korean sample). In the U.S. sample, service reliability, one of the SERVPERF dimensions, produced a standardized coefficient of .36 and a t -value of 4.34, which was significant at $p < .001$. In the case of the Korean sample, two independent variables, reliability and assurance, were significant predictors of customer satisfaction. Reliability produced a standardized coefficient of .56 and a t -value of 7.48 which was significant at $p < .001$. In addition, assurance also proved to be a significant predictor of customer satisfaction, with a standardized coefficient of .18 and a t -value of 2.41 which was significant at $p < .05$. The results were consistent with most of the cross-cultural studies that have sought to employ SERVPERF variables as predictors of customer satisfaction. In fact, the interesting studies are those that failed to demonstrate that reliability was a significant predictor. The only key change in this particular result was that assurance also proved a significant independent variable.

The regression analysis for the U.S. sample also indicated that airline connection was a significant independent variable. The standardized coefficient produced by connections was .37 and the t -value was 4.54 which was significant at $p < .001$. In addition, in-flight comfort was significant with a coefficient of .22 and the t -value was 2.65 which was significant at $p < .01$. However, the Korean model for customer satisfaction demonstrated some characteristics which were substantially different than those in the model produced by the U.S. sample. Specifically, in the Korean model, customer satisfaction was successfully predicted by three risk variables. These variables were performance risk ($\beta = -.14$, $t = -1.83$, $p < .07$), physical risk ($\beta = .21$, $t = 3.45$, $p < .001$), and psychological risk ($\beta = -.15$, $t = -2.08$, $p < .05$). Perhaps the most intriguing finding was that physical risk had a positive coefficient on customer satisfaction, holding reliability and performance risk constant. Indeed, although physical risk was negatively associated with satisfaction on the bivariate correlation matrix, when reliability was entered into the model, the coefficient for physical risk became positive. When performance risk was added to the model, the coefficient for physical became positive and significant.

The current study seems to suggest some interesting cultural connections between satisfaction and physical risk. In particular, the results seem to suggest that Korean travelers, when measured from a post hoc perspective, connect their levels of satisfaction with those of physical risk. Thus, the researchers might have measured on a post hoc basis the adrenaline rush that people experience when they successfully survive stressful situations with moderate physical risk. In the U.S., this feeling is likened to the exhilaration one feels at the end of a roller coaster ride.

Another set of regression analyses also sought to predict intention to repatronize using SERVPERF, industry-based measures and risk variables. Table 6 shows the results of the analyses.

Again, both models were highly significant ($R^2 = .36$, $F = 25.20$, $p < .001$ for the U.S. sample; $R^2 = .37$, $F = 39.22$, $p < .001$ for the Korean sample). The U.S. sample produced a model with two significant independent variables, service reliability and empathy. Reliability produced a standardized coefficient of .42 and a t -value of 4.12, which was significant at $p < .001$ while empathy produced a standardized coefficient of .26 and a t -value of 2.55, significant at $p < .05$. The Korean sample also featured two significant independent variables. One variable was reliability with a standardized coefficient of .56 and a t -value of 8.00 with $p < .001$. Overall risk was also significant as an independent variable producing a $-.15$ standardized coefficient and a t -value of -2.15 , significant at $p < .05$.

Table 6. Impact of SERVPERF, Industry Indices, and Risk Factors On Intention to Repatronize: Results of the Stepwise Regression Analysis

Variable	U.S.		Korean	
	Standardized Coefficient	t-value	Standardized Coefficient	t-value
<i>SERVPERF Measure</i>				
Tangibles	—	—	—	—
Reliability	.42	4.12***	.56	8.00***
Responsiveness	—	—	—	—
Assurance	—	—	—	—
Empathy	.26	2.55*	—	—
<i>Industry-based Measure</i>				
Baggage Handling	—	—	—	—
Bumping Procedure	—	—	—	—
Operations and Safety	—	—	—	—
In-flight Comfort	—	—	—	—
Connections	—	—	—	—
<i>Perceived Risk</i>				
Overall Risk	—	—	-.15	-2.15*
Financial Risk	—	—	—	—
Performance Risk	—	—	—	—
Physical Risk	—	—	—	—
Psychological Risk	—	—	—	—
Social Risk	—	—	—	—
		$R^2 = .36, F = 25.20***$		
			$R^2 = .37, F = 39.22***$	

* $p < .05$, ** $p < .01$, *** $p < .001$

CONCLUSIONS

The results of the study indicate that U.S. passengers are generally more satisfied with their airline service than Korean customers on most of the SERVPERF dimensions. However, the industry-based measures produce many interesting contrasts between the two groups of customers. Specifically, Koreans are generally more satisfied with the bumping procedures, whereas U.S. participants feel happier with the airline's baggage handling, safety/operations, and connections.

An interesting and important finding is the different levels of perceived risk. The results of the study suggest that U.S. participants perceive higher levels of performance and financial risks, whereas Koreans feel greater social risk in choosing an airline. From a risk perspective, these findings imply that U.S. participants generally evaluate airline alternatives based on service performance and costs whereas Koreans select an airline that they think would be acceptable to other people they know. In other words, Koreans may be more susceptible to social influences in their choice of an

airline. Therefore, international airlines serving Korean passengers should formulate promotional strategies that encourage word-of-mouth communications among potential customers. Finally, U.S. participants generally seem to feel a higher level of overall risk when choosing an airline. Airlines targeting U.S. passengers should use risk-reducing strategies in the airline choice. For instance, companies can emphasize value for the money to reduce financial risk and service quality to alleviate performance risk.

The results from the regression analyses offer significant insight for international airlines. First, the results indicate that U.S. customers think of service reliability and connections as the key factors determining the airline service quality. Fortunately, the airlines serving U.S. travelers are evaluated favorably on these two dimensions. On the other hand, Korean passengers generally consider reliability and assurance as the most important factors and other industry-based service items as less important. However, they perceive the airlines they fly with less favorably on these SERVPERF dimensions than U.S. customers. Thus, the international airlines targeting Korean passengers should focus efforts on improving such core services.

Secondly, as described above, Koreans generally seem to perceive a lower level of risks in selecting an airline. However, when they evaluate their satisfaction with an airline, their perception of risks becomes important. The results indicate that the higher the perception of performance and psychological risk, the less favorable their satisfaction levels. This reaction might be caused by cognitive dissonance or feeling of regret, that is, a thought that they made a poor choice of an airline. The airline could probably reduce the negative impact of perceived risk by providing the core services consumers want (i.e., reliability and assurance) and confirming that travelers made the right choice.

Finally, the study results point out several key variables that determine customer intention to repatronize the airline. Those variables are reliability and empathy for participants, and reliability and overall risk for Korean customers. International airlines serving U.S. or Korean passengers should focus on these variables in order to develop and maintain long-term relationships with customers.

Implications

The results of this study have methodological and managerial implications. The study demonstrates that the SERVPERF scale is applicable and usable in cross-cultural studies. The scale worked well when applied to Korean customers and seems to offer some predictive ability for satisfaction and repatronization of services. This conclusion can be supported by prior research in other cultures as well as by other studies

conducted in the Korean environment. Further, this study also demonstrates the validity of service reliability as a key predictor in both satisfaction and repatronization. This finding is consistent with prior research dealing with airline service quality (e.g., Young, *et al.*, 1994a, 1994b).

The results of this study, considered in totality, suggest that implementing a simple-minded service standardization across different countries for cost reduction can be risky in the international airline industry. Consumers view the same service differently and evaluate its merits and faults differently. Although airlines cannot ignore cost constraints, they should make an effort to recognize cultural perceptions of their service and to customize services to the differing needs of international passengers.

Future Research Directions

In earlier studies conducted in the U.S., Lee, *et al.*, (1993), and Young, *et al.*, (1992) and Young, *et al.*, (1994a, 1994b) found that the best prediction of airline satisfaction and repatronization occurred when SERVPERF dimensions were combined with industry measures of service quality. While industry measures did not prove to be particularly significant or predict satisfaction and repatronization in the Korean environment, there is reason to believe that industry measures are useful in predicting these dependent variables in cultures other than in the U.S. While the findings in this study are limited to the airline industry, there is the possibility that industry measures would prove extremely helpful in other service industries as well as in other cultures. Future research needs to investigate these possibilities.

Perhaps the most important finding of the study is the role of perceived risk in predicting satisfaction and repatronization. In specific, types of perceived risk seemed to play important roles in the selection of services. Further, based on the results of this study, one might hypothesize that perceived risk varies a great deal from culture to culture as a factor in predicting satisfaction and repatronization. The current study also seems to suggest some interesting cultural connections between satisfaction and physical risk as noted in the results section. The positive relationship between physical risk and satisfaction after holding reliability and personal risk constant is one that deserves further study. Is there a true roller coaster effect as stated earlier? If this hypothesis is indeed valid, the findings suggest that there is an opportunity in certain cultures to develop standardized services which successfully reduce psychological and performance risk, while at the same time, providing users with some perceived exposure to moderate physical risk.

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APPENDIX A

SERVPERF Dimensions and Measures

Tangibles. Physical facilities, equipment, appearance of personnel (alphas = .62, .76)^a

1. XYZ has up-to-date equipment.
2. XYZ's physical facilities are visually appealing.
3. XYZ's employees are well dressed and appear neat.
4. The appearance of the physical facilities of XYZ is in keeping with the type of services provided.

Reliability. Ability to perform service dependably and accurately (alpha = .82, .73)

5. When XYZ promises to do something by a certain time, it does so.
6. When you have problems, XYZ is sympathetic and reassuring.
7. XYZ is dependable.
8. XYZ provides its services at the time it promises to do so.
9. XYZ keeps its records accurately.

Responsiveness. Willingness to help customers and provide prompt service (alphas = .73, .68)

10. XYZ does not tell customers exactly when services will be performed. (-)^b
11. You do not receive prompt service from XYZ. (-)
12. Employees of XYZ are not always willing to help customers. (-)
13. Employees of XYZ are too busy to respond to customer requests promptly. (-)

Assurance. Knowledge and courtesy, ability to inspire trust and confidence (alphas = .69, .81)

14. You can trust employees of XYZ
15. You feel safe in your transactions with XYZ's employees.
16. Employees of XYZ are polite.
17. Employees get adequate support from XYZ to do their jobs well.

Empathy. Caring, individualized attention (alphas = .82, .80)

18. XYZ does not give you individual attention. (-)
19. Employees of XYZ do not give you personal attention. (-)
20. Employees of XYZ do not know what your needs are. (-)
21. XYZ does not have your best interest at heart. (-)
22. XYZ does not have operating hours convenient to all their customers. (-)

^a Cronbach's alphas for the U.S. and Korean samples, respectively.

^b (-) indicates that the measure is reverse scored.

APPENDIX B**Airline Industry-based Dimensions and Their Measures**

Baggage Handling (alphas = .68, .71)^a

1. Airline baggage handling is prompt and efficient.
2. Airline interline agreements work well for the consumer.
3. Airline check-in is efficient.

Bumping Procedures (alphas = .70, .67)

4. Airline bumping procedures are unfair/inconvenient. (-)
5. Airline bumping procedures provide inadequate compensation for the trouble caused to the consumer. (-)
6. Information provided by airline at airport is inadequate. (-)

Operations and Safety (alphas = .70, .67)

7. Ticket and reservations procedures prior to arrival at the airport are adequate.
8. Airline is safe.
9. Airline selects the right equipment for trips.
10. Amenities provided by airline are important to the comfort of passengers.
11. Airline distinguishes between each class through service

In-flight Comfort (alphas = .82, .80)

12. Airline seats have good pitch.
13. Airline seats are wide enough.
14. There is enough room in the aisles.
15. The layout of seats in aircraft is just right.
16. Airline food and beverage service is good.

Connections (alphas = .86, .81)

17. Airline offers sufficient flight frequency.
18. Airline offers flights at right times of the day and night.
19. Airline correctly coordinates connections.
20. Airline offers sufficient non-stop flights.
21. Airline offers sufficient connecting flights.

^a Cronbach's alphas for the U.S. and Korean samples, respectively.

^b (-) indicates that the measure is reverse scored.

THE CIVIL AVIATION SECTOR IN LEBANON – PART I: INSTITUTIONAL REFORMS

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ABSTRACT

Civil aviation is one of the key contributors to a successful economic system. This has been recognized within Lebanon, which is undertaking developing a new civil aviation strategy encompassing a program of organizational reform, coordinated internationally, to meet the challenges of the new century. Such strategy is vital, as it will provide a coherent vision for the sector, compliment the extensive investments deployed by Lebanon in its aviation infrastructure, and guide future planning and investments. The proposed Civil Aviation Strategy for Lebanon has two major components: (a) institutional reform aiming at creating effective overall legal and regulatory frameworks in-line with current international best practice and (b) implementation of liberalization measures and open skies policy. This paper aims to: (a) present Lebanon's current institutional arrangements, (b) review the institutional arrangements in key select countries (in order to define current trends in best institutional practice), (c) discuss the proposed institutional reforms (which are at the basis of Lebanon's Draft Civil Aviation Reform Law) while showing that they conform with the identified best institutional trends, and (d) outline an implementation plan. The Draft Law has been approved by the Council of Ministers and now awaits Parliamentary endorsement.

INTRODUCTION

Prior to the start of the civil disturbances in 1975, Lebanon's civil aviation and tourism sectors flourished. Beirut International Airport (BIA) handled 2.5 million passengers in 1975 and served as the gateway to the Gulf countries. The national airliner [Middle East Airlines (MEA)], owned a fleet of 20 planes and dominated the skies of the Middle East. Over the next 15 years of conflict, Lebanon's civil aviation sector was decimated. BIA suffered major destruction along with prolonged periods of closure

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while MEA sustained severe ridership and financial losses. MEA shrunk down to a secondary airliner, leasing nine aircraft only and incurring annual losses requiring a total Treasury subsidy of about USD 400 million. Hiring in the Directorate General of Civil Aviation (DGCA) was minimal, resulting in its employment falling to 340 employees from an allocated 1,100 total. Over the same period, the Gulf countries enjoyed increased oil revenues since 1974 and were developing their own aviation sectors with ambitious airport development plans and major fleet expansion. BIA and MEA had clearly lost their roles and dominance. Following the cessation of military activities, a national plan for the development of the civil aviation sector had to be formulated and implemented. Such multi-component plans called for several changes (Baaj & Chaouk, 2000).

1. Investments in the aviation infrastructure through rehabilitating BIA and expanding its capacity to handle 6.0 million passengers annually should be made. The program, costing about USD 500 million, has been completed and involved the construction of a new terminal building and a new runway.
2. The complete re-write of the Aviation Safety Act should be completely rewritten so as to modernize aviation rules and regulations concerning safety and operations. This came per recommendation of International Civil Aviation Organization (ICAO), following its safety oversight check.
3. All equipment at BIA should be upgraded to enhance the level of safety and as required by BIA's rehabilitation program.
4. Institutional reform of the sector should be completed including the establishment of an independent regulatory authority.
5. A national civil aviation strategy for the sector's growth and development should be formulated, including the restructuring of the national airliner and the possibility of adopting an open skies policy.

External assistance was provided to DGCA by the following organizations.

1. The International Civil Aviation Organization (ICAO) carried out a study of the sector, an oversight safety check. ICAO is currently developing and updating the full set of rules, regulations, and procedures for airworthiness and licensing.
2. The European Investment Bank (EIB) provided funding for the runway and airport facilities rehabilitation and equipment. The funding contract required Lebanon to set up a commercial enterprise to operate the BIA.

3. The Government of France funded nine contracts as part of the French-Lebanese Cooperation Protocol. The contracts were mostly for meteorological, air traffic control, radar and aeronautical information services equipment, software and training, and technical assistance for implementing institutional reforms. Technical studies were carried out by Aéroports de Paris - Institut du Transport Aérien (ADP/ITA).
4. The World Bank funded a study to formulate a civil aviation strategy for Lebanon. Prior to the completion of the study, the new Lebanese Government, which took office in October 2000, announced the adoption of an open skies policy based on fully liberal third, fourth, and fifth freedom rights. This made Lebanon the first country in the Middle East region to adopt such policy, long known for its resistance to open skies (for status of open-skies policy adoption in other regions, see Morrell, 1998; Toh, 1998, and Findlay, Sien, & Singh, 1997). The study's recommendations supported the government's decision on open skies policy adoption and quantified the expected economic benefits of such policy under various traffic growth scenarios.
5. The International Finance Corporation (IFC) provided investment banking services in the context of the potential privatization of the national airliner MEA.

The focus of this paper is not on the open skies policy adoption and its projected benefits (this would be the subject of a separate paper). It is on another key component of Lebanon's civil aviation strategy, namely, the sectoral institutional reforms. The next section presents the current institutional arrangements in Lebanon. This is followed by reviews of the existing institutional arrangements in select countries, with the aim of identifying current trends in institutional best practice. These countries are the United States of America, France, Canada, the United Kingdom, and New Zealand. The proposed institutional arrangements for Lebanon and demonstrates that they conform to the identified current trends in institutional best practice will be discussed along with reviews of the regulatory characteristics of the proposed General Authority for Civil Aviation (GACA). The final section outlines the proposed implementation plan and its risks and challenges and concludes with some remarks.

CURRENT INSTITUTIONAL ARRANGEMENTS IN LEBANON

The DGCA currently under the Ministry of Public Works and Transport is responsible for the civil aviation sector in Lebanon. It is charged with the

following higher level missions: (a) supervising air transport, (b) managing the airspace and ensuring the safety of air navigation, (c) operating the BIA, (d) investigating incidents and accidents, (e) supplying meteorology information to users outside of civil aviation, and (f) performing support functions. DGCA is comprised of seven directorates and departments as shown in Figure 1 (Directorate General of Civil Aviation, 1971).

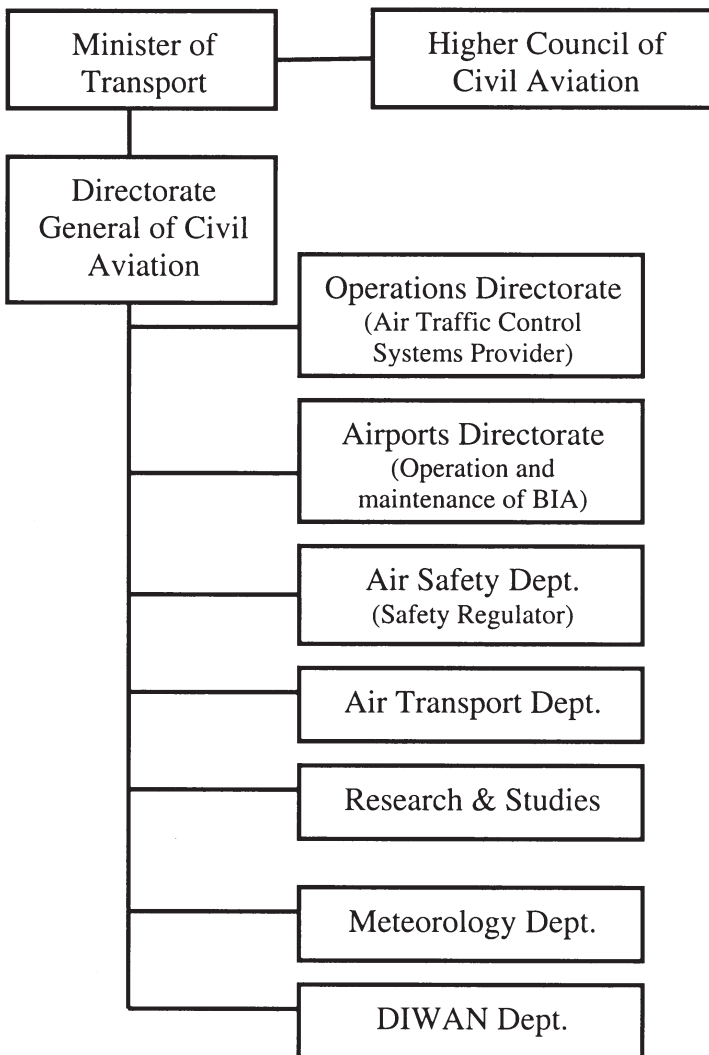


Figure 1. Current Institutional Arrangements in Lebanon

1. The Technical Operations Directorate is responsible for the provision of air traffic services, operation of telecommunications, and the maintenance of aids to navigation and telecommunications, telephone, and electrical equipment.
2. The Airports Directorate is responsible for the operation and maintenance of BIA.
3. The Air Safety Department consists of three sub-departments overseeing aircraft operations, airworthiness, and personnel licensing.
4. The Air Transport Departments consists of two sub-departments overseeing international agreements and legal and economic studies.
5. The Research and Studies Department is responsible for coordinating with international organizations such as ICAO.
6. The Meteorology Department consists of three sub-departments of observation, forecasting, and climatology.
7. The Diwan Department is in charge of the administration, accounting, legal affairs, revenue, documentation and archiving, and purchasing supporting functions.

In addition to the DGCA, a Higher Council for Civil Aviation (HCCA) was established as an advisory body (to the Minister) proposing economic policy for civil aviation, giving opinions on the requests for creation and operation of airlines as well as bilateral agreements. It has representation of all relevant ministries and the two national passenger and freight airlines (who attend but do not vote). Under the current institutional arrangements, DGCA is a monopoly responsible for policy, regulation, airport operation and air traffic control service provision, as well as accident investigation. Transparency has been lacking at all levels and there are no formal mechanisms for competition and dispute resolution. Thus, the need was evident to propose new institutional arrangements for the civil aviation sector that would be in line with current trends in institutional best practice.

REVIEWED INSTITUTIONAL ARRANGEMENTS IN SELECT COUNTRIES

In order to propose new institutional arrangements for Lebanon's civil aviation sector, a series of case studies were performed in order to identify the advantages and disadvantages of the various approaches in different select countries. The countries studied were the United States of America, France, Canada, the United Kingdom, and New Zealand. The goal of

reviewing the institutional arrangements in these countries was to identify the current trends in institutional best practice, so as to ensure that such trends are met by the proposed reform institutional arrangements for Lebanon. These trends related to policymaking, the regulatory framework, the provision of services, competition, and the appeals process. Three broad areas of regulation were examined: (a) economic regulation involving air transport licensing, fares and tariffs' setting, and negotiation of international agreements; (b) safety regulation involving flight operations, airworthiness, personnel licensing, airports standards, and air traffic service standards; and (c) airspace regulation to ensure that an efficient service is provided to meet reasonable demand.

On the operations side, the focus was on the ownership and operation of airports and the provision of air traffic control (ATC) services. The discussion and figures that follow have been adapted from a study that aimed to formulate a national civil aviation strategy for Lebanon (Booz-Allen & Hamilton, 2001).

In the United States of America airports are generally publicly owned and operated on a non-for-profit basis. Charges are typically set by legally binding User Agreements. There is no federal regulation of charges and, where these agreements do not exist, disputes sometimes go to the courts. The Federal Aviation Administration (FAA) of the U.S. Department of Transportation (USDOT) is the safety regulator and the provider of air navigation services. Its Office of Accident Investigation liaises with the National Transportation Safety Board to investigate air accidents. Anti-competitive behavior in the aviation sector (like other sectors of the economy) is investigated by the Justice Department's Anti-Trust Division. The Office of Aviation Negotiations of the Department of State deals with international aviation affairs while coordinating with the FAA's Office of Policy, Planning, and International Aviation. The aviation industry is regularly reviewed by the General Accounting Office which reports to Congress. The advantages of the U.S. system are a clear separation of economic regulation and service provision, transparency in regulation, and strong institutions for research and investigation. However, the FAA simultaneously operates the air navigation services, regulates its safety, and investigates its accidents. Additionally, the fact that air navigation services are free at the point of delivery implies weak market signals. Figure 2 shows the institutional arrangements in the U.S.

