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THE JOURNAL

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- Other areas of air and space transportation research, policy, theory, case study, practice, and issues

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Sorenson Best Paper Award Recipient
**FOUR GENERATIONS OF MAINTENANCE
RESOURCE MANAGEMENT PROGRAMS IN
THE UNITED STATES: AN ANALYSIS OF THE
PAST, PRESENT, AND FUTURE**

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Santa Clara, California
and
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San Jose, California**

ABSTRACT

This paper analyzes four generations of Maintenance Resource Management (MRM) programs implemented by aviation maintenance organizations in the United States. Data collected from over ten years of survey research and field observations are used for this analysis; they are presented in a case-study format. The first three generations of MRM programs were episodic efforts to increase safety through teamwork, focus group discussions, and awareness courses, respectively. Now, the fourth generation programs, characterized by a commitment to long-term communication and behavioral changes in maintenance, are set to build on those earlier generations, toward a culture of mutual trust between mechanics, their managers, and regulators.

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INTRODUCTION

More than a decade ago the aviation maintenance community was startled to discover the importance of the human factor in safety—not merely in the design of jobs and tools, but in the aspects of interpersonal behavior and the management of people.

Starting in 1989, airlines in the U.S. began to address open communication to improve safety. Now, ten years after embarking on a journey to learn from these and subsequent communication programs in aviation maintenance we can step back and review the larger implications of this movement. This is an overview of trends and results observed during that time.

MRM Definition

In the past seven years Maintenance Resource Management (MRM) has become one of the pillars in aviation human factors. The industry leaders from a multiparty cooperative program in maintenance, which was designed to improve communication and reduce errors (Taylor & Christensen, 1998, pp. 48, 105–6), coined the term MRM in 1992. The industry correctly defines MRM as “...an interactive [emphasis added] process focused upon improving the opportunity for the maintenance technician to perform work more safely and effectively” (ATA, 1999, Chapter 2). In that same ATA document MRM is referred to as a training program, but MRM is much more than training. MRM is a tool to provide individuals and groups with the skills and processes to manage errors that are within their control, such as communication, decision-making, situational awareness, workload management, and team building. Part of MRM is training, but part of it must be the application and management of the attitude, skills, and knowledge that training and behavior can provide.

The MRM Evaluation Research Program

With the visible success of Cockpit Resource Management (CRM) in flight operations during the decade of the 1980s, the first two airlines intentionally improving communication in maintenance each modeled their maintenance efforts after CRM programs within their company’s flight operations (Taggart, 1990; Fotos, 1991). Naturally the creators of these pioneering maintenance programs drew heavily on the available research and hands-on experience from CRM. That included proven evaluation tools (Gregorich, Helmreich & Wilhelm, 1990) and successful training programs (Helmreich, Foushee, Benson & Russini, 1986) that were lightly modified and quickly applied to the initial maintenance communication program (Taylor, Robertson, Peck & Stelly, 1993).

Development of attitude measurement related to MRM topics, as well as of self-reports of subsequent behaviors—which began in 1989 (Taggart, 1990)—has continued and expanded (Taylor, 2000a). A multilevel data base of over 30,000 mechanics, maintenance managers, and other maintenance personnel from some dozen air carriers and repair stations is now available at Santa Clara University and is used to compare city and company results against standardized scores.

The evolution of locally developed maintenance communication programs has progressed through three generations and is entering a fourth. The four generations of MRM have been, or currently are, being measured and evaluated. The results of these evaluations will be described below, together with an assessment of communication improvement and safety benefits, where available.

FOUR GENERATIONS OF MRM AND SUSTAINED SUCCESS

In the paper to follow, four generations or steps in the evolution of MRM will be discussed. Each generation will be illustrated by at least one airline maintenance case of an MRM-type program. With the exception of Case 1 all data reported here have been subjects of our ongoing MRM Research Program. All cases are numbered in the order presented and case numbering does not start over with each generation. The following characteristics will be described for each case, where available: a) purpose and objectives or instructional topics of the program, b) reported likelihood of voluntary change resulting from the program, c) attitude and opinion changes resulting from the program, d) specific intentions to change as a result of the program, e) behavior changes resulting from the program, self-reported or observed, f) changes in safety performance.

Generation 1: CRM-based Training in Communication Skills and Awareness

Case 1: Change in interpersonal behavior and open communication through teamwork.