France has a highly centralized institutional framework. The DGCA (acting through different directorates) is: (a) the economic policy maker, economic regulator, and international agreements' negotiator (Air Transport Directorate), (b) the safety regulator (Safety Directorate), and (c) the provider of air traffic control navigation services (Directorate of Air

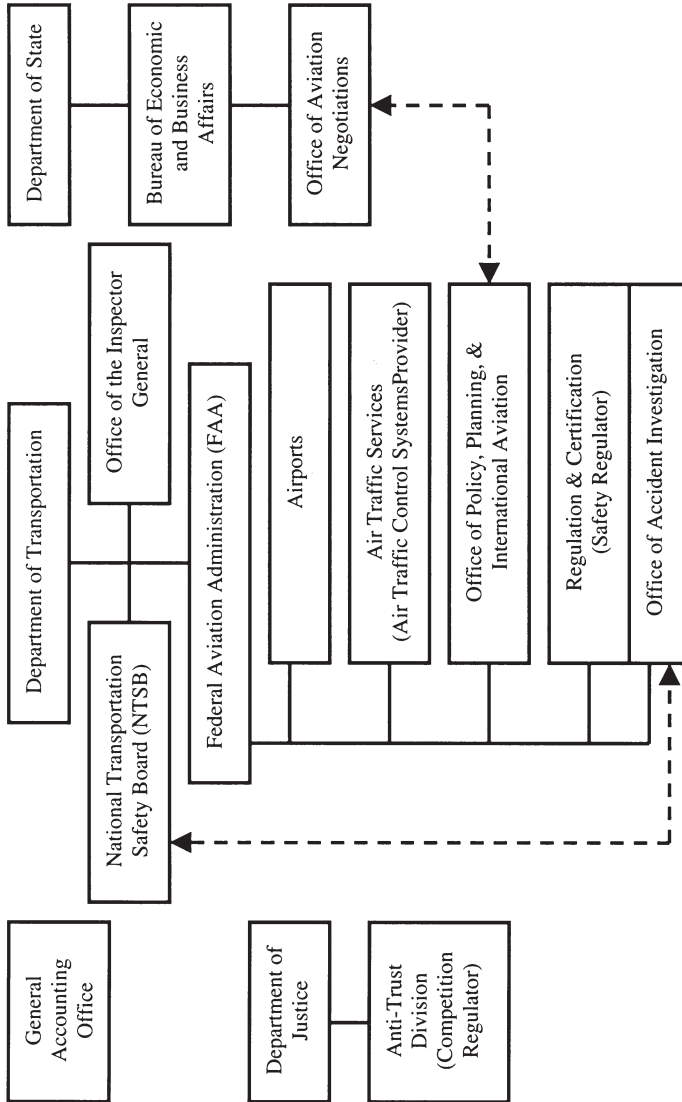


Figure 2. Institutional Arrangements in the Civil Aviation Sector in the United States of America

Note: From *Civil Aviation Strategy*. Technical Report submitted by Booz-Allen & Hamilton. (2001). Beirut: Ministry of Public Works and Transport. Copyrighted 2001 by Ministry of Public Works and Transport. Adapted with permission.

Navigation). Airports are publicly owned and are supervised by DGCA's Airports Directorate. Accident investigation is conducted by the Accident Investigation Bureau which reports directly to the Minister of Transport (who authorizes aviation charges). While infrastructure projects have been timely completed to match the demand, regulation of the sector has been producer-led rather than user-led and political interference has been high due to the centralized structure of the sector. Figure 3 shows the institutional arrangements in France.

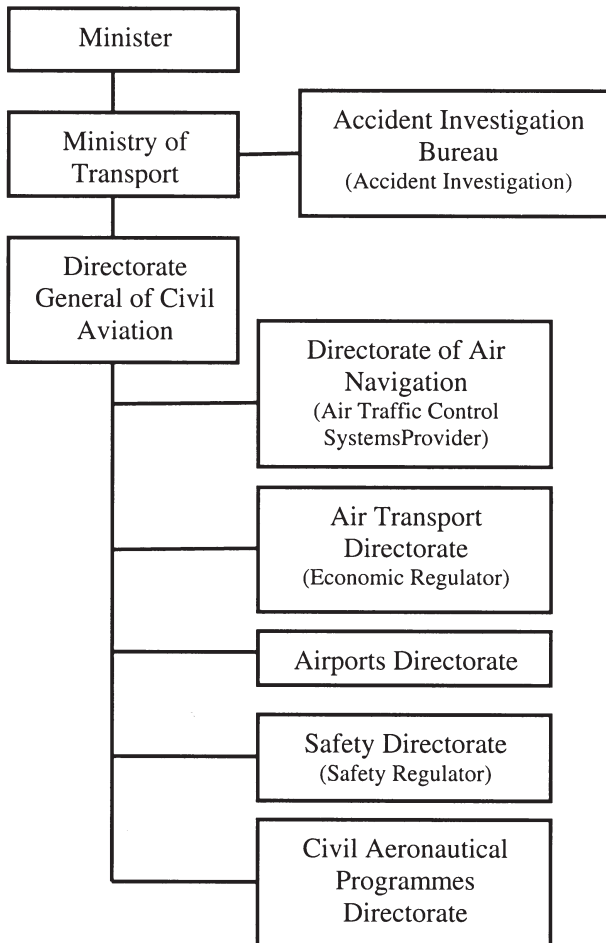


Figure 3. Institutional Arrangements in the Civil Aviation Sectors in France

Note: From *Civil Aviation Strategy*, Technical Report submitted by Booz-Allen & Hamilton. (2001). Beirut: Ministry of Public Works and Transport. Copyrighted 2001 by Ministry of Public Works and Transport. Adapted with permission.

Canada uses a mix of direct governmental regulation of safety and general transport and competition authorities for economic regulation. The Canadian Transport Agency (established in 1997) is the economic regulator and the appeals body for the air navigation charges. The Canadian Competition Bureau of the Federal Ministry of Industry is the competition regulator. Air navigation services are provided by Nav Canada, a private not-for-profit corporation, which has representatives of all stakeholders in its Board of Directors. This arrangement has been reported to be a success for all parties involved (Betancor & Rendeiro, 2000). The Civil Aviation Tribunal is the appeals body for Ministerial decisions. The Federal Ministry of Transport is the safety regulator while accident investigation is conducted by the Transportation Safety Board. The 26 essential airports identified within the National Airports System (NAS) are leased to Canadian Airport Authorities. The leasing of NAS airports has given them greater commercial focus, however, the not-for-profit status of Nav Canada results in weak efficiency incentives. Figure 4 shows the institutional arrangements in Canada.

In the United Kingdom the Civil Aviation Authority (CAA) under the Department of Environment, Transport & the Regions (DETR) is the economic regulator (Economic Regulatory Group, ERG) and the safety regulator (Safety Regulation Group, SRG). Air navigation services are provided by National Air Traffic Services (NATS), a public corporation. NATS is being considered for transformation to a public/private partnership which would be regulated by the CAA's ERG. The Competition Commission of the Department of Industry and Trade is the competition regulator. The three London airports and the four Scottish airports have been privatized and are owned and operated by the British Airports Authority (BAA), a private shareholding company regulated by the CAA's ERG. Accident investigation is the responsibility of the Air Accidents Investigation Branch of DETR. Such institutional arrangements have led to a user-driven system that ensured full separation of transparent regulation from service provision, albeit at a costly regulatory framework due to its large overhead. Figure 5 shows the institutional arrangements in the U.K.

New Zealand presents a clear example of light-handed regulation resulting from the country adopting a liberal policy in an effectively free market. The New Zealand Commerce Commission of the Ministry of Commerce is the economic regulator and competition regulator. Air navigation services are provided by Airways Corporation, a public corporation owned jointly by the Ministry of Finance and the Ministry of State-Owned Industries and is considered the nation's best-managed public enterprise (Betancor & Rendeiro, 2000). The CAA is the safety regulator and accident investigation is carried out by the independent Transport

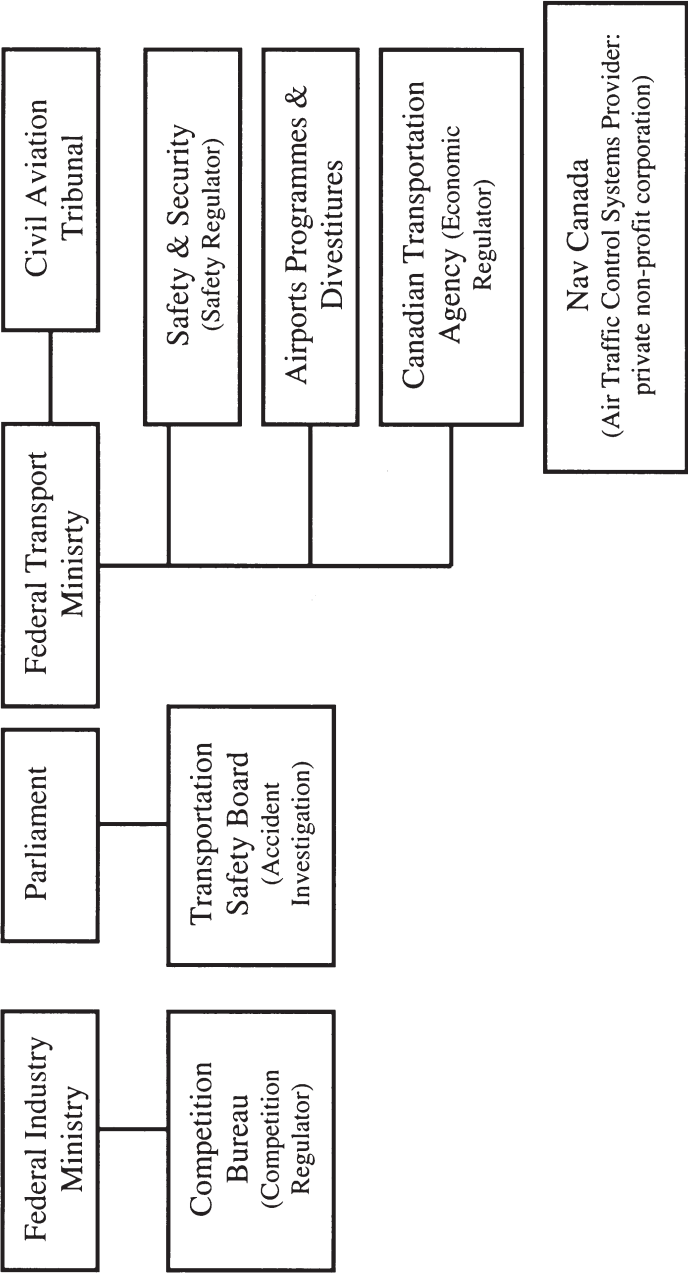


Figure 4. Institutional Arrangements in the Civil Aviation Sectors in Canada

Note: From *Civil Aviation Strategy*, Technical Report submitted by Booz-Allen & Hamilton. (2001). Beirut: Ministry of Public Works and Transport. Copyrighted 2001 by Ministry of Public Works and Transport. Adapted with permission.

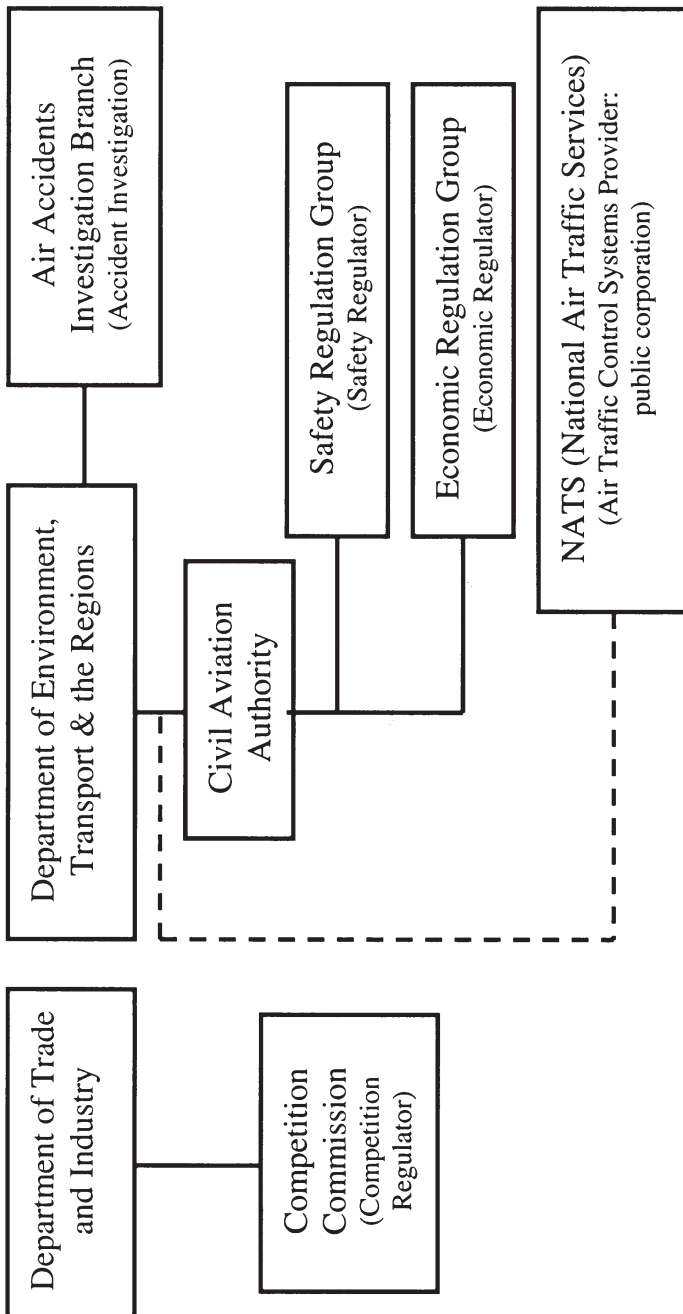


Figure 5. Institutional Arrangements in the Civil Aviation Sector in The United Kingdom

Note: From *Civil Aviation Strategy*, Technical Report submitted by Booz-Allen & Hamilton, (2001). Beirut: Ministry of Public Works and Transport. Copyrighted 2001 by Ministry of Public Works and Transport. Adapted with permission.

Accident Investigation Commission (TAIC). The Minister promulgates the civil aviation rules and meets regularly with the CAA Chair and Director. The CAA reports quarterly to the Minister (who also conducts a performance review of the CAA every three years) and annually to Parliament. CAA decisions can be appealed in court, while Airways Corporation's charges can be appealed in court or the Commerce Commission can be approached for assistance. Airways Corporation has been efficient and commercially-focused, however, the light regulation has led to airport/airline disputes that necessitated Government intervention. Figure 6 shows the institutional arrangements in New Zealand.

Table 1 summarizes the institutional arrangements in the five selected countries.

The above review indicated that the current trends in best institutional practice call for (a) the separation of policymaking, regulation, and service provision; (b) regulation to have the means to enforce decisions while establishing mechanisms that ensure consultations with all stakeholders [additionally, regulators should demonstrate independence with a reasonable amount of discretionary powers, autonomy and expertise, and accountability (Estache and de Rus 2000)]; (c) corporatization of the operation of airports and of the air navigation services (and where possible, their eventual separation); (d) an appeals process that is independent, transparent, and efficient in addressing the disputes between any of the actors within the institutional framework; (e) competition issues to be dealt with through establishing formal mechanisms; and (f) accident investigation to be independent from both the regulator and the service providers.

These trends have been endorsed by the Minister of Public Works and Transport (Baaj, 2001) and are at the foundation of all ministerial reform plans formulated for other transport sub-sectors, such as land transport (Baaj, 2000) and maritime transport (Baaj & Issa, 2001). As such, it was necessary that the proposed new institutional arrangements in Lebanon's civil aviation sector comply with the above identified trends.

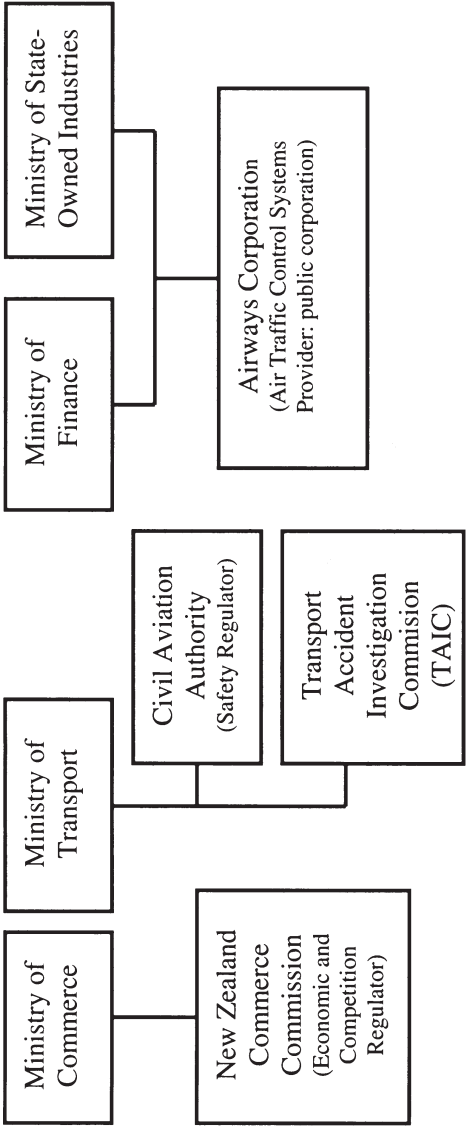


Figure 6. Institutional Arrangements in the Civil Aviation Sector in New Zealand

Note: From *Civil Aviation Strategy*, by Booz-Allen, ? and Hamilton, ?. 2001 Beirut: Ministry of Public Works and Transport. Copyrighted 2001 by Ministry of Public Works and Transport. Adapted with permission.

Table 1. Institutional Arrangements in the Civil Aviation Sectors in Select Countries

Institutional Arrangement	USA	France	Canada	UK	New Zealand
Economic Regulator	Unregulated charges (set by User Agreements)	Directorate General of Civil Aviation (Air Transport Directorate)	Canadian Transportation Agency	Civil Aviation Authority (Economic Regulatory Group)	New Zealand Commerce Commission
Safety Regulator	Federal Aviation Administration	Directorate General of Civil Aviation (Safety Directorate)	Ministry of Transport (Safety & Security)	Civil Aviation Authority (Safety Regulation Group)	Civil Aviation Authority
Operation of Airports	Regional airports, publicly owned (non-profit)	Regional airports, publicly owned companies	26 essential airports are leased to Canadian Airport Authorities	British Airports Authority, private company.	Airport companies
Provision of ATC	Federal Aviation Administration	Directorate General of Civil Aviation (Air Navigation Directorate)	Nav Canada (private not-for-profit corporation)	National Air Traffic Services, public corporation	Airways Corporation, publicly-owned corporation
Accident Investigation	Federal Aviation Administration & National Transportation Safety Board	Accident Investigation Bureau	Transportation Safety Board	Department of Environment, Transport & the Regions (Air Accidents Investigation)	Transport Accident Investigation Commission
Competition	Department of Justice, Antitrust Division	Directorate General of Civil Aviation	Federal Industry Ministry, Competition Bureau	Dept. of Trade and Industry, Competition Commission	New Zealand Commerce Commission
Appeal Process	Users' Agreements, disputes resolved in courts	Directorate General of Civil Aviation	Civil Aviation Tribunal (for Minister decisions) and Canadian Transportation Agency (for Nav Canada charges)	Courts	Courts or Commerce Commission

PROPOSED INSTITUTIONAL ARRANGEMENTS IN LEBANON

In compliance with the above identified trends in best institutional practice, the Draft Civil Aviation Reform Law (Ministry, 2001) calls for the replacement of the existing DGCA with: (a) an independent sectoral regulator (the GACA) and (b) a separate joint stock company (the Beirut International Airport Company, BIAC) for airport operations, meteorological services, and air traffic service provision, both at the airport and area control. It was noted that the provision of air traffic services was likely to remain a relatively small activity, and as such, it would not be cost effective to separate it from the airport operations. However, in order to ensure transparency and the absence of cross-subsidization, both airport operations and air traffic control operations must have clearly separated accounting systems and a reliable method of allocating shared costs. Additionally, the Draft Law called for accident investigation to become the responsibility of an independent office reporting directly to the Minister of Public Works and Transport.

GACA would become both the safety and economic regulator. As the safety regulator, it would oversee flight operations, airworthiness, personnel licensing, airports' standards, and air traffic services standards. As the economic regulator, it would oversee air transport licensing, fares and tariffs, and international agreements. GACA would also set the general principles of air transport policy (including the management and utilization of Lebanese airspace), subject to the general directions and guidelines set by the Minister of Public Works and Transport.

BIAC would be established as a joint stock company, initially fully owned by the Lebanese Government. This would be a corporatization that may lead in the future to privatization, should the Government decide that it would sell its shares, in accordance with the recently approved national Privatization Law. The corporatization (as required by the EIB contract) allows operation outside of government civil service constraints and enables commercial freedoms in the provision of services, as long as BIAC has management and financial control devolved from government. BIAC's management must provide GACA with the necessary information (on a regular basis) which would enable effective performance monitoring. It should also take all the necessary measurements that are need to protect and preserve the environment. The Draft Law also allowed for the establishment of other corporations to operate Lebanon's other airports (such as the Quleiaat Airport in North Lebanon). Such corporations would also be regulated by GACA. Figure 7 shows the proposed institutional arrangements for the sector.

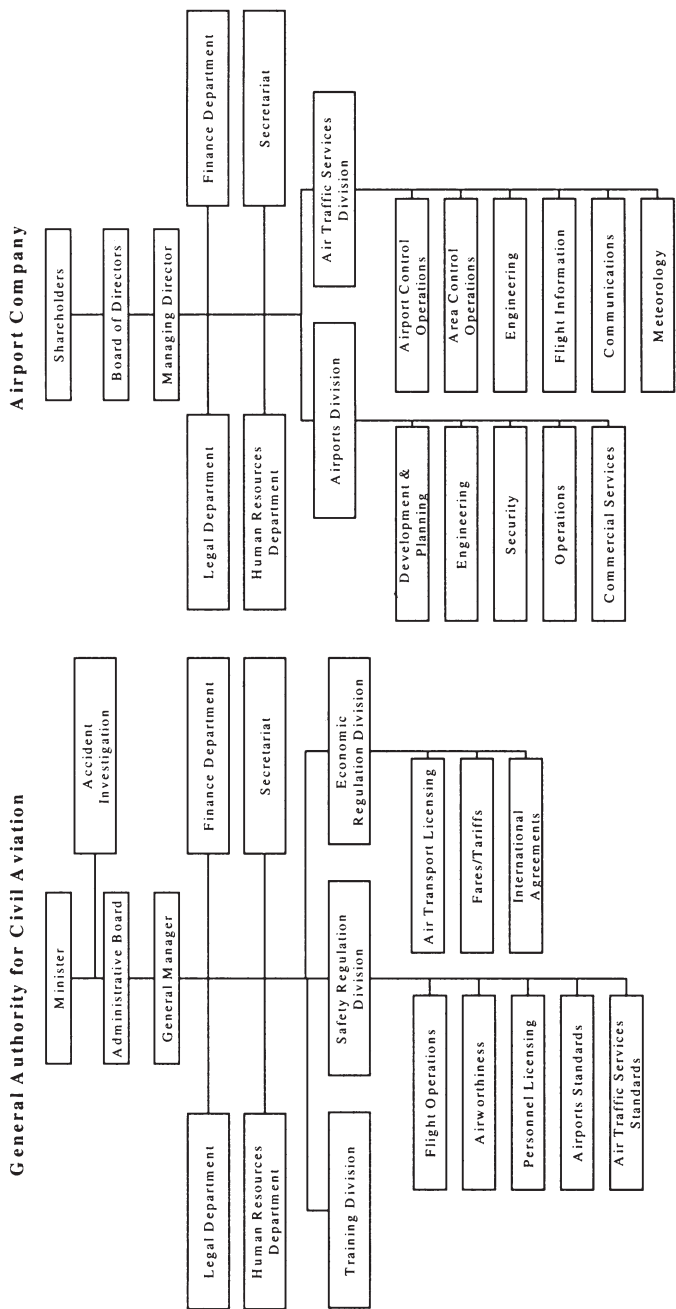


Figure 7. Proposed Institutional Arrangements in Lebanon

REGULATORY CHARACTERISTICS OF THE PROPOSED GACA

The main desirable characteristics usually recognized for a regulator are (a) independence with a reasonable amount of discretionary powers, (b) autonomy and expertise, and (c) accountability (Estache & de Rus, 2000). According to the Draft Plan the proposed GACA meets these requirements. The proposed GACA should (a) be at arm's length from both the political pressures (usually coming from the ministries) and the regulated enterprises; (b) have its regulators chosen on the basis of professional rather than political criteria and ensure that they would be protected from arbitrary removal during their appointment term; and (c) have regulators with enough discretionary power to make and enforce the right decisions without any risks of interference (Ministry, 2001). Such risks are minimized if clear rules are spelled out in the contracts and in the chart creating the GACA (Estache & de Rus, 2000). These requirements were satisfied by the proposed Draft Civil Aviation Reform Law which (in article 8) required that all its five regulators be university graduates with degrees in any of the following majors: airport management, business administration, economics, law, engineering, and aeronautical sciences. The chair of the board of regulators would be a full-time manager with at least five years of experience in the civil aviation sector. All regulators would be appointed for an initial period of five years which may be renewable (Ministry).

The proposed GACA needs to (a) have access to its own funding resources (through imposing levies on the regulated firms and/or the consumers of the regulated services) and not rely on budgetary transfers which are decided by politicians; (b) be able to recruit the best experts and remunerate them adequately (this typically implies exemption from civil service pay scale and recruitment procedures); (c) be able to subcontract certain activities when the required skills are unavailable locally; and (d) have specific instruments that enable the effective monitoring of compliance and enforcement (such as penalties that are imposed according to clearly defined rules) (Estache & de Rus, 2000). These requirements were satisfied by the Draft Civil Aviation Reform Law which (in article 10) allowed GACA to generate its own resources (by levying fees on the regulated enterprises) and exempted it from civil service pay scale and recruitment procedures (Ministry, 2001).

Accountability requires transparency in the decision making process and an operating environment subject to simple and clear procedural rules, including stipulated deadlines for reaching decisions, detailed justifications for decisions, nonpolitical reviews of decisions, adequate opportunities for all concerned parties to be heard through public hearings, and venues for appeals. Accountability can be enhanced by having several

(three to five) regulators rather than a single one (Estache & de Rus, 2000). These requirements were satisfied by the Draft Civil Aviation Reform Law which (in articles 8 and 13) emphasized accountability and provided the regulated enterprises with the right to appeal GACA's decisions in courts (Ministry, 2001).

PROPOSED IMPLEMENTATION PLAN

ADP/ITA had in the past provided technical assistance to the Ministry of Public Works and Transport (under contracts funded by the French-Lebanese Cooperation Protocol). Recently, ADP/ITA submitted a technical assistance proposal to the Ministry outlining an implementation plan for the proposed reforms (ADP/ITA, 2001). The proposal has been accepted and as a result ADP/ITA will carry out the multi-year implementation plan enabling the transition from the existing institutional arrangements to the proposed reform ones. The plan consisted of the following tasks.

1. Develop the overall plan for the creation of GACA and BIAC.
2. Define the detailed organizational and functional structure for GACA and BIAC. For BIAC, this requires defining its constitution (which should comply with the requirements of the Privatization Law, identifying the government shareholding rights together with the composition of the Administrative Board). It also requires defining the licences under which BIAC will operate.
3. Analyze the organizational and functional structure of the existing DGCA, in order to carry out the gap analyses (Task 7).
4. Perform financial audit and establish pro-forma Profit and Loss accounts. A thorough financial audit of existing operations would be performed to identify revenue streams, identify and allocate costs to the various functions within the organization, determine the asset base, profit and loss accounts, financial liabilities and the balance sheet (this process will be critically important in establishing the future business plans for both GACA and BIAC).
5. Perform Gap analyses through comparing the requirements identified for GACA and BIAC with the capabilities available in the existing DGCA, in order to identify gaps and surpluses (the output of this task will define training, recruitment and redundancy requirements and would result in the initiation of the necessary training and recruitment programs).

6. Define the migration plans from the existing DGCA to the new GACA and BIAC ensuring a smooth and effective transition.
7. Manage and implement the migration plan from the existing structure to the new structures.
8. Create the body responsible for accident investigation.
9. Monitor the initial performance of the new organizations in order to identify problems and propose potential solutions.

The proposed implementation plan is not without its risks and challenges. The Draft Civil Aviation Reform Law has yet to clear Parliament. Developing and issuing the proper detailed implementing rules and regulations (establishing GACA and BIAC with their desirable features and characteristics) require a strong political commitment from the Government and the Minister to carry through with the reforms. Gap analyses upon completion will indicate the training, recruitment, and redundancy requirements, a process that clearly needs to be adequately funded and well protected from political interference. The proper leadership and talent need to be recruited at the helm of GACA to successfully manage and implement the migration plans from DGCA to GACA and BIAC.

This paper aimed at providing an overview of a third world country's plans to develop and invigorate its civil aviation sector following years of poor performance. This may be achieved through the adoption of a sectoral strategy that enables its transition from a non-transparent highly centralized rigid structure to a more liberalized one, whose reformed institutional arrangement matched the current trends in best institutional practice. The proposed strategy has two major components: (a) institutional reform aiming at creating effective overall legal and regulatory frameworks in-line with current trends in international best practice and (b) implementation of liberalization measures and open skies policy. The current trends have been identified through the examination of the institutional arrangements of select countries and Lebanon's proposed sectoral reforms have been shown to comply with such trends. A multi-year implementation plan has been proposed and is being carried out with technical assistance from France. The risks and challenges of successful execution of such plan have been pointed out and relate principally to political commitment and political non-interference.

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FUTURE TRENDS IN BUSINESS TRAVEL DECISION MAKING

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ABSTRACT

This research surveys twenty large companies and their travellers to identify and evaluate the effects of pressures on the business travel market in the future. The influence of the following areas on the decision making process are addressed: (a) Corporate travel policies & increasing professionalism in corporate purchasing; (b) The development of global strategic airline alliances; (c) The emergence of low cost airlines on short haul markets; and (d) The development of internet based booking tools and travel agency IT.

The survey shows differences in views between travel managers and travellers with regard to corporate travel policies. While travel managers see policy rules, travellers interpret these as guidelines, indicating travel managers will need to take further actions to exercise true control of travel budgets. The data shows that companies are more likely to prescribe a class of airline ticket, than the choice of airline itself. Corporate hierarchical bias in travel policies is still common both for short and particularly long haul flying.

Other findings show that while travel managers believe that their companies are likely to sign global deals with strategic airline groups within a five year period in a bid to consolidating spending, they also believe that nearly a third of short haul flying will be taken with low cost carriers, indicating further penetration in this business travel market by these carriers.

The paper also provides other predictions about the business travel market, based on the survey findings.

INTRODUCTION

The business travel market saw a marked change throughout the 1990s. The introduction of competitive pressures in the marketplace, attributable to the liberalisation of many markets, has lead airlines to attempt to increase market share and network coverage while trying to reduce their costs. At the same time, companies have been increasingly recognising the

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importance of travel expenditure to their businesses, and have been making efforts to reduce this cost element. This article reports the finding of a study to identify future trends in business-travel decision-making within the U.K.

The business travel market remains vital to the airline industry. Within the European Union (EU), business travel accounts for 48 percent of all air travel passenger trips (CAA, 1996). One of the main problems for airlines is not the volume of business travel (which has remained consistently high) but the decline in fares that business travellers and their companies are prepared to pay. The IATA Corporate Air Travel Survey shows that a large proportion of business travellers are no longer buying business class tickets, and that many are purchasing highly discounted economy tickets (IATA, 1999). This downgrading activity has led in part to the dramatic 32 percent fall in real yields reported by the International Civil Aviation Organisation for the ten years between 1988 and 1998 (ICAO, 1999).

The liberalisation of the air transport in the EU has led to the development of a more highly competitive market. The U.K. CAA (CAA, 1998) has noted fairly modest increases in competitive activity across all routes; however, the densest routes have experienced quite dramatic increases in competition. The most obvious evidence of the introduction of competitive pressures in the market has been the introduction and rapid development of low-cost airlines such as Ryanair, EasyJet, Go, and Buzz. These airlines have reported that significant proportions of their passengers are travelling for business purposes. Go has indicated that about 30 percent of its passengers are business travellers, while EasyJet reports over 50 percent of passengers on some of its routes are travelling for business purposes (Mason, et al, 2000).

Earlier research showed that travellers that work for small and medium sized companies are more likely than those that work for very large companies to choose a low-cost airline service (Mason, 2000). The research detailed in this article investigates the reasons for those differences in behaviour and evaluates whether companies that seek to reduce travel expenditure will use low-cost airline services more or will continue with present purchase behaviour.

In more highly competitive markets, traditional airlines have sought means in which to defend their position in the market, grow in new markets, and reduce their costs. During the 1990s the industry has seen a dramatic rise in the number of alliances. According to the annual Airline Business Alliance Survey (Airline Business, 2000), in 2000 there were 579 alliance agreements in place, up from 280 agreements in 1994 when the survey was first conducted. Five major alliances (Star, Oneworld, Qualiflyer, Sky Team, and Wings) now account for some 60 percent of all air travel (Airline Business, 2000). While a large body of literature has developed over a short

period of time that investigates the benefits (and to a lesser extent the costs) of strategic airline alliances from a supply side perspective (see for example *Journal of Air Transport Management*, 1997), relatively little work has been undertaken that looks at the demand side. This research aims to go some way to rectify this imbalance by investigating the influence of strategic alliances on the purchase decisions of business travellers and travel managers.

While the airline industry has been changing, companies that demand business travel have also been taking greater control of their expenditure on travel. In many companies, travel expenditure is the second largest controllable cost item, behind only labour (Collis, 2001). Consequently, the role of travel manager in many companies has changed from a general administrative role responsible for booking travel to one of managing this highly significant element of expenditure. The 1990s saw the development of organisations for travel managers (such as the National Business Travel Association in the United States and the Institute of Travel Management in the U.K.). These organisations have developed training programmes to increase the skills level of travel managers in their member companies. The research presented here also assesses the effect of corporate travel policies and increasing professionalism in corporate purchasing.

Distribution costs can account for some 20 percent of airlines' total expenditure, ranking again as the second largest cost item after labour (IATA, 1999). The principal distribution channel for airlines is via travel agents. Commission costs account for about 10 percent of costs, while ticketing costs the airlines 2-3 percent, fees to computer reservations systems (2 percent) and credit card fees (2-3 percent) take up the rest of the costs. Consequently, airlines have been seeking methods to lower the costs of distributing their products-costs that have included cutting commission payments and trying to seek a more direct relationship with their customers. The development of Internet technology is a potential source of structural change in the distribution channel and needs to be assessed.

The research presented in this article, therefore, addresses the relationships between travellers, travel managers, airlines and business travel agents. These relationships have been changing: (a) as airlines seek to reduce their distribution costs, and therefore seek to increase their direct contact with travellers and companies; (b) as corporates seek single global travel agency deals; and (c) as the growth of Internet-based information and booking systems allow companies to exercise greater control over their travelling executives.

Beyond the distribution channel, information technology such as video-conferencing, e-commerce, and Internet communication is becoming increasingly commonplace in the workplace. The research also investigates

whether this technology is viewed by travellers and travel managers as an effective substitute to business travel.

RESEARCH OBJECTIVES

The introduction has highlighted a number of areas of change in the business travel market. The development of airline alliances and the expansion of low-cost airlines have affected the supply side of industry. The demand side of the industry has seen the development of an increasingly professional attitude towards the management of travel expenditure. The supply chain is also in a period of change as airlines seek to reduce their distribution costs, leading travel agents to reassess their roles. Internet technology also provides many new distribution possibilities.

This research seeks to identify and evaluate the effects of these pressures on the business travel market in the future. It addresses the influence of the following areas on the decision making process are addressed:

- Corporate travel policies and increasing professionalism in corporate purchasing;
- The development of global strategic airline alliances;
- The emergence of low-cost airlines on short-haul markets;
- The development of Internet-based booking tools and travel agency IT;
- Substitution of air travel by other forms of communication.

METHODOLOGY

Literature has generally reported surveys of individual air travellers (Nako, 1992; Mason & Gray, 1995). However, Mason (1999) has also highlighted the effect of corporate involvement in the purchase decision, and therefore the effect of corporate decision-making should be considered in evaluating buyer behaviour. While the views of both individual traveller and corporate travel managers have been considered together (Stephenson & Bender, 1996), surveys have not been performed on travellers and travel managers from the same firms. It has not been possible, therefore, to compare and validate the results of both sets of surveys.

For this study, corporate travel managers and travellers of the same organisations were surveyed. The Institute of Travel Management, the major corporate travel management association in the U.K., provided an email list of companies that are major purchasers of air travel. Matched questionnaires were developed that were designed to investigate

differences in opinions between travel managers and the travellers that work for their companies. The purpose of survey was profiled in the Institute's monthly magazine, and follow up emails were sent six weeks after the first electronic posting along with a reminder in the magazine. The travel managers of twenty companies responded to the survey that was sent electronically. All the companies had more than 1000 employees, and together they spent some £95 million on air travel in 1999. This represents about one percent of the total outbound U.K. business travel market (estimated at £8.72 billion by Mintel, 2000). The large company sector of the market is estimated at 46 percent of the entire market (CATS, 1999) and so the survey represents some 2.4 percent of this market. Forty-four traveller surveys were returned from 16 of the companies that had completed the travel manager survey. Higher responses for both the travel manager and traveller surveys would have been beneficial; however, the results are viewed as being representative of the large company sector of the business travel market in the U.K.

RESULTS

Company and Traveller Demography

The companies in the survey were all multinational organisations. The average corporate size was 37,000 employees. The organisations were generally European-based, and the average size of the local organisation (either U.K. or European depending on the structure of the company) was 18,600 employees. The companies spent £95 million on air travel in 1999. The average number of short haul trips taken in 1999 was over 9,000, and the average number of long haul flights (longer than three hours) was 2,260.

Most of the travel managers (80 percent) indicated that the amount of spend on air travel was greater than three years ago. Only 15 percent of the companies spent less in 1999 than three years earlier, with the remaining 5 percent spending about the same. This growth looks set to continue, with half of the respondents indicating that the company is likely to spend in excess of 10 percent more on travel (per annum) in the next five years. A further 30 percent thought the company would spend between 5 percent and 10 percent more per year. It would seem that travel for these companies is a large and growing cost to their business. The management of this cost is therefore important, and the survey indicates that it is not left to junior staff, with the average age of the travel managers in the survey being 45. The group was evenly split between the genders, with 55 percent being female.

The travellers surveyed were mainly (86 percent) male, with an average age of 44 with a standard deviation of 8 years. They were employed in

various management roles. Nearly a fifth of the sample (18 percent) were company directors, with 43 percent in senior management positions, and a further 30 percent in middle management roles. The remaining 9 percent were employed in other roles. The travellers make, on average, 17 short-haul trips and 6 long-haul trips a year. Nearly half of the travellers (45 percent) said their number of trips was greater than three years earlier, while 21 percent had travelled less in 1999 than 1996.

Corporate Travel Policies and Booking Behaviour

All the companies surveyed had travel policies of some kind. This is not surprising, as the sampling frame was of companies that are members of the Institute of Travel Management, with an obvious interest in managing corporate travel.

Of the companies surveyed, 80 percent only used one travel agent, with the remainder using two agents. Use of only one travel agent allows the company to manage its spend more easily than using a number of agents, as all expenditure can be consolidated and tracked through one account. The travel managers indicated that, on average, 92 percent of their air travel expenditure is placed with their main travel agent.

The main booking channel (used by nearly 85 percent of travellers and their travel managers) was by phone calls to the agent. A further 10 percent used email to send booking requests. It would seem that the most respondents still preferred to talk to an agent than to merely send an email. The interactive nature of booking over the phone perhaps provides bookers with a reassurance that the booking request has been properly understood and that the booking has been processed. This is particularly important for complex itineraries.

The average amount of air travel on the corporate's biggest airline supplier is 54 percent. However, the standard deviation of 25 percent indicates marked differences in behaviour in spending between the corporates. These differences can be partially explained by (a) types of routes flown, and (b) the amount of travel on the most commonly used routes. The strategies adopted by the travel managers will also affect this proportion. The average proportion of total expenditure made on routes covered by route deals was 32 percent, however, the wide standard deviation of this variable also indicated clear differences in travel behaviour between the companies surveyed. When asked whether the proportion of flights placed with their biggest supplier would change within a five-year time frame, 44 percent thought that the company would use this airline proportionately more in the future. Just over a quarter thought that the proportion would remain the same, while the rest of the sample thought the amount of business placed with their main supplier

would fall. Consolidating travel with a major supplier allows the corporate to negotiate the best volume discount possible, and for some companies in the sample this strategy would seem to have been adopted. However, the potential for changing the amount of business with any one supplier needs to be evaluated carefully to ensure that the best total cost situation for the corporate is achieved.

Nearly two-thirds of the companies in the survey (65 percent) pay a management fee to their agents to take bookings, provide management information, and perform other services. This agency basis has become the standard approach for most large firms in the last five years. In this system, the full amount of commission paid by the airline is passed directly to the corporate client. A management fee is then charged to the corporate for managing the client's travel requirement with a profit element included. The amount of reward given to the agent may be based on some pre-determined service levels to suit the client. The rest of the companies have a rebate arrangement with their travel agent. Rebates may be offered by airlines to agents that can ensure high volume. Rebates may retroactively reward agents of specific corporate clients four percent discounts on fares if pre-determined volumes from the named corporate are met. The rebate paid to the agent is usually passed directly back to the corporate. The system provides airlines with a fairly assured amount of traffic, and the corporate gains a discount.

As airlines seek to reduce their distribution costs, the amount of commission paid to the agent has been reduced. Agents that have rebate arrangements with corporates will be less able to pass a commission rebate onto these clients. Indeed, in the U.K., British Airways has radically altered the method by which it remunerates travel agents. In April 2001, the airline ceased paying commission on a percentage basis to travel agents. Instead, British Airways airline introduced set payments for each sector booked by an agent. The level of payment depended on the length of the sector and the class of travel. While short-haul domestic payments have remained similar (if not slightly better) than under the previous regime, agents have lost substantial payments when booking long-haul or business class tickets. The development of management fees has provided a method by which agents can seek to charge corporate clients for added value services they provide. American Express has taken this remuneration method further by passing back to clients all commissions and payments received from airline; it charges the client a fee for each transaction performed (American Express, 2001). This effectively changes the agency role from acting on behalf of the airline to acting for the corporate. This shift in agency allegiance will allow the corporate to be sure that the agent will be seeking the fares that minimise its spending rather than suggesting itineraries that would

maximise the agent's commission.

While in the majority of cases (52 percent) it is travellers that select their flights, nearly half of flights are chosen by either the traveller's secretary (25 percent) or by the travel department (23 percent). The purchase decision within the business travel market is clearly not made by the consumer—the traveller—in a large number of cases, and the airline marketer must recognise other decision-stakeholders and their influence when constructing marketing strategies. Corporate influence in the purchase decision has been noted in earlier studies, but in this research the proportion of travellers that do not make the purchase selection is 12 percent higher than an earlier study (Mason, 1999) where the samples were drawn from a wider range of companies. In this sample, the companies are all large with more than a thousand employees. It would seem that travellers in larger companies are more likely to leave the travel selection to others in their organisation. Given this reduction of traveller involvement in the travel decision-making process, it becomes more important to focus marketing attention to other players in the process. Since (a) airlines are reducing their ability to (financially) influence agents to win business, and (b) secretaries and travel managers have an increased role in the purchase decision, it is important for airlines to develop direct links with these people. While the airlines have increasingly well developed loyalty programmes for their consumers, it is also important to develop customer relationship marketing programmes for these purchase stakeholders.

Once the flight is selected, the traveller takes even less involvement in the purchase. Only 15 percent of travellers book their flights while secretaries (45 percent) and travel departments (40 percent) process the bulk of the flights.

Of the firms in the survey, 65 percent negotiate deals directly with airlines. Here the firms have sufficiently large purchasing power to negotiate deals better than those offered via the travel agency market. Travel agencies, however, can provide benchmarking data to a corporate so that it can ensure that the deals negotiated are as good as possible for that company's level of air-travel expenditure.

Table 1 shows the differences in views between travel managers and their travellers when considering aspects of the corporate travel policy. It would seem that travellers view travel policies as being much more flexible than their travel managers may have intended. 42 percent of travel managers described their policies as "airline and class level rules to be strictly followed." Only 16 percent of the travellers agreed with their travel managers, whereas 44 percent described their policies as "policies to be followed where possible."

Table 1. Travel manager and traveller attitudes to travel policies

	<i>Travel Manager</i>	<i>Traaveller</i>
Type of Travel policy (%)		
Policies to be followed where possible	15.8	44.2
Airline and class level guidance	10.5	14.0
Airline and class level rules to be followed where possible	15.8	23.3
Airline and class level rules to be strictly followed	42.1	16.3
Other types	15.8	2.3
CTP wrt to Airline Choice		
Written policy	52.6	32.6
Unwritten policy	15.8	41.9
No policy	31.6	25.6
CTPs wrt to class of travel		
Written policy	889.5	69.8
Unwritten policy	5.3	25.6
No policy	5.3	4.7

CTP: "Corporate travel policy" wrt: "with regard to"

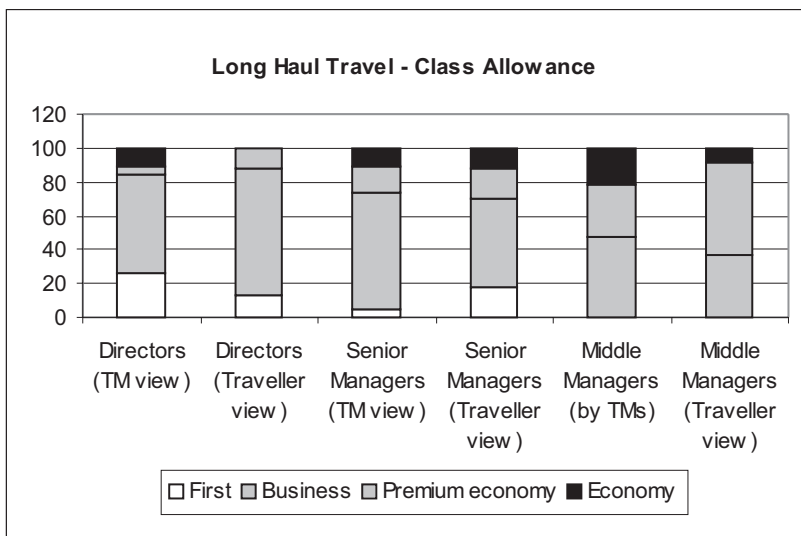
These differences in understanding about corporate travel policy are also in evidence when each group was asked to explain their policy with respect to airline choice and class of travel. The choice of airline and class of travel is very important to travellers, and prescriptions in these areas will affect traveller's comfort in-flight as well as their ability to accumulate frequent-flyer awards on a favoured airline scheme. Conversely, travel managers will be able to save their companies money if they focus on where their company can get the best deals when making the choice of airline and class of ticket for the traveller.