The very first reported CRM program for maintenance in a large U.S. airline began in November 1989.

Program purpose. The purpose of the maintenance CRM training was similar to that of the company's flight crew CRM training—to ensure that teamwork and coordination are optimal and best use is made of all resources, including people, information, and equipment (Taggart, 1990). The training topics were interpersonal communication, assertion and

conflict, stress, critique skills, value of briefings, situation awareness, leadership behavior, and case studies.

The program was conducted for small groups over a several weeks and finally included over 80 maintenance managers and supervisors. Although it was intended that all 750 persons in maintenance management in the company would be trained, the program was suspended and the company was liquidated before that occurred. But as the first experience, that program set high standards.

Likelihood of voluntary change. Participant enthusiasm for the course was very high—over 80 percent said there would be at least a moderate change in their on-the-job behavior.

Case 2: Assertive management communication skills and performance.

Beginning in June 1991 a second airline company undertook a CRM in maintenance training course for communication and safety (Fotos, 1991). This training continued for over two years. This early and highly successful version of MRM emphasized open and assertive communication, both in theory and in practice, as well as an awareness of others. The detailed results of the evaluation study having been published in previous papers will not be repeated here, and bibliographic citations will direct the reader to the appropriate references

Program purpose. The purpose of the course was stated as “equipping participants with the skill to use all resources to improve safety and efficiency” (Taylor & Robertson, 1995). Specific objectives, or topics covered were a) diagnose organizational norms and their effect on safety, b) promote assertive behavior, c) understand individual leadership styles, d) understand and manage stress, e) enhance rational problem solving and decision making skills, f) enhance interpersonal skills.

Time was taken during the two-day training program to role-play giving and receiving assertive communication (Stelly & Taylor, 1992), and participants praised that activity highly (Taylor & Robertson, 1995). All maintenance management and professional engineering staff (N > 2,000) attended the program.

Likelihood of voluntary change. Enthusiasm for this program actually exceeded the high marks earlier reported by Taggart (1990)—at the end of the two-day training nearly 90 percent of the participants said there would be at least a moderate change in their on-the-job behavior (Taylor & Robertson, 1995).

This program was brought to completion by August 1993 (a 26-month period).

Attitude changes. The post-training attitudes showed improvement in feelings toward participation, stress management, and communication; but no immediate improvement in attitudes about assertiveness—those would come later. These maintenance managers also initially indicated intentions to change in rather passive ways (e.g., “to be a better listener”) than to immediately practice assertiveness and “speaking-up.” Two months following training however, feelings about assertiveness increased for many of these managers—and their intentions for further steps were more active as well (Robertson, Taylor, Stelly, & Wagner, 1995; Taylor & Robertson, 1995; Taylor & Christensen, 1998).

Performance changes. For 24 months following the onset of the program, the incidence of lost time injuries and aircraft ground damage decreased (Taylor & Robertson, 1995), and the former was highly correlated with the improvement in attitudes toward assertiveness just noted (Taylor, 1995).

In August 1993, upon completing the training for maintenance management and achieving these improvements in attitude and safety, plans were laid to move the program into the ranks of mechanics. Other concerns interfered with the continued progress of MRM and eventually only a small proportion of mechanics were trained. By that time top management’s concerns had turned from communication and safety to station closures and cost cutting, and the excellent results of their MRM program began to reverse (Taylor & Christensen, 1998, pp. 128–129).

Case 3: Assertive AMT communication skills and performance.

Program purpose. Before the above reversal began in earnest, the MRM program was modified for mechanics by changing only the case studies to maintenance-caused accidents or incidents and leaving the purpose, the timing, the major topics and the exercises in place.

Beginning in September 1993 about 450 participants (one-third new supervisors and two-thirds mechanics) from 28 work units attended MRM training. By June 1994, after a period of just over six months, the pace for this training had declined to a trickle—mainly as a result of top management succession and changes in maintenance priorities.

Little, if any, of this type of intervention with mechanics (hereafter called Aviation Maintenance Technicians, or AMTs) and other operational hourly personnel had been previously attempted in North America. Common wisdom held that communication training for AMTs and other hourly workers was an unnecessary expense in a period of prolonged financial hardship—and, in any event, that this kind of interpersonal training would probably benefit management participants more than hourly

employees. Recurrent training for AMTs was typically limited to passively viewing videos produced by the company's Technical Training Department, or to on the job training (OJT) by lead or senior mechanics. Given those assumptions, the results of this MRM training were surprising.