The class of travel is more heavily regulated than the choice of airline in these decisions. This distinction is not surprising, as differences between ticket classes will be much more significant than those between airlines in the same ticket class. Nearly 90 percent of travel managers indicated that their company had written policies with respect to class of travel, whereas only 53 percent had written restrictions about airline choice. The lower proportion of travellers that described the policies as written indicates that they are not aware of the policies, are not sent the policies, or have forgotten them. (It is possible that these travellers make so many trips that they know the rules and are unaware that they are written down somewhere in the organisation as they do not need to refer to them.)

The hierarchical differences in the class of ticket that travellers are allowed for long haul travel and for short haul travel are shown below in

Figures 1 and 2, respectively. The views of the travel managers and travellers are shown.

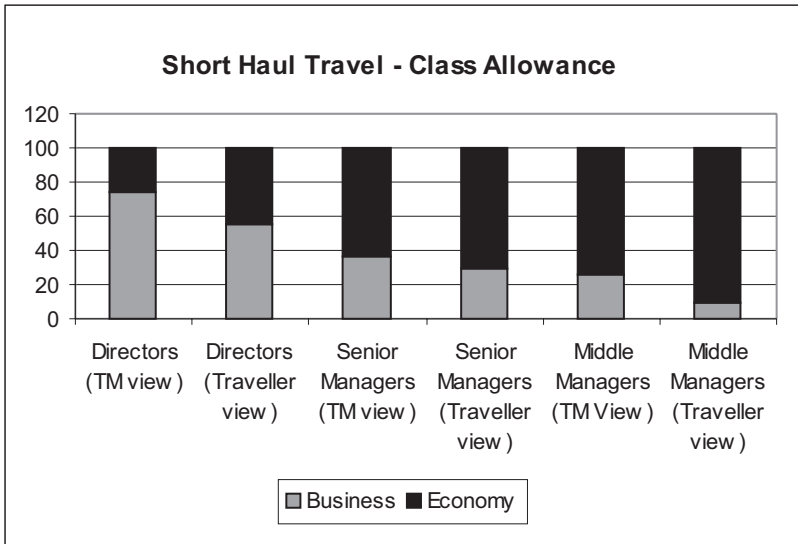
Figure 1: Fare class differences between traveller hierarchical levels for long-haul travel



For long-haul travel, over 80 percent of directors are allowed either first or business class tickets. This proportion is lower for senior managers, and lower still for middle managers. While the hierarchical difference is not great between director and senior manager level, there is a marked difference for middle managers. The development of premium-economy-class travel on long haul seems to be well targeted at this sector of the market, as a large proportion of this group is allowed this slightly-better-than-economy service.

There are only two classes available for short-haul European travel. Again, for short-haul travel, there seems to be a hierarchical bias towards those in the most senior positions, with the vast majority of middle managers having to travel in economy while over 70 percent of directors are allowed to fly in business class.

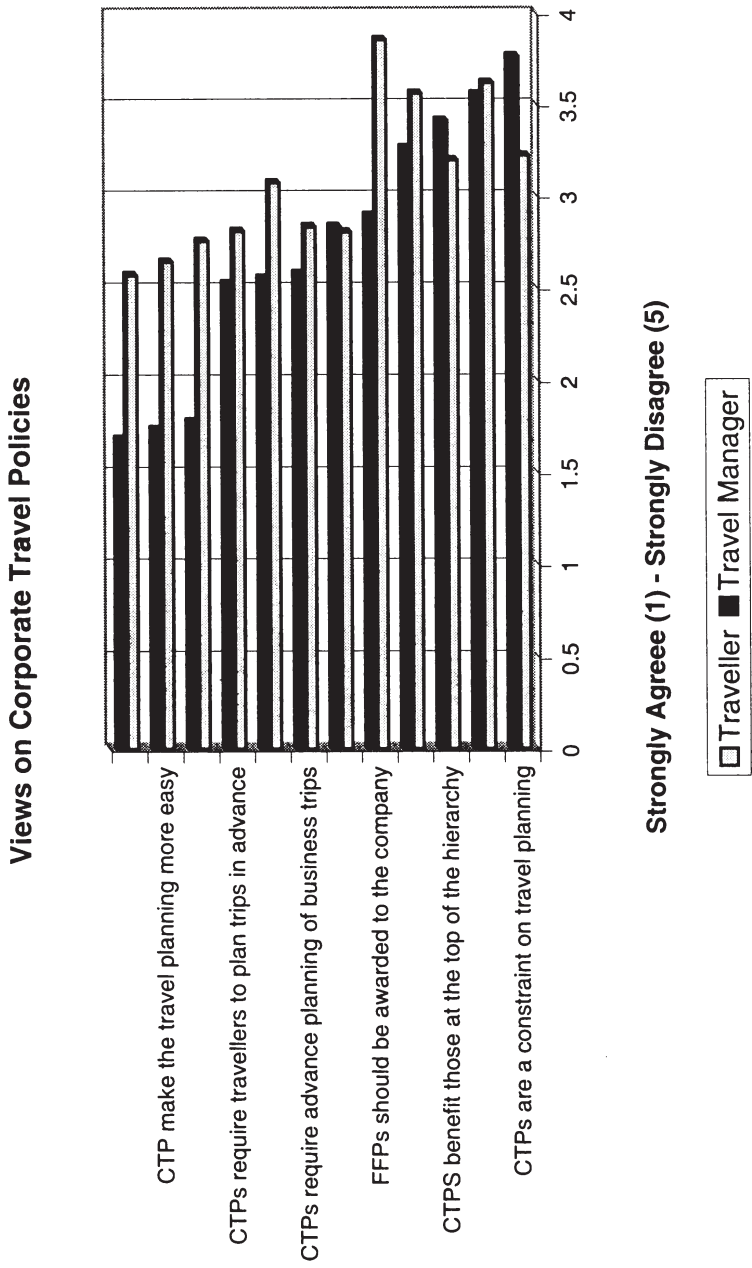
Figure 2. Fare class differences between traveller hierarchical levels for short haul travel



The two groups seem to be in general agreement with the allowances granted to different corporate level, but the travel group holds a general belief that is more restricted than the travel managers say it is. Perhaps the travellers see that policies are becoming stricter. This perception is confirmed by the travel managers, of whom 63 percent indicated that their company's travel policy would become more stringent in the next five years; a quarter of the group said that their policies would be greatly more stringent. These hierarchical differences may soon, however, diminish, as the vast majority of the travel managers (84 percent) indicated that the stricter policies would be applied to all travellers irrespective of status.

The two groups were asked to indicate their level of agreement with a number of statements about corporate travel policies. A Likert five-point scale was used for this element of the questionnaire. The differences in attitudes between the two groups can be seen in Figure 3. Strong agreement with the statement was given a score of one, and a score of five was attached to a "strongly disagree" answer.

Figure 3. Attitude toward travel corporate policies between travel managers & travellers



The general profile of the two groups is similar. The largest differences in opinion were on the following statements:

- Corporate travel policies (CTPs) makes the whole process of travel planning more easy;
- Frequent-flyer points should be awarded to the company;
- CTPs reduce traveller uncertainty;
- CTPs save the company money.

While the travel managers thought that CTPs made travel planning easier, the travellers were clearly less convinced of the ability of the travel policies to do this. It is logical that travellers and travel managers should disagree about who should benefit from FFP rewards, but is perhaps surprising that the difference was not more marked. While travel managers view CTPs as reducing traveller uncertainty, travellers disagree; and here there is a case to build internal communications to highlight the corporate and individual benefits of having a policy. The travel managers disagreed with the opinion that CTPs put a constraint on travel planning, while the travellers were neutral in their opinion. It is perhaps surprising that the travellers did not see CTPs as placing a constraint on their travelling behaviour. Both travellers and travel managers agree that travel policies reduce travel choice, while travel managers agree much more strongly with the statement that CTPs saves the company money than the travellers. Again, there is an opportunity for travel managers to communicate the benefits of the CTP to those that have to work within it.

The travel managers were asked what processes they use to ensure traveller compliance with the travel policy. Their responses suggest two approaches. The first allows the traveller to book the flights they request. Management information systems are used later to identify those travellers who have fallen outside the policy's prescriptions. The manager relies on the agent to report the transgressors, and then the travel manager can take the action deemed appropriate. An extreme (but effective) method is to refuse to reimburse all costs incurred by travellers who have booked outside the policy. Other travel managers indicated that a quiet word to the traveller would be the method used to get the traveller to stay within the policy in future. The second approach applied by travel managers to ensure traveller compliance was the prevention of travellers from booking outside the policy. Some managers funneled bookings through their office and thus could refuse to book travel outside the policy. In other cases, the manager would rely on the agent either refusing to book outside the policy without appropriate signed approval, or to provide pre-trip alerts of non-compliant

travel. Some travel managers saw the Internet and on-line booking systems as a means by which the company, with its agent, could construct an electronic barrier to non-compliance.

The Effect of Airline Alliances

For many companies a large proportion of travel is on a small number of routes, and on these routes the companies may have deals with individual airlines. However, the ability of an airline group to provide global coverage for all of a company's air travel requirements can be beneficial for both parties. The company is able to negotiate better discounts on their most travelled routes by ensuring a higher proportion of their travel is on the preferred airline group's services worldwide. The airline group ensures increased volume throughout its network and is able to build yield on the less-travelled services.

The development of global airline alliances has enabled the alliance groupings to compete to provide global coverage for a company. Consolidating spending with an alliance group to negotiate higher discounts is perceived as beneficial by about half the travel managers (47 percent). A further 37 percent of the respondents thought that alliance development has a neutral effect on the company's air travel expenditure. Although none of the companies surveyed had a global deal currently, a quarter had been approached by one or more global alliance to try to negotiate a global deal. A further 15 percent of the companies had approached alliance groups to discuss the possibility of a global deal. While this global deal development is in its infancy, 75 percent of the travel managers surveyed believed that their companies would sign a global deal with an alliance group within the next five years.

Alliances groupings indicate that the traveller will reap many benefits from alliance developments. These include: (a) "seamless" travel across the group's network; (b) better customer services at airports as the airlines group together their ticketing, check-in, and customer service desks; and (c) a wider route network on which travellers can collect FFP points and spending loyalty rewards. More than half of the travel managers surveyed (55 percent) believed that the travellers benefit from airline alliances as the alliances begin to deliver the improvements in service. Only 5 percent of those surveyed thought alliances would have a detrimental effect on travellers, but a large proportion (39 percent) of the sample thought that alliances would have little effect on their traveller. In comparison, one in five of the travellers surveyed thought that alliance developments would be detrimental to their travel experiences. Differences in the quality of on-board service between code-sharing and alliance partners can lead to traveller confusion and dissatisfaction. The alliance groups will need to

work hard to provide a “seamless” level of service throughout their networks to minimise such business traveller attitudes.

In addition, since eight out of ten travellers and nine out of ten travel managers believe that traditional airlines do not offer value for money, traditional scheduled carriers will need to demonstrate a greater level of value for money in their products.

Effect of Low-cost Airlines

One of the key reasons why travellers question the value of traditional airlines' service is the development of low-cost airlines. Currently, only a small number of flights bought by the companies surveyed are taken with low-cost airlines. Earlier research (Mason, 2000) showed that travellers working for smaller companies are more likely to use a low-cost airline for making a business trip. Travel expenditure may be more tightly restricted in a small company compared with a larger one; a small company also will not be in a position to negotiate volume discounts with traditional airlines, as the amount of business they generate will not be sufficient.

Table 2. Attitudes towards low-cost airlines

	<i>Travel managers</i>	<i>Travellers</i>
Traditional airlines do not offer value for money	88.9	81.4
Low-cost airlines do offer value for money	84.2	73.7
Attitude towards using low-cost airlines for business		
Positive	65.0	31.7
Neutral	10.0	36.6
Negative	0.0	29.3
No opinion	25.0	2.4
Attitude toward low-cost airlines		
Positive	65.0	31.7
Neutral	10.0	36.6
Negative	0.0	29.3
No opinion	25.0	2.4
Proportion of short-haul travel on low-cost airlines in five years	24.2	29.3

Travellers working for small companies will probably more involved in their air-travel purchase decisions, and consequently will (a) be more likely to be aware of the cost of tickets, and (b) seek cheaper prices. In contrast, travellers working for larger companies are more likely to work within the prescriptions of a travel policy, and (as we have seen in this set of results) are likely to be less involved in the purchase and to seek cheap flights. Where a large company has a complex set of deals with various airlines,

travellers are likely to be discouraged from making their own travel decisions, as those decisions are likely to be (a) sub-optimal from the company's perspective, and (b) a waste of a significant amount of time. Travel managers will have focused on deals with traditional airlines that (a) can be monitored, and (b) enforced through booking procedures that rely on the travel agent to flag travel plans falling outside the travel policy. Travel agents are loathe to book low-cost airlines, as they receive no or very low commission from these transactions; so it is not surprising that only 4 percent of the flights booked by the companies surveyed were with these budget airlines. However, 60 percent of travel managers said that their company encourages the use of low-cost airlines where appropriate, indicating that the proportion of short-haul travel placed with low-cost airlines for these large companies is set to rise. Indeed, travel managers thought the proportion of short haul trips made on low-cost airlines would rise to 22 percent in five years time. Travellers thought this proportion would be even higher (29 percent). If low-cost airlines aim to achieve this level of penetration in the large-company market, these airlines will need to show a satisfactory level of service while also providing sufficient cost savings to recompense for the poorer deals corporates would subsequently be able to achieve with traditional airlines because of their reduced volumes of traditional-airline travel.

The majority of travel managers and travellers thought low-cost airlines offer good value for money. Sixty-five percent of managers indicated a positive attitude towards these budget airlines, but a significant proportion of travellers (29 percent) held negative opinions about the services low-cost airlines offered. Figures 4 and 5 show the main advantages and disadvantages of low-cost airline services indicated by the respondents.

Respondents were asked to suggest up to three advantages and three disadvantages of these airlines. Price is clearly seen (by both travellers and travel managers) as the main advantage of low-cost airlines, with the ease of use being suggested by 15 percent of travel managers as an advantage.

Both travel managers and travellers highlighted a number of disadvantages of using low-cost airlines. Schedule was identified as being the main disadvantage, followed by the ticket restrictions generally applied to low-cost airline tickets. A number of travellers noted a general lack of quality on these airlines, while travel managers were more concerned about punctuality and reliability.

For the low-cost airlines to gain in the business-traveller segment of the market, travel managers must shift their strategies to consolidate travel in one alliance group's services. To persuade the travel managers to switch, the low-cost carriers will need to: (a) provide consistent, reliable, high frequency services on a widened route network; and also (b) alter the non-

Figure 4. Advantages of low-cost airlines usage

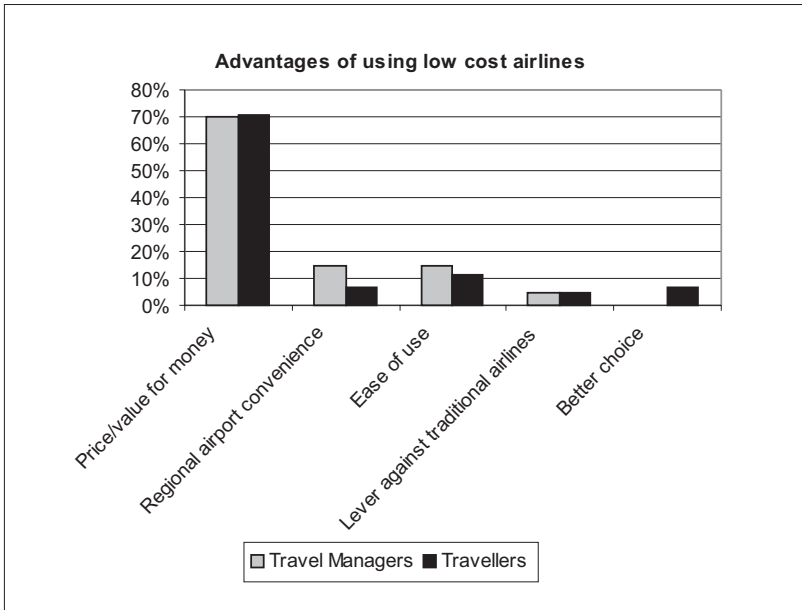
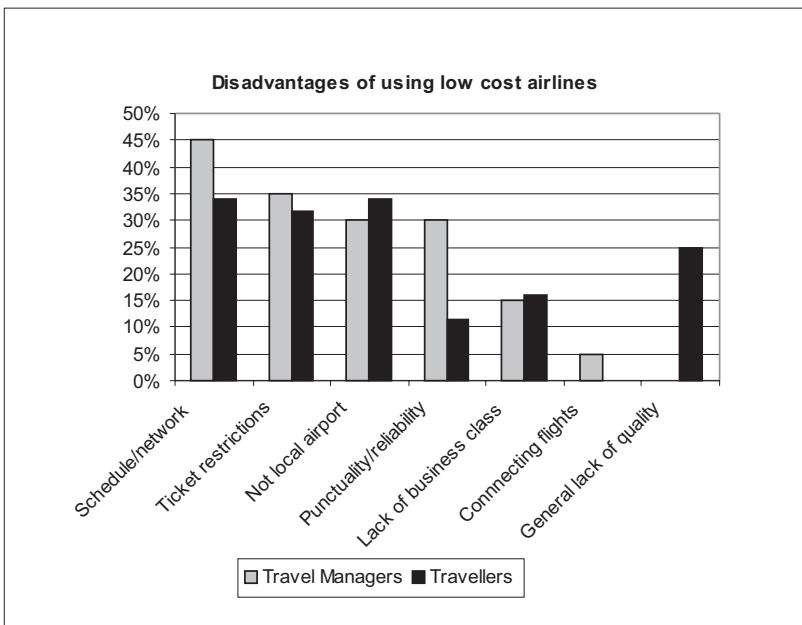


Figure 5. Disadvantages of low-cost airline usage

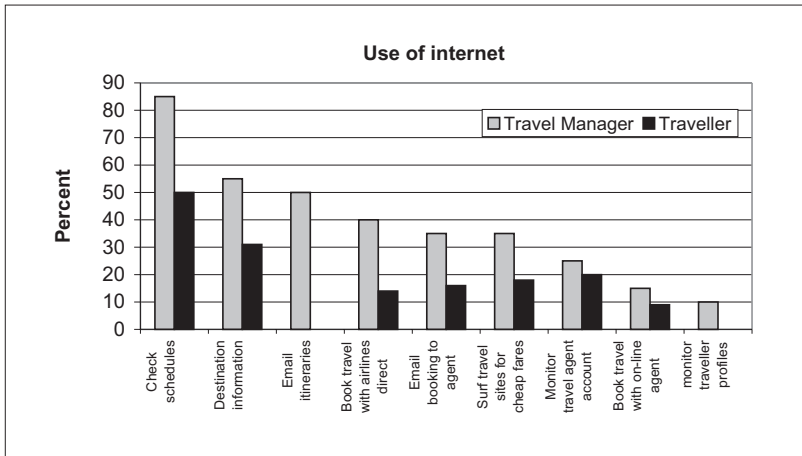


flexible ticketing regime. While some low-cost airlines have introduced flexible "business" fare types and have increased frequency on some routes to levels expected by frequent flyers, none yet have the wide route network, high frequency and flexible ticketing necessary.

Effect of Changing Distribution Patterns and Booking Tools

Internet technology has begun to change the way in which airlines can distribute their products. A company can either book online via travel-agency booking sites, an Internet-based booking agent, with the airline direct, or via various portals provided by airline groups (such as Orbitz), CRSs (such as Travelocity), or consolidators (such as priceline.com). With such a wide range of booking options, it is perhaps surprising that travel managers and travellers in the survey book less than 5 percent of their flights online. This general reticence is not due to lack of Internet infrastructure. Ninety-five percent of travel managers and 91 percent of travellers in the survey currently have access to the Internet. Of the companies surveyed, 15 percent have an extranet account with their agent and allowed travellers to book online. However, 72 percent of travel managers discouraged travellers from booking online. Nearly half (47 percent) of the managers believe that traveller online-booking hinders their role to minimise travel spending and also makes it harder to monitor and control such spending. One in four travel managers thought, however, that they were aided by travellers' use of online booking, mainly through the reduction of administrative burdens. The general feeling was that online booking was set to grow. The travel managers believed that, on average, 42 percent of travel would be booked online by their travellers within a five-years time span. Travellers thought this amount would be even higher (62 percent).

With the development of so many potential channels open to the corporate, should the corporate try to direct all bookings via a single port? This may be possible in some companies, particularly if booking lead times are long and changes in itinerary are rare. But for most companies, such rigid administration may be onerous. The use of traveller-held corporate credit cards for all travel expenses is one method through which travel managers can monitor and control their companies' spending while allowing the use of many different booking channels. The fairly rigid approach of the travel managers in the study to limit their travellers access to Internet booking may be overcome if real-time booking approval systems (using a credit card) are made available.

Figure 6. Travel manager and traveller use of the Internet

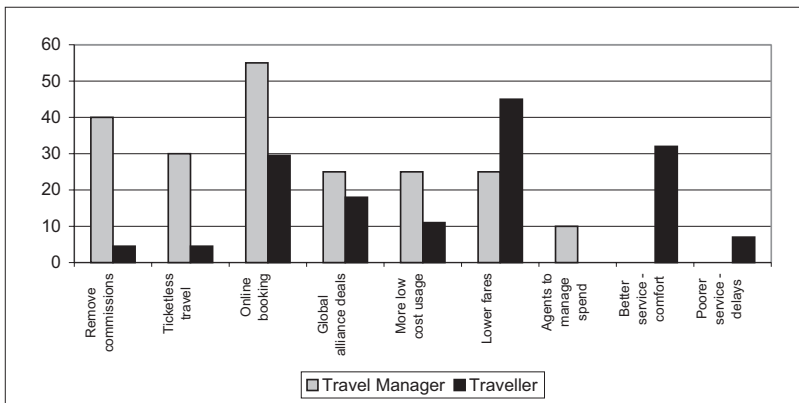
Substitution of Air Travel by Other Forms of Communication

The final area considered in the survey was the effect of the development of video conferencing and the Internet on the demand for business-derived air travel. The vast majority (over 70 percent) of both travellers and travel managers believed these technologies have not had any substantial effect on the number of trips taken. While these forms of communication currently have little effect on the demand for air travel, both groups of respondents believed that, within a five-year time frame, these technologies will have improved sufficiently to allow for some substitution (depending on the time of work being performed). Twenty-two percent indicated that internal meetings and some meetings with well-established business partners might be conducted over some improved information technology solution, but the total proportion of such substitution would be small. However, the general feeling was that there is no substitute to meeting people face-to-face.

Indeed, 66 percent of travel managers thought that the company would increase its volume of business travel in the next five years. A large group (36 percent) believed that their company would increase the number of trips consumed by more than 15 percent from its currently level.

Future Changes

Figure 7 shows the unprompted responses to the question: "What do you see as the three main changes likely to happen in the business travel market in the next five years?"

Figure 7. Future changes in the business travel market

The travel managers highlighted changes in the airline/agent/corporate relationship, as commissions are removed and online booking and ticketless travel become much more widespread. A quarter of the managers viewed alliances (if these groupings can achieve global network coverage) as having an increasingly important role to play in the market. A significant number of travel managers also highlighted the growing use of low-cost carriers for short-haul travel, with fares falling as competition increases. Ten percent of respondents indicated that travel agents will become managers of a company's travel spending, as travel managers outsource the management and administration of this purchasing function. This outsourcing is a logical extension of the consultancy role that agents are increasingly looking to pursue as the airline/ agent/corporate relationship alters.

Travellers have a slightly different perspective on the business travel market in the next five years. They see continued growth in competition between airlines as providing lower fares, improved levels service, and better comfort. The other main change for travellers is the increase in online booking.

CONCLUSION

The research presented in this article aimed to provide further insights into the decision-making processes and buying behaviour of business travellers and the companies for which they work; it also sought to identify future trends in the market. The focus of the article was on larger companies, but it also compared findings about these companies with trends in business travellers that work for small and medium-sized companies.

There are two principal reasons for differences in the use of low-cost airlines by large and small companies. First, large companies travel 33 percent of the time on routes for which they have signed route-specific deals with traditional airlines, and this is likely to keep the majority of their business with these larger carriers. As airline alliances grow to enable carriers to offer global coverage of travel needs, large companies are likely to stay with one alliance grouping and to negotiate global deals.

Second, travel agents have been the traditional channel through which companies book travel. For small companies, the development of the Internet has provided a method through which they can compare prices. Without the volume of business to enable the company to negotiate route deals, small companies are increasingly using the Internet to select flights; travel agents have thus lost the ability to influence travel-purchasing decisions towards the larger traditional airlines. In contrast, large companies have used specialist business travel agents for booking travel as well as hotel accommodation and car rentals. Corporate infrastructure and monitoring and management systems are well developed for quick and efficient travel booking. This infrastructure is sufficiently well developed for the companies to continue using the travel agency channel for future booking. As the low-cost airlines generally do not sell through agents, this market is effectively closed to these carriers.

The companies surveyed have not yet embraced new booking technologies, with the majority of flights booked by phone. However, travel managers believe that online booking will become at least as popular as phone booking in the next few years. Not only does the technology need to develop further for this change to happen, but travel managers will also need to release travellers and secretaries to book online. Currently, travel managers discourage this practice.

The introduction of transaction fees by agents is changing the relationship between the airline, traveller, and agent, with the agent working on behalf of the traveller, not the airline. This change may lead to outsourcing of the travel-expense management to travel agents, with the travel-manager role changing into one of contract management. To do this, the agent, agents, or airline principal must demonstrate the ability to enact the chosen travel policy effectively.

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NATIONAL SURVEY RESULTS: RETENTION OF WOMEN IN COLLEGIATE AVIATION

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ABSTRACT

Since the numbers of women pursuing technical careers in aviation continues to remain very low, a study on retention of women was undertaken by a team of university faculty from Embry Riddle Aeronautical University, Arizona State University, and Kent State University. The study was initiated to discover the factors that influence women once they have already selected an aviation career and to ascertain what could be done to support those women who have demonstrated a serious interest in an aviation career by enrolling in a collegiate aviation program.

This paper reports preliminary results of data collected in the first and second years of the study. The data was collected from surveys of 390 college students (195 women and 195 men) majoring in aviation programs in nine colleges and universities, representing widely varied geographic areas and including both two- and four-year institutions.

Results revealed significant areas of concern among women in pilot training. When queried about these concerns, differences were evident in the responses of the male and female groups. These differences were expected. However, a surprising finding was that women in early stages of pilot training responded differently from women in more experienced stages. These response differences did not occur among the men surveyed. The results, therefore, suggest that women in experienced stages of training may have gone through an adaptation process and reflect more male-like attitudes about a number of subjects, including social issues, confidence, family, and career.

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INTRODUCTION

Looking ahead, we see a tremendous rise in the numbers of women entering the workforce. U.S. Department of Labor statistics (Rosser, 1995) predict that 80-90% of workforce growth after 2000 will be women and minorities—a population that is apparently not attracted to careers in aviation (Turney, 2000). The percentage of women working particularly in the technical side of aviation has not significantly increased in the past twenty years. Women, for example, still constitute less than 6% of the airline-qualified pilots (FAA pilot data, 1997) and less than 5% of aviation maintenance/avionics technicians. This is somewhat surprising since a number of barriers have been lifted in the past twenty years, notably the exclusion by the military of women pilots in combat aircraft and the emergence of women airline captains.

Studies in science and engineering indicate that less than 10% of the programs studied were specifically focused on the recruitment and retention of women (Matyas & Malcolm, 1991). The small numbers of women entering careers in aviation is evidenced in collegiate aviation where enrollment and retention of women remain low. After close analysis of demographic trends in the aviation workforce, a team of university faculty from Embry Riddle Aeronautical University (ERAU), Daytona Beach, FL, Arizona State University, Phoenix, AZ, and Kent State University, Kent undertook a research project, OH. The research was funded by grants from the Department of Education Fund for the Improvement of Secondary Education (FIPSE) and the Alfred P. Sloan Foundation.

The research focused on the question of why greater numbers of women do not choose aviation career opportunities. The goals of the research team were (a) to identify factors that affect the numbers of women pursuing a pilot career in the aviation industry, (b) to create a model that reflects those factors and fosters retention of women in aviation, and (c) to disseminate the model throughout academic institutions and industry training centers. Although the study data was collected from a collegiate aviation population of both men and women, it was understood that many of the findings may apply to a number of technical career options in which women are seriously underrepresented.

BACKGROUND

Since women are seriously underrepresented in aviation, the problem was to discover the factors that influence women once they have already selected an aviation career, and to support those women who have demonstrated a serious interest in an aviation career by enrolling in a

collegiate aviation program.

The research team from the three universities jointly developed a series of open-ended questions to reflect the major themes that had emerged from the women's studies literature. Focus groups were held at each university for the purpose of identifying topics and commonalities that could be used to design a survey. Experience levels of the focus group members ranged from a private pilot with 12 hours of flight time to an 800-hour flight instructor seeking regional airline employment. Two of the women had recently dropped out of flight training.

The responses of the focus groups were analyzed and seven areas of concern emerged from the data. The researchers compared the results of the focus groups and designed a thematic architecture for the survey phase of the study. The survey included 65 Likert scale items, a learning style inventory, and 14 open-ended items. In order to replicate some of the "richness" of the focus groups, it was decided to include some open-ended questions designed in a similar format as those used in the focus groups. The results of that phase of the study will be published at a later date. Only the Likert scale items are included in this paper (see Appendix A); however copies of the entire survey can be obtained from maturney@asu.edu.

PRELIMINARY FINDINGS

This paper reports preliminary results of data collected in the first and second years of the study. The data was collected from surveys of 390 collegiate aviation majors (195 women and 195 men). The participants were selected from nine colleges and universities, representing widely varied geographic areas and including both two- and four-year institutional members of the University Aviation Association (UAA). Since the researchers decided to maximize the number of potential survey responses, the entire female population was surveyed in each institution and a matching number of male participants were selected randomly at each institution. Institutional participation was voluntary and the researchers selected colleges and universities that represented a broad spectrum of geographic location and size; thus the conclusions are restricted to this representative group.

A quantitative statistical analysis was completed on the 65 Likert scaled items in the survey (see Appendix B). These items queried student subjects on seven areas of concern including social issues, mentoring, faculty support, learning styles, family and career, standards, and confidence. Differences between women and men were analyzed for each of the 65 items using a pooled *t test* of unequal variances on the average response rates (linear ordinal scale). The test was performed at the 5% significance

level. A number of items tested revealed significant differences (see Appendix B Table 1). However, the size of the difference was small for many of the questions. This led researchers to further in-depth item analysis.

A further study of the data was performed based on both the sex and flight experience of the respondents. The flight experience variable was considered to have two levels: novice and experienced. For each of the 65 items in the survey, the number of agreement/disagreement responses was counted in each of the four categories (female novice, female experienced, male novice, male experienced). A Chi-square test was performed on the categorical data at the 5% significance level (see Appendix B Table 2). The resulting table of significant items (see Appendix B Table 2) shows the agreement/disagreement percentages for the four categories. Many of the items in the initial findings revealed unique responses from one group—the novice women, that is, female students who were student or private pilots. The responses of this group often differed from the responses of experienced women, that is, commercial pilots with advanced flight ratings, and from the responses of males with both novice and advanced flight ratings. It should be noted that the student and private pilots were generally freshmen and sophomores and the commercial pilots were generally juniors and seniors in collegiate aviation programs.

A significant finding was that as women progress to experienced pilot status, they respond more like males. This suggests an adaptive process and is not unlike the findings of Seymour and Hewitt (1997) in their study of women in engineering program throughout the United States. The analysis revealed that novice women pilots differed from males in their responses considerably more than experienced women pilots. The regularity of these response differences between the novice women pilots and the experienced women pilots suggests that experienced women pilots are more adapted to the male-oriented aviation culture and have, in fact, acquired more male-like attitudes than the novice women. If this is the case, it follows that a novice's lack of ability to undergo such an adaptation, or her lack of understanding that an adaptation generally takes place by the time women reach experienced training, may be a factor in the attrition rate among this population.

Following is a detailed discussion of response differences between novice and experienced women pilots. These responses are also compared to the responses of male pilots in the novice and experienced group. Appendix C contains a complete graphic representation of these comparisons and can be cross-referenced with the item numbers identified in bold in the following text

LEARNING STYLE PREFERENCES

In order to maximize transfer of knowledge, educators conducted extensive studies of learning style differences among individuals regardless of gender. Some learning style theorists suggest that differences can be identified by models such as auditory learners, visual learners, and kinesthetic learners and that all dominant learning styles should be addressed in the classroom situation (Karp, 2000). In the process of these studies, several researchers noticed trends indicating a pattern of gender differences (Belenky et al, 1986; Emanuel & Potter, 1992; Gilligan, 1982; Sitler, 1999; Tannen, 1990). Recent discoveries using magnetic brain imaging, offer evidence of men and women using different parts of the brain while engaged in the same cognitive task (*New York Times*, 1995; *New York Times*, 1997). Based on an in-depth study of flight students, Sitler (1999) concludes that the time has come to make major changes in curriculum and instruction in order to make flight careers more appealing to women and to fill the expected pilot shortage.

Based on strong evidence of gender differences in learning, this study asked participants several questions about learning differences between women and men. For example, Item 29 asked whether participants agreed or disagreed with the statement, "Women and men both learn the same way." Women disagreed while men were neutral. Only women's responses suggest an awareness of learning differences between women and men.

Another item related to learning differences was Item 47, "I do better working alone than working in a group." Women's responses were neutral while men agreed. When asked about learning style preferences ("I prefer to learn by discussion with others, rather than by myself" Item 2) the novice women showed more agreement. The literature on women's learning styles suggests that women prefer cooperative learning. (Belenky et al., 1986; Gilligan, 1982; Tannen, 1990). However, in this study, since the degree of agreement among the experienced women is less, it seems that they have adapted to a more independent, male-like learning style.

SOCIAL ACCEPTANCE

When asked about social acceptance in Item 20, "I don't think men like women who fly better than they do," novice women agreed more strongly than the other groups. This would suggest some social concerns (associated with competition) among the novices—concerns that the experienced women pilots do not share. Similarly, when asked to respond to Item 36, "I have to prove myself to be accepted by the men in the flight program," women's levels of agreement were higher than men's levels of agreement with novice women's responses showing stronger agreement than

experienced women showed. Possibly the experienced women disagree more often because they have already proven their abilities.

Novice women agreed with the statement, "Sexist remarks annoy me" more than did experienced women pilots (see Item 51). The response of novice women pilots in contrast to experienced women pilots may reflect the difference in levels of adaptation to sexist language in aviation and a male-oriented environment.

Experienced women disagreed with the statement "I sometimes feel like an outsider with men around airplanes" (Item 58). Novice women's responses showed much greater agreement. The issue of inclusivity is likely related to the disproportionate numbers of men and women and may be related to lack of a women-friendly atmosphere in the aviation environment.

Even though all groups showed some agreement with the following statement, "My male peers always want to decide who is in charge" (Item 8), novice women agreed to a greater extent than other groups. This response suggests more sensitivity to status-related issues among novice women pilots.

STANDARDS

When queried about standards ("I think that women have to work harder than men do when learning to fly," Item 24) responses of novice women were mixed while the other three groups disagreed. The mixed response may mean that novice women are not clear about whether standards are the same for both men and women. Similarly, when asked to respond to the statement "Women who go into aviation have to be psychologically stronger than other women" (Item 39) women agreed more than men agreed with this statement (with novice women agreeing more strongly than experienced women). In contrast, women in both groups disagreed with the statement "Men have to prove themselves to be accepted by women" (Item 62).

Mentors

Gender studies suggest that mentoring is an effective means of supporting retention in science-related careers. Successful women and men scientists credit their mentors who were helpful in establishing contacts and connections; others have experienced fewer opportunities when advisors held prejudicial views about women scientists in the workforce (Sonnert, 1995).

When asked if "Women need mentors to succeed in aviation" women agreed and men disagreed (see Item 22). Similarly, women agreed that

“Women should mentor women who are learning to fly” (see Item 59). Interestingly, more women than men disagreed with the statement “I am acquainted with women experienced in aviation” (Item 14). These responses would suggest a need for a closer look at mentoring among women in aviation.

FACULTY SUPPORT

Seymour and Hewitt’s extensive research on factors that influence retention in science, mathematics, and engineering suggests that faculty support is crucial to student success (1997). Astin and Sax (1996) found that interacting with faculty actually had a negative effect on women’s mathematics confidence, the opposite effect of that observed in men. They stated that science faculty, most of whom are male, can tend to discourage women from science, downplay women’s intellectual capabilities, and make women feel unwelcome in the classroom. These findings suggest that before simply advocating more faculty-student interaction, we should focus on the nature of the interaction, especially for women students (p. 110).

When asked to respond to Item 27 “Some faculty members treat women with a ‘stand off’ attitude because they believe aviation is a man’s world” data from novice women were mixed. The mixed response may suggest ambivalence among novices about whether or not they belong in aviation. Men, in contrast, disagreed with this statement. Not surprisingly however, more novice women agreed, “Women faculty are more supportive than male faculty”(Item 46).

CONFIDENCE

Gender studies reveal that confidence is a significant issue related to women’s career success (Turney, 1994). A major study by Sitler on teaching women to fly suggests that women are slower than men to gain confidence (1999). Women avoid taking chances and thus prefer to spend more hours of preparation prior to solo flight. Women also express a need to understand a subject thoroughly before proceeding in their training. They do not like the trial and error method of flight training.

When responding to the statement “I prefer my flight instructor demonstrate a maneuver before I have to try it,” women agreed more than men (see Item 6).

FAMILY AND CAREER

Studies in technology, science, and aviation reveal that family matters can become obstacles to women pursuing professional careers. Young women consider marriage and family as desirable goals and they are willing to make sacrifices to attain those goals. Although researchers found no negative effect of marriage and motherhood on productivity, women who persist in their careers may appear to violate societal role expectations (Sonnert, 1995; Turney, 1996).

Responses to Item 5 on the survey "I may be unable to have a family and a career" showed disagreement from experienced men. Novice men and women's responses were mixed. Although flexible time and scheduling have done much to alleviate family pressures for women professionals, structural and attitudinal barriers related to family and careers still exist for women.

SUMMARY

Interesting differences among the four groups of collegiate aviators were observed in the preliminary findings from this broad research effort. Novice women seem to need women role models and to perhaps have less confidence. They also like to work in teams more than their male counterparts and are more concerned that aviation is male-dominated. Family concerns are a strong issue for all groups of women surveyed. As women progress through early flight training to a more experienced level, they respond more like men, gain confidence and adopt more male-like attitudes. Greater awareness of this adaptation factor particular to women in collegiate aviation is needed. Some women may adapt quickly and others may need more time and encouragement in order to sustain retention of novice women in aviation.

The problem of retention for the future of the aviation industry, however, should now focus on identifying how many women are lost before they can adapt to the industry culture. As Tony Bailey, Vice President of the Boeing Company, recently stated, "The aviation industry is not at the leading edge, but at the trailing edge with the flaps and spoilers. Dynamic women are leaving aviation and going to other industries with their talents" (2001).

As research continues, new challenges emerge regarding potential industry and training adaptations that could support retention of women who have made an initial commitment to a technical career in aviation.

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APPENDIX A

1. Using the following choices, select the response that most reflects how strongly you feel about each statement. Write the letter of the response in the line preceding the statement. If you have not had experience with the issue, please write an X on the line

- | | |
|-------------------|--|
| A. Strongly Agree | D. Disagree |
| B. Agree | E. Strongly Disagree |
| C. I am not sure | X. I have no experience with this issue. |

- _____ 1. I have fun when I am flying
- _____ 2. I do not hesitate to ask my flight instructor any questions.
- _____ 3. It intimidates me if my flight instructor yells if I make a mistake.
- _____ 4. My friends support my flying aspirations.
- _____ 5. I may be unable to have a family and a flying career both.
- _____ 6. I prefer my flight instructor demonstrate a maneuver before I have to try it.
- _____ 7. I prefer to learn by discussion with others, rather than by myself.
- _____ 8. My male peers always want to decide who is in charge.
- _____ 9. Other women in the aviation program are friendly toward me.
- _____ 10. I get discouraged when a male peer advances faster in flight training.
- _____ 11. My male peers focus too much on my appearance.
- _____ 12. I experience frequent misunderstanding with my flight instructor.
- _____ 13. Sometimes my flight instructor talks down to me.
- _____ 14. I am acquainted with women experienced in aviation.
- _____ 15. My flight instructor moves too quickly through the flight lessons.
- _____ 16. I am sometimes uncomfortable working in a male oriented environment.
- _____ 17. Some of the comments made by my male peers make me feel uncomfortable.

- _____ 18. I prefer hands-on learning to learning from books.
- _____ 19. I believe women think and act differently from men.
- _____ 20. I don't think men like women who fly better than they do.
- _____ 21. My female peers always want to decide who is in charge.
- _____ 22. I think women should mentor women who are learning to fly.

Using the following choices, select the response that most reflects how strongly you feel about each statement. Write the letter of the response in the line preceding the statement. If you have not had experience with the issue, please write an X on the line

- | | |
|-------------------|--|
| A. Strongly Agree | D. Disagree |
| B. Agree | E. Strongly Disagree |
| C. I am not sure | X. I have no experience with this issue. |

- _____ 23. I think that women have to work harder than men do when learning to fly.
- _____ 24. I think that male flight instructors have an attitude that "flying is a man's profession."
- _____ 25. Male flight instructors often want to start a relationship with their female students.
- _____ 26. I get discouraged when a female peer advances faster in flight training.
- _____ 27. I feel that some faculty members treat women with a "stand-off" attitude because they believe aviation is a man's world.
- _____ 28. My parents did not believe I was serious about a flying career.
- _____ 29. Women and men both learn the same way.
- _____ 30. I prefer to learn by observing others.
- _____ 31. Some of the comments made by my male flight instructors make me feel uncomfortable.
- _____ 32. There should be more camaraderie between women and men classmates.
- _____ 33. I enjoy the attention I get from my male peers.
- _____ 34. I often worry about the costs of my flight lessons.

- _____ 35. Women are often excluded from peer socializing (like going to lunch) with male students.
- _____ 36. I have to prove myself to be accepted by the men in the flight program.
- _____ 37. Women should be actively recruited into aviation.
- _____ 38. My male flight instructors seem to feel uncomfortable with me in the cockpit.
- _____ 39. Women who go into aviation have to be psychologically stronger than other women.
- _____ 40. Most male flight instructors take female students seriously.
- _____ 41. I feel that the classroom faculty at my school support women students.
- _____ 42. Some flight instructors send the message that flying is something that men are supposed to do.
- _____ 43. My family has encouraged my flying.
- _____ 44. My male classmates seem to feel uncomfortable with me in the classroom.
- _____ 45. I am not sure I can afford to continue working toward a pilot career.
- _____ 46. Women faculty are more supportive of me as a flight student than male faculty.

Using the following choices, select the response that most reflects how strongly you feel about each statement. Write the letter of the response in the line preceding the statement. If you have not had experience with the issue, please write an X on the line

- | | |
|-------------------|--|
| A. Strongly Agree | D. Disagree |
| B. Agree | E. Strongly Disagree |
| C. I am not sure | X. I have no experience with this issue. |
- _____ 47. I do better working alone than working in a group.
- _____ 48. I like to share my feelings to my peers.
- _____ 49. A good response to rude male behavior is to ignore it.
- _____ 50. I want to know who is in charge.
- _____ 51. Sexist remarks annoy me.
- _____ 52. In a group of my peers, women talk more than men do.

- _____ 53. I am comfortable with the level of competitiveness in aviation.
- _____ 54. Sexual jokes make me uncomfortable.
- _____ 55. Women are not asked to answer in class as often as men.
- _____ 56. Some of the comments made by my male classroom instructors make me feel uncomfortable.
- _____ 57. Expectations and class standards are the same for men and women.
- _____ 58. I sometimes feel like an outsider working with men around airplanes.
- _____ 59. I think women need mentors to succeed in aviation.
- _____ 60. I am not bothered by the special attention that I get from the men in my flight program.
- _____ 61. Women in aviation like to “hangar fly” without men around.
- _____ 62. Men have to prove themselves to be accepted by the women.
- _____ 63. I had difficulty learning the communication style required by ATC.
- _____ 64. Other women students resent attention I get from male peers.
- _____ 65. When a male peer is offensive, I confront him.

APPENDIX B

Table 1. Comparison of Response to Factors That Influence Women Pursuing Aviation Careers

<i>Item</i>	<i>Average Response</i>			<i>t test</i>	<i>Item</i>	<i>Average Response</i>			<i>t test</i>
	<i>Female</i>	<i>Male</i>				<i>Female</i>	<i>Male</i>		
1	1.302	1.258		0.418	34	1.837	1.985		0.203
2	1.456	1.527		0.339	35	3.978	4.118		0.132
3	2.733	2.784		0.724	36	2.995	3.571		0.000 *
4	1.461	1.557		0.135	37	1.907	2.314		0.000 *
5	3.361	3.494		0.274	38	3.953	4.210		0.007 *
6	1.641	1.849		0.021 *	39	2.649	3.028		0.001 *
7	2.540	2.613		0.527	40	2.127	2.102		0.704
8	3.482	3.538		0.621	41	1.874	1.860		0.821
9	1.969	1.844		0.149	42	3.388	3.572		0.099
10	3.736	3.396		0.005 *	43	1.508	1.508		0.976
11	3.410	3.649		0.029 *	44	3.974	3.989		0.820
12	4.030	3.879		0.131	45	3.359	3.577		0.079
13	3.775	3.789		0.865	46	3.024	3.463		0.000 *
14	2.508	2.189		0.008 *	47	2.979	2.747		0.071
15	4.068	3.849		0.011 *	48	2.479	2.719		0.054
16	4.047	4.116		0.465	49	2.755	2.803		0.659
17	3.395	3.926		0.000 *	50	2.104	2.160		0.549
18	1.606	1.534		0.373	51	2.325	2.698		0.003 *
19	1.974	2.203		0.025 *	52	3.359	3.041		0.003 *
20	2.565	3.017		0.000 *	53	2.130	2.183		0.555
21	3.652	3.594		0.572	54	3.359	3.738		0.001 *
22	2.253	2.865		0.000 *	55	3.781	3.721		0.525
23	3.346	3.523		0.123	56	3.691	4.148		0.000 *
24	3.494	3.549		0.603	57	1.974	1.852		0.167
25	3.735	3.517		0.060	58	3.365	3.901		0.000 *
26	3.718	3.710		0.958	59	2.881	3.420		0.000 *
27	3.296	3.706		0.001 *	60	2.420	2.000		0.000 *
28	3.676	3.871		0.149	61	3.241	2.983		0.031 *
29	3.352	3.016		0.004 *	62	3.780	3.556		0.019 *
30	2.882	2.908		0.776	63	3.721	3.645		0.538
31	3.737	3.857		0.292	64	3.339	3.593		0.018 *
32	2.397	2.409		0.921	65	2.236	2.431		0.109
33	2.570	2.206		0.000 *					

* denotes significance at the 5% level

Note: Response value 1.0 represents strong agreement; Response value 3.0 represents neutral; Response value 5.0 represents strong disagreement

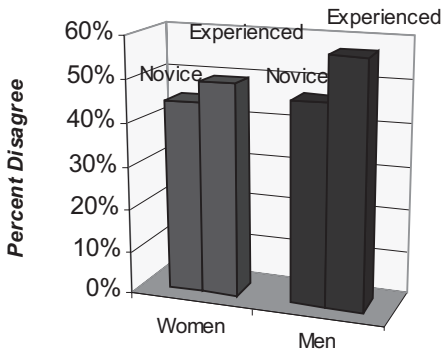
Table 2. Percent Agreement with Selected Factors that Influence Women Pursuing Aviation Careers

<i>Item</i>	<i>Agree / Disagree</i>	<i>Average</i>			
		<i>Novice</i>		<i>Experienced</i>	
		<i>Women</i> (<i>n</i> = 75-85)	<i>Men</i> (<i>n</i> = 75-90)	<i>Women</i> (<i>n</i> = 85-90)	<i>Men</i> (<i>n</i> = 85-100)
5	Disagree	44.7%	46.7%	49.4%	57.0%
6	Agree	88.1%	81.3%	90.0%	86.5%
7	Agree	63.2%	51.1%	46.7%	51.4%
8	Agree	27.6%	17.7%	13.9%	15.9%
14	Disagree	34.1%	25.0%	30.9%	8.7%
20	Agree	61.3%	38.9%	44.3%	33.7%
22	Agree	54.9%	29.5%	63.3%	44.0%
24	Disagree	50.6%	63.9%	68.2%	67.3%
27	Disagree	48.3%	75.0%	56.3%	68.1%
29	Disagree	58.9%	32.6%	50.0%	42.9%
36	Agree	46.6%	26.5%	40.0%	16.2%
39	Agree	51.1%	41.8%	49.5%	30.0%
46	Agree	43.0%	12.1%	26.3%	14.3%
47	Agree	33.7%	42.7%	38.9%	48.5%
48	Agree	71.1%	59.8%	62.6%	51.9%
51	Agree	73.6%	57.5%	64.8%	52.0%
58	Agree	38.6%	11.0%	24.7%	4.5%
59	Agree	34.4%	14.1%	46.7%	27.4%
62	Disagree	79.1%	60.5%	70.6%	66.0%

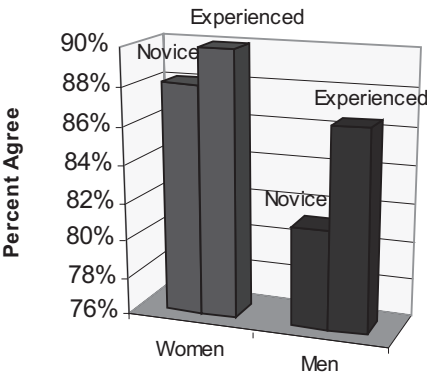
Note: Number of responses varied within (n) ranges.

APPENDIX C

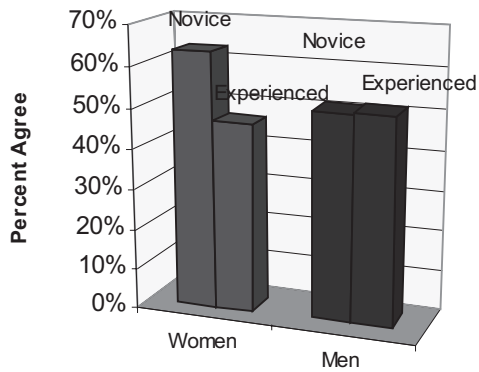
Question 5 - I may be unable to have a family and a flying career both



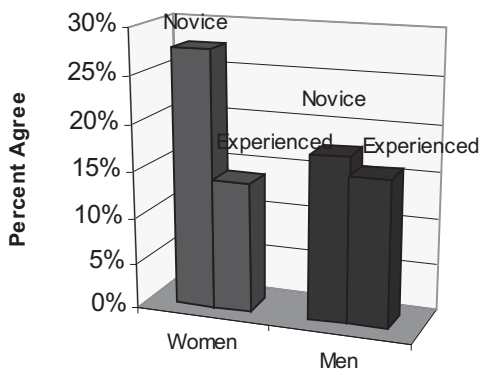
Question 6 - I prefer my flight instructor demonstrate a maneuver before I have to try it

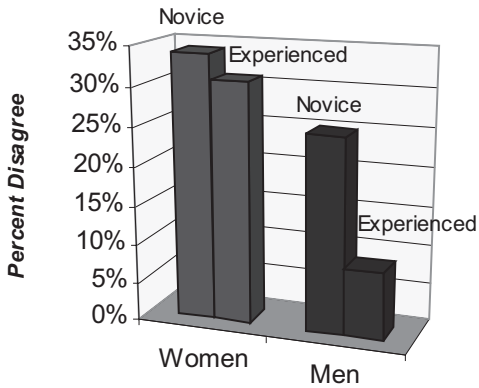
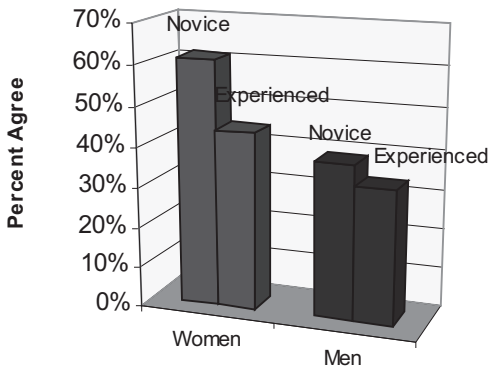


Question 7 - I prefer to learn by discussion with others, rather than by myself

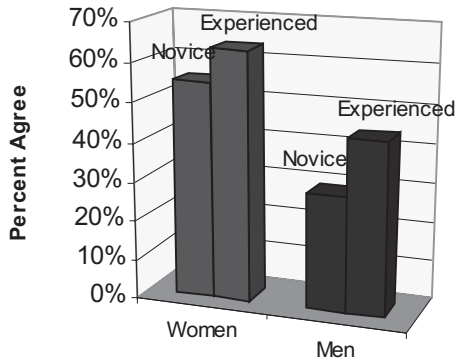


Question 8 - My male peers always want to decide who is in charge

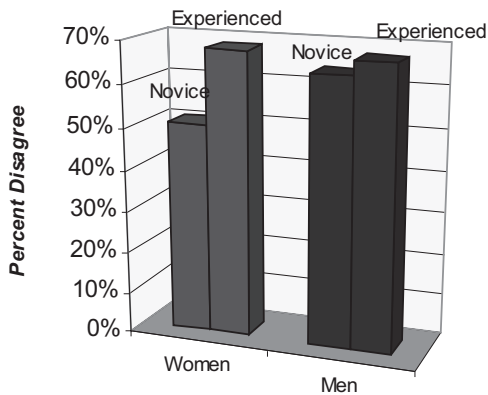


Question 14 - I am acquainted with women in aviation**Question 20 - I don't think men like women who fly better than they do**

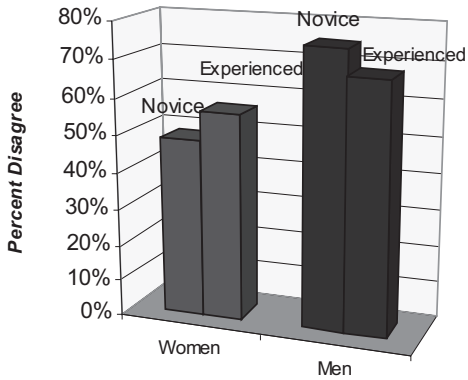
Question 22 - I think women should mentor women who are learning to fly



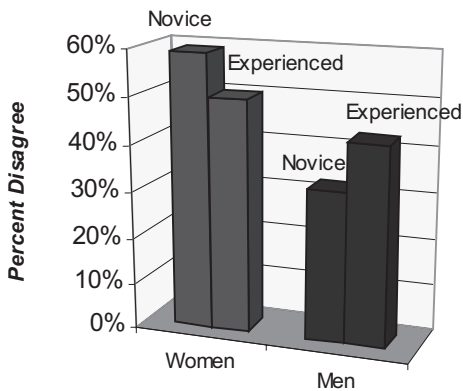
Question 24 - I think that women have to work harder than men do when learning to fly



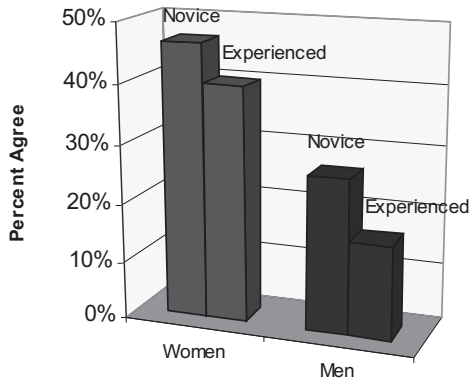
Question 27 - I feel that some faculty members treat women with a "stand-off" attitude because they believe aviation is a man's world



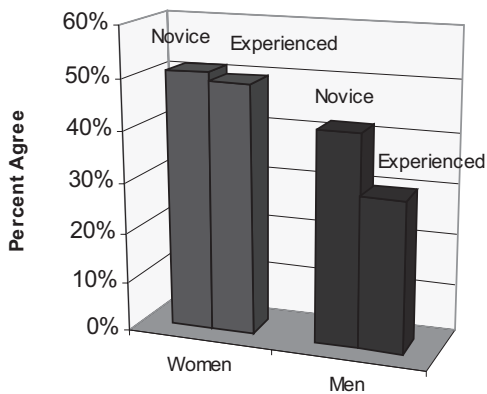
Question 29 - Women and men both learn the same way



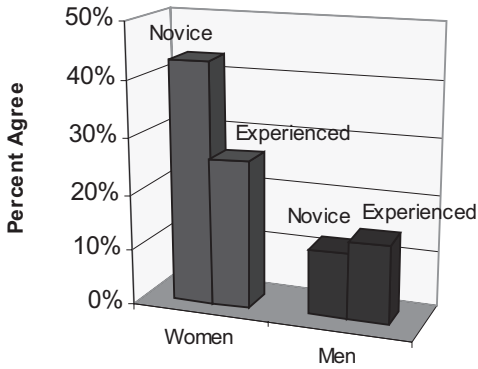
Question 36 - I have to prove myself to be accepted by the men in the flight program



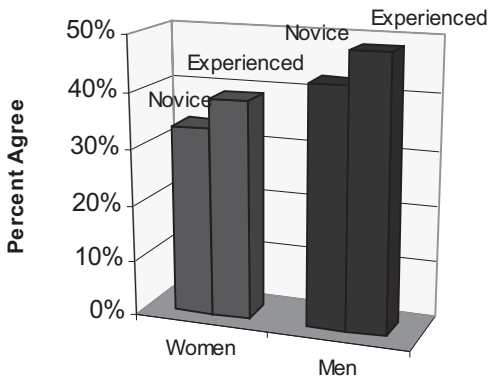
Question 39 - Women who go into aviation have to be psychologically stronger than other women



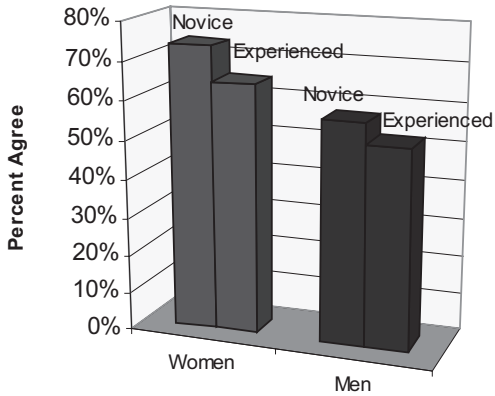
Question 46 - Women Faculty are more supportive than male faculty



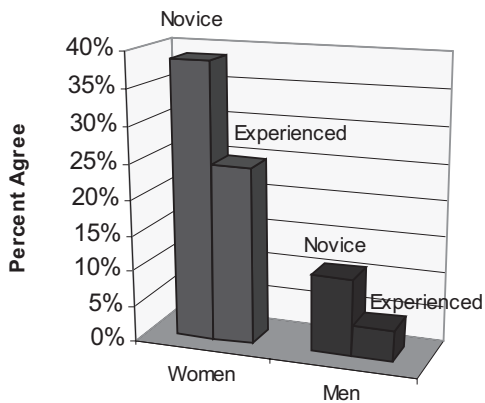
Question 47 - I do better working alone than working in a group



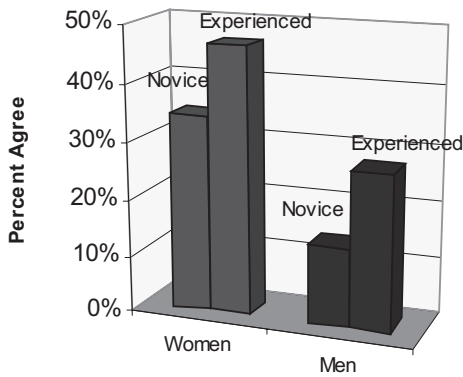
Question 51 - Sexist remarks annoy me



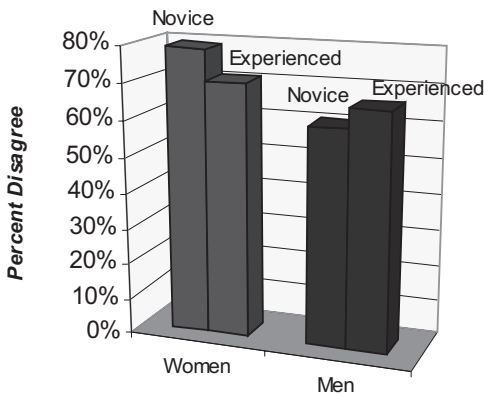
Question 58 - I sometimes feel like an outsider working with men around airplanes



Question 59 - I think women need mentors to succeed in aviation



Question 62 - Men have to prove themselves to be accepted by the women



FUEL CONSUMPTION MODELING OF A TRANSPORT CATEGORY AIRCRAFT USING FLIGHT OPERATIONS QUALITY ASSURANCE DATA: A LITERATURE REVIEW

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ABSTRACT

Fuel is a major cost expense for air carriers. A typical airline spends 10% of its operating budget on the purchase of jet fuel, which even exceeds its expenditures on aircraft acquisitions. Thus, it is imperative that fuel consumption be managed as wisely as possible. The implementation of Flight Operations Quality Assurance (FOQA) programs at airlines may be able to assist in this management effort. The purpose of the study is to examine the literature regarding fuel consumption by air carriers, the literature related to air carrier fuel conservation efforts, and the literature related to the appropriate statistical methodologies to analyze the FOQA-derived data.

INTRODUCTION

Air carriers spend vast sums of money on fuel to operate their fleets of aircraft. This major cost area must be managed as wisely as possible. Extensive research is being conducted by a host of organizations, including government, industry, and academia, but the research is essentially confined to engineering related areas. Little exists in the literature on efforts to examine, on a routine basis, the fuel efficiency of operational air carrier aircraft to determine if improvements are possible.

It is hypothesized that Flight Operations Quality Assurance (FOQA)-derived data can be used in the effort to manage fuel more efficiently through a statistical analysis of the data, specifically using multiple

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regression analysis and modeling. Thus, the purpose of the literature review is to examine the evidence relative to this hypothesis. To accomplish this objective, the author examined literature related to efforts to conserve fuel, FOQA studies, and statistical methodologies used in studies of this nature.

The logical next step following the current study is to apply these statistical tools revealed in the literature to FOQA data and develop a model for fuel consumption for a specific aircraft model.

IMPORTANCE OF THE STUDY

The importance of the current study is based on the consumption of jet fuel by the industry, and the cost savings to the industry and the public that might be realized by using FOQA data to detect higher than normal fuel consumption, which might be caused by airframe or engine abnormalities.

Air Carrier Fuel Consumption

Certified U.S. air carriers consumed more than 13.6 billion gallons of jet fuel in 1997 (domestic operations only), which represents an average increase of 3.5% during each of the previous five years (*Fuel Consumption*, 2001). Based on the following projections, fuel usage will continue to trend upward. The Department of Transportation (DOT) projects that there will be a 3.6% annual increase in passenger enplanements over the next twelve years. The average annual increase of airborne hours for U.S. air carriers is expected to increase by approximately 3.5% during the same period (DOT Federal Aviation Administration [FAA], 1999). These data suggest a substantial growth in the industry and, thus, the potential for even more fuel consumption by air carriers.

Partially offsetting industry growth in terms of fuel consumption are the many improvements that have been made in commercial aircraft fuel efficiency. Greene (1990) points out that air travel tripled between 1970 and 1989, but the growth of fuel use was restrained by a near doubling of efficiency, measured in seat miles per gallon (SMPG). Commercial aircraft delivered 26.2 SMPG in 1970 and improved to 49 SMPG less than twenty years later. Aircraft manufactured in the 1990s achieve approximately 65–80 SMPG.

As a result of the growth in the industry, but tempered by gains in fuel efficiency, fuel usage is expected to increase to more than 19.8 million gallons by 2010 (domestic operations only) (*Total Jet Fuel*, 2001).

According to the Air Transport Association (ATA, 2000), fuel costs is the airline's second largest operating cost category representing approximately 10% of total expenditures. Only labor costs (35%) exceed expenditures for fuel. As might be surmised based on these data, the economics of the air transportation industry are extremely sensitive to fluctuations in fuel usage, as well as fuel cost. As reported by the ATA, jet

fuel prices increased about twenty-cents from March 1999 to December 1999. This increase in the price of fuel resulted in a \$750 million increase in total fuel costs to the industry.

Others concur with Greene that there have been many improvements in the past several years that have resulted in an increase in fuel efficiency, and there will continue to be various gains made in the years ahead. Dobbie and Eran-Tasker (2001) report that a recent survey of airlines determined that a number of different approaches are being taken to minimize fuel consumption and associated emissions. These include continuous descents from altitudes, increased efforts to monitor fuel use to improve information systems, improvement in the effectiveness of aircraft loading process, minimization of fuel tankering, sophisticated route and fuel planning, use of lighter cargo containers, reduced use of paint applications, and many others. Although these approaches may seem minor when considered individually, when taken together and applied system-wide, the resulting savings may be considerable.

RESEARCH METHODOLOGY

The literature review was begun by searching several databases such as ProQuest, the Missouri Education and Research Libraries Information Network (MERLIN), ArticleFirst, FirstSearch, Dissertation Abstracts, aerospace databases, the Federal Register, and others, for relevant articles written in the past several years. The search was limited to more recent articles due to the rapid pace of technological change in the airline industry and the recent development of FOQA technologies. In these databases, several hundred articles were located using keywords of *fuel conservation*, *fuel consumption*, *fuel efficiency*, *fleet performance*, *flight operations* (or *operational*) *quality assurance*, *regression analysis*, and other similar search terms. The abstracts of each of these was read, and approximately 125 abstracts were determined to be relevant to the topic. Full text articles were obtained for 56 articles and all were studied in detail. Of these articles, 14 were deemed valuable and provided the basis for the literature review. Supplementary materials such as DOT fuel usage reports, FAA policy statements, and statistics textbooks were used to round out the literature review.

RESULTS

The literature discussing FOQA, transport aircraft fuel consumption characteristics, aircraft fuel studies, and statistical methodologies appropriate for such an analysis were reviewed.

FOQA

In 1995, the DOT sponsored an aviation safety conference in cooperation with representatives from industry and government. The focus of the conference was the development of additional measures that might be implemented to reverse the trend of increasing number of accidents in the airline industry. One of the significant conclusions of the conference was that the voluntary implementation of FOQA might be the most promising initiative to reduce the number of accidents. Upon the recommendation of the conference attendees, the FAA sponsored a FOQA demonstration project with the following objectives: to develop hands-on experience with FOQA technology in a U.S. environment, document the cost-benefits of voluntary implementation of FOQA programs, and initiate the development of organizational strategies for FOQA information management and use (DOT FAA, 1998). The FAA-funded \$5.5 million demonstration project was begun in July 1995.

Essentially, "FOQA is a program for obtaining and analyzing data recorded in flight to improve flight crew performance, air carrier training programs and operating procedures, air traffic control procedures, airport maintenance and design, and aircraft operations and design" (U.S. General Accounting Office, 1997). FOQA is a voluntary program that involves the routine downloading and systematic analysis of aircraft parameters that were recorded during flight. The recording unit, which receives data from the flight data acquisition unit(s), is either a crash-protected device or a quick access recorder (QAR). The QAR is a device that allows convenient access to the recording medium and typically records more data than crash-protected devices. Three types of analysis can be performed on the data: (a) exceedance detection—this is the continuous comparison of recorded operational data with predefined parameters to detect occurrences that exceed those parameters, (b) data compilation—used to determine the operation and condition of engines and systems, and (c) diagnostics, research, and incident investigation (Holtom, 2000).

Most air carrier aircraft store FOQA data on an optical storage device and then transfer the data to a ground analysis system where it is processed by expert software. Typically, modern digital aircraft capture and store between 200 and 500 parameters per second (U.S. General Accounting Office, 1997), including gauge readings, switch positions, control wheel deflections, control positions, engine performance, hydraulic and electrical system status, and many others.

Along with the benefits of FOQA to flight operations, the data can also have value for the air carrier's maintenance operations. Using data analysis techniques, analysts should be able to detect aerodynamic inefficiencies such as out-of-trim airframe configurations, deterioration of the powerplant, and other deficiencies in the aircraft's systems. Given the

quantity of fuel consumed by commercial aircraft, as discussed earlier, the identification of problems that result in an increase in fuel consumption by FOQA, and subsequent correction of the deficiency, can lead to considerable fuel savings to the airline industry.

Several airlines have implemented voluntary FOQA programs and the benefits are beginning to be documented. Several examples of safety and operational problems for which FOQA provided objective information are cited by the U.S. General Accounting Office (1997). An airline discovered through its FOQA program that the number of exceedances was greater during flight in visual conditions than in instrument conditions. This finding caused the airline's training managers to change the training program to emphasize flight in visual conditions. That is a clear quality and safety benefit provided by FOQA. Another airline's FOQA analysis determined that the incidence of descent-rate exceedances was unusually high at one particular runway at an airport. The cause was determined to be a poorly designed instrument approach procedure that required flight crews to descend steeply during the final approach segment. When these findings were shared with the FAA, the approach was redesigned to correct the problem.

FOQA has provided a number of airlines objective, quantitative information that can be used to evaluate approach procedures that are unusual with respect to rate of descent or excessive maneuvering at low altitude. Airlines have reported that they have used FOQA information to identify and correct a variety of safety problems through changes or renewed emphasis in standard operating procedures, retraining, and the repair of faulty equipment.

The FAA's preliminary estimates of costs versus benefits of FOQA programs are encouraging to FOQA advocates. The annual cost of a U.S. program with 50 aircraft is approximately \$760,000 per year. Savings from reduced expenditures for fuel, engine maintenance, and accident costs are estimated at \$1.65 million per year, resulting in a net annual savings of \$892,000 (U.S. General Accounting Office, 1997).

There were no studies located in the literature that use FOQA data for any purpose. This is not surprising given the relative newness of the technology.

Many airlines plan to integrate the use of FOQA with other quality-based safety and operational programs, such as safety reporting systems and action plans. This will enable FOQA to be one, albeit important, component of an airline's overall quality program.

Fuel Studies

Numerous fuel efficiency or conservation studies were located in the literature, but the vast majority of them are concerned with engineering rather than operational issues. Several articles were located, though, that

have some implications for the current study, mostly in terms of the appropriate statistical analysis. A brief description of these studies follows.

Kauser and Burcham (2001) conducted a study to predict the off-design performance of a generic low-bypass, mixed flow, augmented turbofan with a triple spool layout. Using estimated performance data based on developed by the National Aeronautics and Space Administration (NASA) engine cycle simulation code, the authors compared the data claimed by the manufacturer with the estimated data. The authors' conclusion was that there was significant disagreement between the estimated engine performance data and the manufacturer's specifications across several parameters. The methodologies used for making that determination were not disclosed in the study.

In another study of gas-turbine aircraft engines utilizing NASA engine cycle simulation code, Patnaik, Guptill, Hopkins, and Lavelle (2001) created two analysis approximators to overcome difficulties encountered in engine cycle analysis. The approximators created were based on neural-network and linear-regression methods. Engine optimization typically adjusts a few engine parameters. An engine design optimization problem was then solved using the three analyzers: the original simulation code, the neural-network derived analyzer, and the linear regression derived analyzer. The computation of regression coefficients for the linear regression analysis was performed using ordinary least squares methods. Patnaik et al. concluded that the performance of linear regression and neural network methods as alternate engine analyzers was found to be satisfactory for the analysis and operation optimization of gas turbine aircraft engines.

Other Studies Using Similar Methodologies

A study employing similar methodologies was conducted by Luxhoj, Williams, and Shyur (1997); using regression and neural network modeling approaches to predict inspection profiles for aging aircraft. A primary concern of the authors of this study was multicollinearity (i.e., a condition in which the predictor variables in a regression model are themselves highly correlated) since a high degree of multicollinearity makes the results not generalizable. The interrelationship inherent in the independent variables—flying hours, number of landings, and age of the aircraft—makes some degree of multicollinearity inevitable. Two statistical measures of multicollinearity were discussed—tolerance (TOL) value and variance inflation factor (VIF). TOL is equal to one minus the proportion of a variable's variance that is explained by other predictors. A low TOL value indicates a high degree of collinearity in the model. The VIF is simply the reciprocal of the TOL; thus, a high VIF value suggests a high degree of collinearity. According to the authors, a high TOL (above 0.10) and a low VIF (below 10) usually suggest a relative small degree of

multicollinearity. An attempt was made to remove multicollinearity by removing the linear trend from the observed variables. Both the dependent and independent variables were transformed by replacing their observed values with their natural logarithms. This approach had the desired effect of reducing multicollinearity, but the resulting regression models all had higher coefficients of variation and lower R^2 values than models without such variable transformations. Also of interest in this study was the process utilized to identify the factors influencing the expected number of events. Data grouping strategies were employed to create robust event prediction models that provided event profiles for a representative aircraft. Multiple regression models were developed to determine the best grouping strategy. This study is important in that it introduces methodologies for coping with multicollinearity, which will be of concern in analyzing FOQA data due to the interrelationships of the variables inherent in that data.

A study conducted by Gibbons and McDonald (1999) compared several different approaches to determining the most appropriate functional form of the regression model for a fuel efficiency problem. One of the primary determinants of this issue is the analyst's knowledge of the relationship that exists between the dependent variable and the independent variables. Utilizing knowledge of the signs and ordering of the regression coefficients is accomplished in a deterministic optimization context, where regression coefficients are estimated by minimizing the residual sum of squares subject to certain constraints on the coefficients. The authors assert, based on their scan of the literature, that this approach is widely used in econometric applications, but not so widely used in physical sciences applications.

Studies that generally support the proposed approach were located in the literature in industries other than aviation. Lin, Jovanis, and Yang (1993) conducted a study in the trucking industry where time-dependent logistic regression techniques were applied to assess the safety of motor carrier operations. Of particular interest were the methodologies used to create the models used for comparison, that is, combining numerous covariates. The authors used several tests to assess the significance of variables and models, including a likelihood ratio test for inclusion or exclusion of a variable as a whole and t-statistics for each category of each variable.

Munson and Khoshgoftaar (1990) conducted a study on regression modeling of software quality. The objective of their work was to explore several statistical approaches to the development of predictive models of program quality. The authors explored three kinds of regression models: the combinatorial method; the stepwise regression procedure; and the reduced model. The latter is accomplished by mapping a set of independent variables onto a smaller number of orthogonal dimensions through factor analysis. Beneficially, the process of factor analysis eliminates the problem of multicollinearity, or severe nonorthogonality, discussed earlier in Luxhøj

et al. (1997). Principal components analysis may be used to detect collinearity in the independent variables, and has been found to be useful in measuring the performance of a regression model. This is significant since the coefficient of determination, R^2 , is not a good tool for evaluation of the final regression model. This is due to the fact that R^2 is defined as: $R^2 = SSR/SST$, where SST is the total sum of squares and SSR is the regression sum of squares. Given that SST is constant for all regression models, R^2 can only increase as additional independent variables are added to the equation. Thus, the R^2 statistic does not evaluate the quality of future prediction, only the quality of fit on the sample data. However, the PRESS statistic is based on a systematic examination of the residuals, and the authors assert that the use of the PRESS statistic offers a superior predictive quality.

A study by Irish, Barrett, Malina, and Charbeneau (1998) provides useful information regarding the selection and inclusion of causal variables in a regression model. According to the authors, the first step in selecting causal variables is to identify those variables that have scientific relevance based on hypotheses about the controlling processes. The second step in the selection process is to use regression analysis to choose those variables that have statistical relevance to the process. This is accomplished through hypothesis tests that determine whether a coefficient of a model variable is statistically different from zero. The authors state,

All relevant explanatory variables exhibit the following three traits: 1.) Some underlying scientific theory explains the response of the dependent variable to a change in the explanatory variable, 2.) The explanatory variable, when included with all of the other explanatory variables, must individually add some new information to the model (i.e., the variable cannot be perfectly collinear with any other variable), 3.) The explanatory variable is known with certainty or at least capable of being measured with a high degree of accuracy (p. 988).

The method of selecting variables to include in the regression model is strictly subjective and left up to the discretion of the analyst. Multicollinearity affects the data, so the modeler must understand that higher values will result for the variance of the estimated coefficients, causing the standard error of the regression to be higher than it would otherwise and, therefore, the t -ratio to be smaller. The predictive performance is not affected by multicollinearity of the data, but the individual affects of each explanatory variable on the dependent variable will be obscured by the phenomenon.

Irish et al. (1998) used a three-step approach to search for the most parsimonious suitable model. The first step was an overfit of the model; that is, the regression equation is formulated using every known causal variable, and each coefficient is evaluated using two tests—statistical

relevance and scientific relevance. Variables that fail both tests are discarded. The regression equation is revised and the new coefficients are examined for relevance. This procedure was repeated until all variables that failed both tests were eliminated. The second step was to make individual judgments about variables that failed only one of the two tests. The final step of the process involved reconsidering the discarded variables, since it was possible for a variable that was previously discarded to become relevant in the new model formulation having fewer variables.

CONCLUSION

This literature review revealed several important facts. First, studies utilizing FOQA are absent from the literature. This should not be taken to indicate the lack of value FOQA data and analysis might have in studies of the nature contemplated in this work; rather, it is indicative of the newness of the technology. In fact, it can be assumed that air carrier personnel are working on analyses of this kind. Given the potential of analysis of safety and operational conditions using FOQA data, and the complexity and extensiveness of the data, there is tremendous opportunity for research in this field by researchers and analysts with interest and expertise.

Second, it is clear that fuel conservation is of major concern to the industry. Studies by IATA and ICAO are evidence that much consideration is being given to various approaches to managing fuel efficiency more carefully. According to ICAO, even seemingly insignificant improvements can amount to substantial savings on a global scale.

Third, regression modeling appears to be the appropriate statistical approach for a study of air carrier fuel consumption using FOQA data and statistical analysis. Several studies in related and unrelated fields demonstrate the use of regression analysis for modeling purposes. These studies use various methods for selection of causal variables and testing procedures to determine statistical relevance. Techniques for coping or compensating for multicollinearity are provided, and extensive discussion of the development of the regression model is presented. It is anticipated that these techniques and methods, as appropriate, can be used in the development of a fuel consumption model using FOQA data for an air carrier aircraft.

Fourth, FOQA data can be compared to manufacturer's specifications at various flight conditions to determine the accuracy of the manufacturer's models. In addition, the development of fuel efficiency models independent of those established by the manufacturer is possible using these methods.

Finally, it should be noted that many airlines have extensive quality programs in place for safety and operations. Any improvements resulting from FOQA data-driven fuel consumption models should be incorporated into the overall quality system.

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INTEGRATED INS/GPS NAVIGATION FROM A POPULAR PERSPECTIVE

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ABSTRACT

Inertial navigation, blended with other navigation aids Global Positioning System (GPS) in particular, has gained significance due to enhanced navigation and inertial reference performance and dissimilarity for fault tolerance and anti-jamming. Relatively new concepts based upon using Differential GPS (DGPS) blended with Inertial (and visual) Navigation Sensors (INS) offer the possibility of low cost, autonomous aircraft landing. The FAA has decided to implement the system in a sophisticated form as a new standard navigation tool during this decade. There have been a number of new inertial sensor concepts in the recent past that emphasize increased accuracy of INS/GPS versus INS and reliability of navigation, as well as lower size and weight, and higher power, fault tolerance and long life.

The principles of GPS are not discussed; rather the attention is directed towards general concepts and comparative advantages. A short introduction to the problems faced in kinematics is presented. The intention is to relate the basic principles of kinematics to probably the most used navigation method in the future-INS/GPS. An example of the airborne INS is presented, with emphasis on how it works. The discussion of the error types and sources in navigation, and of the role of filters in optimal estimation of the errors then follows. The main question this paper is trying to answer is “What are the benefits of the integration of INS and GPS and how is this, navigation concept of the future achieved in reality?” The main goal is to communicate the idea about what stands behind a modern navigation method.

INTRODUCTION—CAPTURING A MOTION

In navigation the systems in which position parameters (e.g., the coordinates¹) change with time, are referred to as kinematic processes or systems. Here we refer to a kinematic rather than a dynamic process—studies made under the heading of kinematics differ from dynamical investigation in that the concept of mass is not considered. Thus kinematics is sometimes referred to as the geometry of motion. A kinematic model

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describes a moving system (e.g., a vehicle or vessel) by putting parameter estimates at successive epochs in a mathematical relation.

A particle that is moving in space, and of position given by a system of curvilinear coordinates \mathbf{x} , as the time t varies describes a certain spatial curve called trajectory. It is given simply by:

$$\mathbf{x} = \mathbf{x}(t). \quad (1)$$

Here \mathbf{x} corresponds to position vector \mathbf{r} of a vehicle or vessel. In navigation it is functionally related to position finding, thus obviously representing the main object of interest for avionics personnel working with navigation applications (see Figure 1). This figure shows the navigation process, differentiation feedback loop (Wells, 1996 based on Anderson, 1966). The first derivative of Equation 1 with respect to time is named velocity vector (\mathbf{v}) of the particle. In navigation it comes into the center of the navigator's attention during the route following. The second derivative with respect to time of Equation 1 is called acceleration vector (\mathbf{a}) of the particle. The aspect of navigation that deals with acceleration is guidance.

In dynamics particles are still idealized as points and their paths are represented by space curves, but because mass (m) is taken into account, the study of velocity and acceleration fields along the curves is replaced by a study of momentum ($m\mathbf{v}$) and force ($m\mathbf{a}$) fields. (Wrede, 1963).

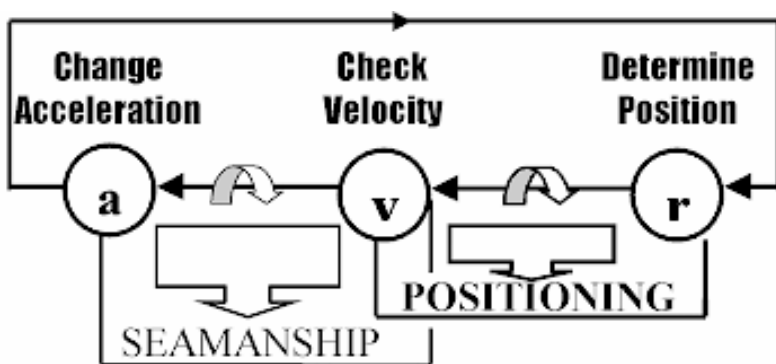


Figure 1. The navigational process and differentiation feedback loop

Note: Wells, D.E. (1996) *Hydrographic Surveying*. Unpublished lecture notes GGE4053, Department of Geodesy and Geomatics Engineering, University of New Brunswick, Canada. Reprinted with permission.

Basically, a kinematic model is represented by the mathematical expression for the predictability of the motion. This predictability is

another way of saying that the position parameters are not entirely random, but have values related to their values at an earlier epoch. To illustrate this, we discuss the error/time frame. (see Figure 2)

Mean error

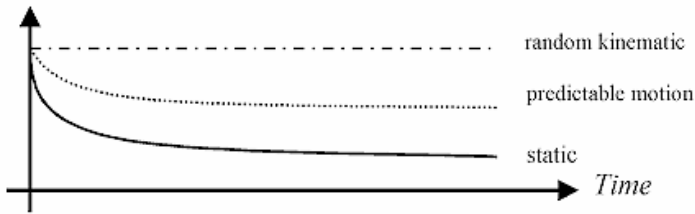


Figure 2. Precision of positioning under various conditions

Note: From *The Kalman Filters in GPS Navigation*, by B. Merminod, 1989 NSW Australia: University of New South Wales. Copyrighted 1989 by University of New South Wales. Reprinted with permission.

Considering the purely random kinematic mode used to describe a motion, each determination of the position is independent of the others. Assuming that all other factors influencing the positioning system (e.g., the GPS) are constant, the precision of a fix is also constant in time (see Figure 2). If, on the other hand, the static mode is used for determining the position (say, a ground mark) each new measurement will contribute to the determination of the same position parameters. Extending an observation session makes more data available for the estimation of the same number of parameters, hence improving their precision. The predictability issue is raised once we accept that the difference in behavior of static versus kinematic solutions is not due to the movement itself, but to the a priori knowledge on the movement. If we could predict the movement of a vehicle as well as that of a ground mark (which, of course, in that case is not moving), the positions at different epochs could be perfectly related to one another and the precision obtainable would approach that of the static case. This applies, e.g., to an object moving along a known trajectory. Therefore, it is the predictability of the object's motion that permits the link between static mode (surveying) and well-behaved kinematic mode (most navigation) to be established. The dotted line shown on Figure 2 then represents the resulting improvement in the quality of the position determination.

INS/GPS INTEGRATION

Among today's trends in navigation are the integrated navigation systems, where the components (sensors) that are usually being integrated are the Inertial Navigation Systems (INS) and the Global Positioning System (GPS). Other sensors used in integration are, for instance, the Doppler Velocity Sensors (DVS). The purpose of combining navigation subsystems into an integrated system is to take advantage of complementary strengths of the subsystems. Thus navigation that is more reliable than that of individual subsystems is provided.

The INS computes the position by a sophisticated form of dead reckoning. In the simplest form of dead reckoning, as practiced by navigators in the past, the navigator multiplies the indicated (or estimated) speed by the estimated time enroute to obtain the estimated distance traveled from his starting location in a fixed direction usually provided by a magnetic compass. The assumptions made here are that velocity and heading are constant. The INS relies upon basically the same principle except it contains accelerometers that sense all specific forces including gravity. Further, it contains gyros that sense all angular rates experienced by the INS with respect to the inertial frame of reference.² With knowledge of angular rate, the INS computes the vehicle's orientation with respect to a geographic reference in the form of attitude (roll, pitch angles) and heading (see Figure 3). With the knowledge of vehicle acceleration, the INS computes the vehicle's velocity and change in position on the Earth, in form of latitude, longitude and altitude.

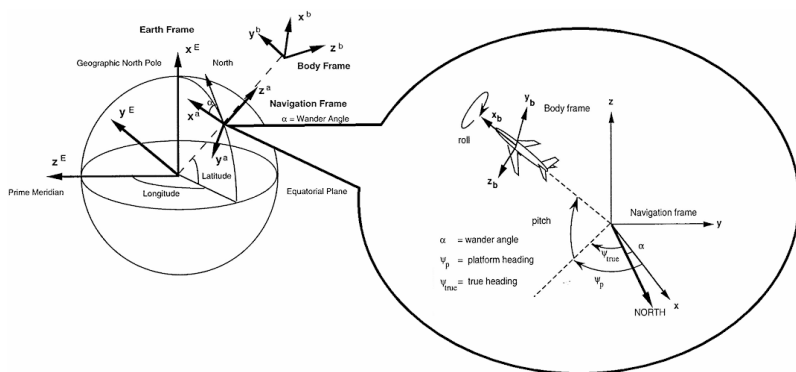


Figure 3. The body frame with respect to the reference frames used in navigation

Note: From "A Report on Navigation Systems Integration and on the Benefits and Costs of Integration," by B.M. Scherzinger, 1993, unpublished report. Reprinted with permission.

Three main forces that an INS has to take into account are: (a) Gravitational acting down; (b) Centrifugal due to Earth's rotation and sensed by gyros—a radial force acting outward from the object, unlike centripetal that acts toward the object; and (c) Coriolis³ force in the direction of the movement, coming from compound acceleration of coriolis (in navigation: Coriolis correction of the sensed acceleration).

$$\mathbf{a}_c = 2\omega \times \mathbf{v}^1, \quad (2)$$

where ω (assumed to be constant—variations in earth's rotation can be neglected in navigation) represents the angular velocity of the rotating body (the Earth), and \mathbf{v}^1 relative velocity (with respect to the Earth). \mathbf{a}_c correction is applied with respect to a frame relative to inertial space.

HOW IT WORKS

An INS designed to navigate on the Earth and in its atmosphere must first subtract the gravitational, centrifugal and the Coriolis effects in form of the corresponding accelerations, from the sensed specific accelerations in order to obtain the INS's acceleration with respect to the Earth. Then it has to subtract the Earth's rotation rate (15° per hour) from the sensed angular rates to obtain the INS's angular rate with respect to the Earth. The INS finally integrates the corrected accelerations and angular rates to obtain changes in velocity, position, attitude and heading, with respect to the Earth.

On Figure 4 is an example (Scherzinger, 1993) of the simplistic view of inertial space-stabilized navigation. The accelerometers are mounted on a platform that can rotate in the azimuth plane on the aircraft and are initially oriented North, East and Down, sensing North and East accelerations and the Down force. A single gyro mounted on the same platform senses the angular rate along the azimuth axis. The aircraft is initially at rest facing East, and accelerates to a velocity of 1 m/s over 1 second. The East accelerometer senses this as acceleration a_{East} that accelerates the airplane. The INS computes the changes in velocity v_{East} and position r_{East} as:

$$\left. \begin{aligned} v_{\text{East}}(t) &= v_{\text{East}}(t_0) + \int_{t_0}^t a_{\text{East}}(\tau) d\tau \\ r_{\text{East}}(t) &= r_{\text{East}}(t_0) + \int_{t_0}^t v_{\text{East}}(\tau) d\tau \end{aligned} \right\}. \quad (3)$$

Then the aircraft enters a turn and thereby changes its heading.

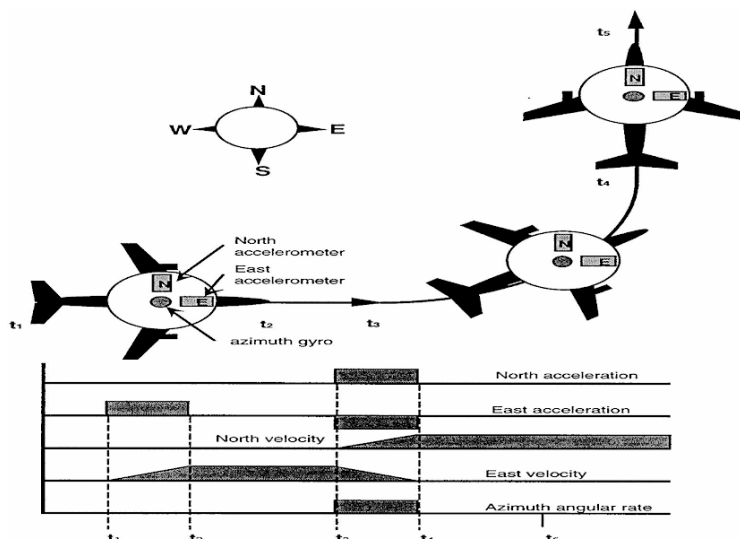


Figure 4. An example of the INS applied in air navigation

Note: From "A Report on Navigation Systems Integration and on the Benefits and Costs of Integration," by B.M. Scherzinger, 1993, unpublished report. Reprinted with permission.

The azimuth-angular rate is sensed by the gyro and is used as a signal to a torque motor that rotates the platform about the azimuth axis in direction opposite to the sensed angular rate (clockwise in our case). The platform rotates with respect to the aircraft's centerline, and not with respect to the Earth's surface below the flying aircraft. Thus the North-East orientation of the accelerometers is being maintained. Worth noting here is that the aircraft's heading is the azimuth angle between the aircraft centerline and the accelerometer North axis. Finally, during the maneuver (a turn) as the aircraft changes its velocity from an East velocity to a North velocity this change is being described by a North acceleration and an East acceleration. The North and East accelerometers, naturally, sense these. In this way, the INS computes an increasing North velocity and decreasing East velocity during the turn. Once the turn is completed, the INS computes a constant North velocity since both the North and East accelerometers sense no aircraft accelerations (see Figure 4). Thus the stabilized platform has maintained its North-East orientation before, during, and after the turn.

In cases when the Down accelerometer senses a specific acceleration as the aircraft begins, for example, to climb, this (equation 4) is the resultant

$$a_{\text{Down}}^{\text{Sensed}} = a_{\text{Down}} + g, \quad (4)$$

(the sum) of the aircraft's vertical acceleration and the gravitational acceleration. Then the INS computes the aircraft altitude change from initial altitude h_0 and sensed acceleration, as:

$$h = h_0 + \iint (a_{\text{Down}}^{\text{Sensed}} - g) dt. \quad (5)$$

In a procedure separate from but analogue to the above-described one (maintaining the North-East orientation of the platform), the level orientation of the platform is being preserved as well. Here the platform ideally defines a navigation frame that is both locally stable and locally level. The accelerometer triad (North, East, and Down), in this case mounted on the platform, outputs a sensed acceleration vector given by:

$$\mathbf{a}^{\text{Sensed}} = \begin{bmatrix} -a_{\text{North}}^{\text{Sensed}} \\ -a_{\text{East}}^{\text{Sensed}} \\ -a_{\text{Down}}^{\text{Sensed}} \end{bmatrix}, \quad (6)$$

which is resolved in the navigation frame with axes oriented North, East and Down. Similarly, the gyro triad (North, East, and Down) outputs a vector of North, East and Down angular rates used for maintaining the platform's stability. All subsequent changes in position and velocity are then computed in the navigation frame defined by the platform.

Let it finally be mentioned how, especially for military applications, besides the above space stabilized (stable platform and gimbals) and local level, also in usage nowadays are so-called strap-down inertial equipment mechanization.

INS Errors

Most INS errors can be attributed to inertial sensors (instrumental errors). These are the residual errors exhibited by the installed gyros and accelerometers following calibration of the INS. The dominant error sources in the INS are shown in Table 1.

As mentioned above, error-characteristics of an INS are the behavior of the free-inertial INS following a nominal alignment (determination of position on take-off). For example, aircraft navigators are familiar with the two dominant error-characteristics. The first is Schöler⁴ Oscillation, coming from the fact that the INS is behaving like a pendulum with the center of rotation in the center of the Earth. The second is Position Error Growth (PEG) is the most significant performance figure that characterizes

Table 1. Errors in the INS

Type/source	Description	Typical magnitude
Alignment errors	roll, pitch and heading errors	
Accelerometer bias or offset	a constant offset in the accelerometer output that changes randomly after each turn-on.	50-100 μ g (1 μ g=9.81x10 ⁻⁶ m/s ²)
Accelerometer scale factor error	results in an acceleration error proportional to sensed acceleration	75-200 ppm
Accelerometer and gyro nonorthogonality	the axes of accelerometer and gyro uncertainty and misalignment	5"-25"
Gyro bias or drift due to temperature changes (and gas circulation*)	a constant gyro output without angular rate presence	0.002-0.01 °/hr
Gyro scale factor error from temperature changes	error in the assumed degrees per second per pulse	< 10 ppm
Random noise		spectral density of (0.002°) ² /hr

* when the gas gyro is used

Note: From "A Report on Navigation Systems Integration and on the Benefits and Costs of Integration," by B. M. Scherzinger, 1993, unpublished report. Reprinted with permission.

an INS. Dominant source of the PEG rate is the gyro bias, contributing 60 nmi/hr. Number of nautical miles per hour position error-rate, that it typically exhibits, classically characterizes an INS.

Lastly we speak of INS state errors (including initial state errors, and inaccuracies in the gravity field modeling) (Linkwitz & Hangleiter, 1988). Equation 4 from our example (Down accelerometer) applies to any sensed acceleration (East or North). Also, we can express the measured (sensed) vector of acceleration (**a**) by a physical law (Linkwitz Hangleiter, 1988):

$$\mathbf{a}(t) = \frac{d^2}{dt^2} \mathbf{x}(t) + \mathbf{b}(t) - \mathbf{g}(\mathbf{x}(t)) \quad (7)$$

$$\mathbf{a}(t)^{Sensed} = \frac{d^2}{dt^2} \mathbf{x}(t) + \mathbf{b}(t), \quad (8)$$

where \mathbf{b} expresses rotational acceleration of the accelerometer frame with respect to inertial space, and \mathbf{g} is the gravity vector. The above-mentioned errors are then exhibited as relative position-errors as the integration takes place:

$$\mathbf{v}(t) = \frac{d}{dt} \mathbf{x}(t) = \frac{d}{dt} \mathbf{x}(t_0) + \int_{t_0}^t [\mathbf{a}(\tau) - \mathbf{b}(\tau) + \mathbf{g}(\mathbf{x}(\tau))] d\tau \quad (9)$$

$$\mathbf{x}(t) = \mathbf{x}(t_0) + \int_{t_0}^t \left[\frac{d}{d\tau} \mathbf{x}(\tau) \right] d\tau. \quad (10)$$

For integration intervals of several minutes these position-errors are of the order of several centimetres, and grow to hundreds of metres for integration intervals of several hours (Linkwitz & Hangletier, 1988). Thus high (decimetre accuracy) short-term stability and poor (hectometre accuracy) long-term stability can characterize the error behavior of inertial positioning (Schwarz, 1986). The way to handle these errors consists in bringing the inertial platform to a complete rest (zero velocity update) after which velocity is reset to 0 value. However this is not feasible during the flight, for which an In-flight Update is performed. For further references on INS errors, see, for example Scherzinger, 1993.

To get a better understanding of the effect of the most significant INS errors, let us consider an aircraft on a 5,000 km long route. Assuming the average speed of $v = 800$ km/hr, we apply this information on the typical magnitudes column from Table 1:

1. *accelerometer bias; 50-100 μ g*
 - best-case scenario: 0.0004905 m/s²
 - worst-case scenario: 0.000981 m/s²
2. *accelerometer scale factor error*
 - best-case scenario: 75 ppm on 5,000 km trajectory: 375 m
 - worst-case scenario: 200 ppm on 5,000 km trajectory: 1000 m
3. *gyro bias*
 - best-case scenario: 0.002°/hr on 800 km: 28 m
 - worst-case scenario: 0.01°/hr on 800 km: 140 m
4. *gyro scale factor*
 - best-case scenario: 0 m
 - worst-case scenario: 10 ppm on 5,000 km: 0.05 km = 50 m

Summarizing the above errors we conclude that total INS error would be, in

- best-case scenario: 0.375 km over 5,000 km + 0.028 km over 800 km
+ 0.01 km over 5,000 km = 560 m \approx **1/2 km**
- worst-case scenario: 1 km over 5,000 km + 0.140 km over 800 km +
0.05 km over 5,000 km = 1925 m \approx **2km**.

It is indicative that the accuracy of a stand-alone INS decreases significantly: the error reaches the order of kilometres. The well-known accuracy of even absolute GPS positioning (stand-alone GPS) is about 100 m horizontally and 150 m vertically. Thus these two systems definitely represent complementary subsystems for the navigation integration, error-wise. In the following we will discuss some characteristics that make them complementary to one another for reasons other than dissimilarity for fault tolerance.

Of course, this very rough investigation did not include all the errors listed in Table 1, or errors from the discussion of equations 7 through 10. The results above should therefore be addressed with great caution.

GLOBAL POSITIONING SYSTEM IN NAVIGATION

Global Positioning System (GPS) can be regarded as a new navigation sensor. GPS provides range and range-rate measurements. The primary role of GPS is to provide highly accurate position and velocity worldwide, based on range and range-rate measurements. The acceleration vector is then determined from positions at different time epochs, by differentiation of these positions with respect to time. Worth noting is that by accuracy we mean how close the average measurement is the actual true value (accuracy measures systematic error), distinguishing it thus from precision that describes how close the measurements are to one another (precision measures random error).

Integration with one or more external systems capable of sensing forces, for example, with an INS, has the goal of achieving reliability in navigation, as the GPS signals may not be available at all times. In that sense, the basic idea behind the integration of GPS and INS is to estimate the inertial sensor errors online using GPS. This means an in-flight calibration (update) or identification of the INS's state and instrument errors in order to provide a precise inertial navigation solution—even during the loss of GPS signal (a few seconds to over a minute)—based on previous knowledge of INS errors. At the same time, the INS can be used to bridge cycle slips and times of loss of lock, but most important it can be

used to bridge the time between two GPS position computations. (Liang, 1992).

Usually a filter code (a mathematical algorithm) that will optimally process such (by an integrated system) collected information is written, burned into a chip and integrated into the integration structure itself. Of course, a filter implementation is not a necessity, but rather an option—an especially desirable one in military aircraft navigation—when losses of GPS signal due to sudden maneuvers are often. Due to a filter implementation the final solution becomes consistently reliable. For example, short-term highly reliable three-axis attitude and heading (from, e.g. INS) may accompany long-term highly accurate position and velocity (from, e.g. DGPS and say, a Kalman filter). The benefit of such (INS/GPS/filter) integration is then obvious. The INS error estimates may be used to improve INS/GPS navigation should GPS become unavailable.

Further, if there would be only INS, then the final solution performance would degrade consistently to the level prescribed by the available aiding sensors. Also, GPS can be subject to jamming and spoofing (Leick, 1995). The INS on the other hand is an autonomous navigator and therefore unaffected by external influences of this sort. Integration also proved to improve estimates of acceleration, attitude, and body rates that can be used for guidance and control. During testing at the NASA Ames Research Center in 1992, Precision (P) Code DGPS/INS positioning root mean square (RMS) achieved was 1 m horizontal and 3 m vertical (Liang, 1992).

GPS can be implemented in navigation in a few basic ways. It can be a stand-alone receiver, as a part of recreational application of GPS (but also a military application, e.g., in Gulf and Kosovo on Tornado aircraft). The operator reads the output on the receiver's display and manually inserts the GPS position into the main computer (if there is one) or applies it in manual navigation. Second, it can be input to a main computer via, for example, digital interfacing. Third, it can be a fixing aid as a part of an integrated navigation system, for example INS/GPS, and input with ability of the main computer to use the GPS data in the navigation solution together with other sensors and to aid GPS data with navigation data. Fourth, it can be input to mission computer, as a form of a military application of GPS: enabling fast adjusting (satellites reacquisition) to sudden maneuvers when the loss of the signal is highly possible using velocity (course and speed) data from INS.

Another benefit of integration is when DGPS is used for precision approach (autonomous all-weather landing)—in a (civil) aviation application of GPS. But such a task is not solved by DGPS itself. The standard integrity requirements for air navigation precision approach require GPS to be integrated with a complementary sensor system like an

INS (Liang, 1992). Only this way (by the strength of the integration), can the Instrument Landing System (ILS) or Microwave Landing System (MLS) (the expensive systems in use at the airports) be replaced by a worldwide (in a unique coordinate frame), all-weather system, that is not expensive and not dependent on the closeness of an airport flight-control.

GPS ERRORS; INS/GPS APPLICATION CLASSIFICATION BASED ON GPS TYPES

Position accuracy of GPS pseudo-range absolute positioning is affected by measurement noise (few metres) and unmodelled short- and long-term systematic effects of the order of a few tens of metres. The propagation of these errors into the position solution can be characterized by a Dilution of Precision (DOP) factor DOP is greater than 1, expressing the geometry between the satellite and the receiver. Therefore, GPS pseudo-range absolute positioning can be said to have medium (tens of metres) short- and long-term stability.

In pseudo-range GPS relative positioning, the position of a receiver is determined relative to another receiver at a known location, from simultaneous pseudo range observations to at least four GPS satellites. Although most of the systematic effects are eliminated in this differencing process, the errors in these position differences remain dominated by metre-level measurement noise and can be characterized by medium (tens of metres) short- and long term stability.

If one of the two stations involved in the relative positioning remains static and the other starts moving, simultaneous GPS carrier phase observations at two locations can be used to determine the change in relative position. As carrier phase measurement noise is much lower than pseudo-range noise, and most systematic errors are removed in the observation differencing, the relative position errors are of the order of a few centimetres over distances of a few tens of kilometres. Therefore, changes in relative positions from GPS carrier phases exhibit high short- and long-term stability.

A GPS receiver becomes an orientation and position sensor if pseudo-ranges and carrier phases are measured simultaneously through three different antennae mounted on a common antenna platform. The position is determined using the pseudo-range observations of one of the three antennae. The carrier-phase observations then determine two linearly independent relative position-vectors between the three antennae and, therefore, yield the platform orientation. (Linkwitz & Hangleiter, 1988).

After acquiring the above-described division for GPS positioning and orientating, to summarize our discussion on INS/GPS integration by

classifying the integration into four types. First integration in absolute positioning requires continuous reception of GPS signals in reasonable geometry (say $DOP < 6$). Due to the possible GPS signal loss, as well as in the high dynamic applications, INS derived position changes can serve as an interpolator. Typical applications are in precise air and marine navigation. Here the integration has to take place in real time. INS is considered as primary navigation system, GPS pseudo-ranges as position-updates provider, and a filter (e.g., Kalman) as the adequate formulation for the system integration. Second, integration in relative positioning provides an improved long-term stability resulting from the elimination of systematic errors in the GPS pseudo-ranges. Typical applications are in (hydrographic) surveying, inshore and river navigation and airborne photogrammetry. INS can be used as interpolator in case of GPS signal loss. Integration in orientation determination is where fiber-gyros are part of the INS. Fourth, is integration for gravity field determination. For more details about this type see, for example, Schwarz, 1986.

ESTIMATION, FILTERING, AND BLENDING

A final (blended) navigation solution is the correct navigation solution (either from a stand-alone or integrated sensors). The corrections to the, for example, INS solution can be computed within an integration (usually by the Kalman filter) which then compares the INS data with the aiding (from the integration) sensor data.

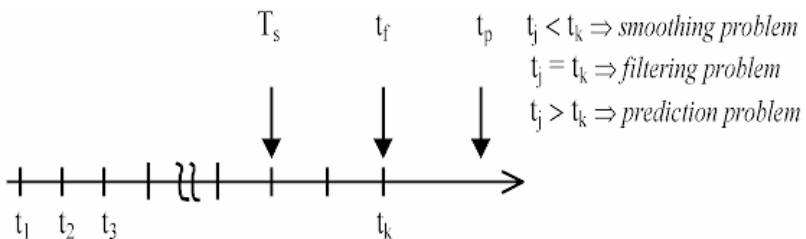


Figure 5. Three types of estimation problems

Note: Wells, D.E. (1996) *Hydrographic Surveying*. Unpublished lecture notes GGE4053, Department of Geodesy and Geomatics Engineering, University of New Brunswick, Canada. Reprinted with permission.

Figure 5 considers the relations between prediction and filtering, as the two very first steps in an estimation procedure. To summarize and relate them to navigation, let us state how prediction understands the computation of expected position (and its precision) of the vehicle at some subsequent time t_k , based upon the latest measurement at t_{k-1} . In this way we now term

filtering to be a process of computing the vehicle's position at t_k (i.e., in real-time: while observations are taken also at t_k). Similarly, we define the third step in the estimation process as smoothing—the estimation of where the vehicle was (say, at time t_k) once all the measurements are post-processed to t_{k+1} . Here we actually talk about the reprocessing (of all the measurements) after the last measurement has been made and the filtering step has been completed.

Previously discussed predictability of the motion makes it an ideal candidate for filter estimation methods. If we imagine a vehicle traveling along a straight line, we soon realize how, after a couple of positions have been determined, future positions can be predicted by extrapolation. Here the uncertainty associated with the prediction grows with time—while a position predicted a few seconds ahead may be more accurate than new measurements-based determination, this will certainly not be the case if positions are predicted over some hours. Therefore, a kinematic model comprises two components: (a) the functional part—the prediction of a position based upon previous results, and (b) the stochastic part—the estimation of the precision associated with the predicted position (see Figure 5).

Similarly, we speak of two classes or approaches for modeling a trajectory. These depend on whether emphasis is on functional modeling or on stochastic modeling. This, however, is not a finite division. Functional modeling contains predicted positions whose stochastic properties were derived from the precision of the estimated parameters. On the other hand, in stochastic modeling contains a position for which the assumed uncertainty applies must be computed as a function of previous position estimates.

The reasoning behind the functional approach to kinematic modeling is to replace the time-varying parameters again (e.g., coordinates) by auxiliary constant parameters (e.g., coefficients of a polynomial). Thus, the outcome of the kinematic model takes the form of a direct measurement of (some or all of) the position parameters, with associated precision estimates. Now the role of a filter is to optimally combine these pseudo-measurements with new actual measurements, that is, to combine the position predicted via the kinematic model with a new position determination derived from subsequent measurements. Thus the kinematic system becomes the static one.

In practical terms, this means that a filter becomes an optimal estimator. By definition, an optimal estimator is a computational algorithm that processes measurements to deduce a minimum error estimate (in accordance with some stated criterion of optimality) of the state of a system. For this purpose the algorithm uses knowledge of system and

measurement dynamics, assumed statistics of system noises and measurement errors, and initial condition information (Gelb, 1994). Thus, for example, the Kalman filter encompasses both filtering (trying to cut off the noise from the signal) and estimating (optimality in providing state⁵ of the system).

Functional approach (e.g., the polynomial filter) is suitable only for very well behaved motions. The stochastic approach possesses an important property. The noise added in each extrapolation progressively reduces the weight attributed to previous position determinations (thus enabling selective weighting of the information). This, so-called fading memory, together with the absence of predefined signature for the trajectory, increase the ability to adapt to a new system behavior, which with this being highly desirable in navigation, makes the stochastic approach in modeling the favorite one. The stochastic approach (e.g., the Kalman filter) to kinematic modeling thus makes the basis of filtering techniques. (Merminod, 1989).

In order for the final navigation solution to be computed, an integrated navigation system combines the navigation data supplied by complementary sensors. Navigation sensors are complementary if they meet the following conditions: (a) the set of sensors generates all the information required to compute a complete navigation solution, and (b) the sensors have complementary error dynamics—all of their error dynamics are observable. Two thus complementary sensors can calibrate each other's errors because their errors are separately observable in any linear combination of their outputs.

Applying this on, for example, an INS/GPS navigation system, we could compare the position obtained from, for example, INS with the one from GPS. The difference in, for example, North component of the position from these two methods equals the difference in the errors these quantities carry. This is obvious since they are actually sums of the true value of position and the specific error(s) (true-position components cancel out). Next we introduce the a priori knowledge on errors: the INS position error grows, say, on the order of 1 nmi/hr in the long-term, and is smooth in the short-term, with a strongly recognizable Schuler oscillation (full cycle every 84 minutes). Also, the GPS North position error is noisy in the short-term but of a constant offset (few metres) in the long-term. Clearly, the INS and GPS position errors exhibit complementary error dynamics. Applying a simple low-pass filter that smoothes out the random noise and passes the INS error plus small GPS offset, we simply subtract this estimate from the INS North position to obtain a blended North error, containing only the constant position offset from GPS that the filter passed. The blended solution now has the best characteristics of both the INS and the GPS: the position

solution is smooth and has a bounded error less than or equal to the GPS position error.

ENDNOTES

1. There are ten basic navigation parameters: three components of each of the vectors (1), \mathbf{v} and \mathbf{a} , plus a time tag (Xu, 1996). There can be more parameters, e.g. attitude components and their derivatives.
2. The *inertial frame of reference* is one which experiences no acceleration or angular rates (Newton's laws of motion apply without corrections for accelerations or rotations of the reference frame).
3. Gustave Gaspard de Coriolis (1792–1843).
4. Maximillian Schüller
5. For more details on observables and their properties, see, e.g., Vaníček & Krakiwsky, 1986.

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BOOK REVIEW

Fallows, J. (2001). *Free flight: From airline hell to a new age of travel*. New York: PublicAffairs. Pp. ix + 254. ISBN 1-58648-040-5. U.S. \$25.00 hard cover.

Reviewed by Mary M. Fink, University of Nebraska at Omaha.

Free Flight: From Airline Hell to a New Age of Travel vividly characterizes the trials associated with modern commercial air transportation that have evolved since the dawn of deregulation of the industry in 1978. The tome, authored by magazine correspondent James Fallows, provides the reader with both a historical evolution of the “slowing” of commercial air travel and the personal experiences of the author as he recalls his flight lessons and a coast-to-coast family trip in a small aircraft. This book is not targeted solely at the aviation enthusiast; rather, anyone who has ever sat in a crowded airport enduring the inefficiencies of today’s hub-and-spoke system would be enlightened by this factual and personal work.

Fallows begins his work with a personal revelation of his lifelong attraction to flying. His passion for aviation is illustrated by tales of boyhood assembly of balsa wood airplanes, models, and aviation merit badges in scouts legitimize the roots of his interest. What follows in the pages of the first chapter, *Visual Romance*, “...the intoxication of seeing the world from above” (p. 23), is a recollection of the author’s flight training. This description provides the non-pilot reader with a basic, yet solid vocabulary of flight terminology.

The following chapters jump to an informational history of general aviation manufacturing firms. The focus quickly narrows to *The Boys from Baraboo*, as chapter two is entitled. The “boys” to whom Fallows is referring are Alan and Dale Klapmeier, founders of the Cirrus Design company. At a time when general aviation manufacturing had nearly come to a halt, the Klapmeiers decided that the stagnation was due not solely to litigation, but had more to do with the reality that “the planes themselves, and the whole experience of small-plane travel, were no longer worth the money... Smaller planes got more expensive each year but didn’t get any

faster, more efficient, or more comfortable” (p. 49). Thus the Klapmeiers, along with a small team of engineers, set out to develop a revolution in the general aviation market.

Fallows switches gears in chapter three to reveal that while the Klapmeiers were beginning their journey, a team of colleagues known as the *GA Mafia* met weekly at a pizza parlor to discuss necessary technological leaps for the future of aviation. NASA’s Dr. Bruce Holmes, organizer of the Advanced General Aviation Transportation Experiments (AGATE) project, led this ‘gang’ and later the Small Aircraft Transportation System (SATS) and General Aviation Propulsion (GAP) research endeavors. Their theme echoed that of the Klapmeiers’: “small planes had to become much better if they were to be of practical use” (p. 64).

The following chapters discuss the advancement of technology and the emergence of new types of aviation manufacturing companies and their products. The next three chapters are dedicated entirely to the development of Cirrus aircraft. Contained within the multitude of pages are tales of the difficulties encountered not only in developing a new breed of aircraft, but also in selling such a revolutionary product to both investors and customers. Chapter seven parallels this struggle as in the general aviation jet market. Eclipse Aviation, an equally entrepreneurial firm, focused on the higher end of the market. *Disruptive Technology*, as the chapter is appropriately named, serves as the theme for the entire book. This concept holds true for members of Cirrus, Eclipse, NASA, and Williams International (a small aircraft jet engine producer contracted by NASA and later teamed with Eclipse). Fallows goes on to explain that disruptive technology provides an “order-of-magnitude change [in an industry] that measured product innovation in single-digit numbers” (p. 185).

Fallows concludes his work by reserving the eighth and final chapter with a personal account of his family’s cross-country adventure from California to Massachusetts in a Cirrus. The reviewer finds balance in this chapter, as the author puts theory into practice. Fallows speaks equally about the vast improvements in general aviation that are embodied in the Cirrus aircraft (added safety, speed, comfort and liberation from the hub-and-spoke system of airline travel) and the inevitable obstacles to overcome (poor weather, turbulence and personal pilotage challenges, to name a few).

Free Flight: From Airline Hell to a New Age of Travel flows freely and is an easy read. The reviewer noted only two errors. On page 62, Fallows incorrectly refers to NASA’s Headquarters as being located in Langley, Virginia. The Headquarters is located in Washington, D.C. While NASA’s Langley Research Center is located in Langley, Virginia. There was a minor typographical error that did not interfere with the understanding of the text.

The reviewer recommends *Free Flight: From Airline Hell to a New Age of Travel* to a wide array of readers, from the aviation enthusiast to the hardened pilot to the curious public. Fallows provides hope for the future of air travel. By reserving a niche in the general aviation market for trips less than 1,500 miles in length, *Free Flight* recognizes the traveler's newly realized need. Commercial aviation is still necessary to accommodate trips intended for further destinations, but the for the rest there may be new options. This book helps to set the stage for an innovative way to look at aviation and travel overall.

Reviewer Description

Mrs. Mary Fink is the Coordinator of Research and Special Programs for the Aviation Institute at the University of Nebraska at Omaha. She holds Master's and Bachelor's degrees in Aviation Administration from the University of Nebraska at Omaha. In addition to administering NASA-funded research programs in excess of \$5 million, Ms. Fink is also an instructor for the Aviation Institute. She recently completed a term serving on the University of Nebraska at Omaha Graduate Council, Committee on Policy and Planning. She is a Federal Aviation Administration licensed pilot and is a member of the American Society for Public Administration; Women in Aviation, International; the Omaha-area 99s; Alpha Eta Rho, International Aviation Fraternity; and Omicron Delta Kappa Leadership Society. Her research interests lie in the areas of transportation policy and intermodal systems.



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