Likelihood of voluntary changes. Like the management results in Cases 1 and 2, the 300 AMTs show clear enthusiasm. Eighty percent (80 percent) of them reported that they expected moderate to large changes in their behavior as a result of the MRM training (Taylor, Robertson & Choi, 1997).

Specific intentions to change. These AMTs were also asked to write their responses to the question: "How will you use this training on your job?" Content coding of those answers resulted in the bulk of the responses divided into five categories: "dealing better with others," "being more assertive," "being more aware of other's behavior," "being a better listener," and "fighting complacency/being more careful at work." The first two categories were classified as active communication intentions—to be carried out with coworkers, while the latter three were considered to be more passive coping behaviors—and could be done alone. Forty percent of the AMTs responses were coded in the first two (active) categories while some 45 percent were coded in one of the three passive categories. This proportional division would prove to be very high for active communication. The AMTs' positive experience with MRM training leads to enhanced performance as well.

Attitude changes. AMT attitudes immediately following the training reveal a marked change toward AMTs assuming command responsibility and an increased appreciation of stress management. In the main these results obtained for technicians parallel those reported for maintenance managers and support professionals (Taylor, 1995; Taylor & Robertson, 1995).

Performance changes. In part the AMT data proved even stronger than the management results in showing positive effects of collaboration and human factors training (Taylor et al., 1997). In particular, stronger relationships between AMT post-training attitudes and safety performance in the six months immediately following training is evidence of the fact that because AMTs are the persons directly effecting performance, their attitudes should most quickly relate to that performance. That brief program proved to be a successful venture into MRM training for AMTs. It is unfortunate that it was halted so soon after it began.

Generation 2: Directly Address Communicating and Understanding Maintenance Errors

Case 4: Using focus groups to reduce errors in aviation maintenance.

During 1992-1994, the Quality Assurance (QA) department in another large airline (employing nearly 2,000 AMTs and foremen in 37 line stations) began an informal cooperative arrangement with the trade union (IAM) representing its AMTs, and with its FAA Flight Standards District Office (FSDO).

Program purpose. This cooperation was intended to reduce a high incidence of errors in maintenance documentation by opening communication channels among the company, the union and the regulator.

The program lasted two years and covered three phases. It began with 30 group interviews, involving over 150 AMTs and foremen in eight line maintenance stations. These interviews focused on maintenance paperwork errors, their causes, and their solutions. In the second phase of the project, the results from the interviews in the first phase were fed back to all parties and management took action based on the proposed solutions. In some cases the solutions/changes affected all of the company's line stations, and in other cases the changes were tried in one station and reviewed against suitable comparisons (a natural experiment). In the third phase, the changes were given time (up to 28 months after the onset of the MRM program) to affect measured error rates in maintenance documentation, and the results were distributed to all parties.

One of the solutions recommended and implemented involved passive engagement (e.g., formal training in paperwork for all line AMTs). The effects of that paperwork training on error rates were immediate, but short-lived (Taylor, 1995, Taylor & Christensen, 1998).

Two other solutions required active involvement and communication (e.g., pre-shift team meetings in order to open communication channels, and AMT group participation in re-designing the aircraft logbook form).

The two active communication solutions were implemented in one line maintenance station—one that had previously participated in the focus group interviews. Four months after their initial MRM focus group session, the station's employees were invited to join in a new activity. First, that station's foremen received training in communication and leading meetings, and they began holding daily start-of-shift crew briefings. Second, the AMTs had the opportunity to attend occasional, informal sessions to discuss ways to improve the aircraft logbook document layout. The logbook improvement sessions were led by a manager from the company's Quality Assurance department. The total paperwork error rates

for this experimental station were matched with those of another line station of similar size and location that did not participate in the focus group interviews or in the crew meetings or logbook improvement effort. The main differences between the experimental and comparison stations were their reputations for morale and their relations with flight crews. During 1992-93, the morale and service reputation of the experimental station was considered poor, while the comparison station enjoyed a better image.

Performance changes. In May 1993, two months after the focus group interviews in the experimental station (but before any feedback to that station), its logbook errors were higher than either the comparison station or all stations combined. When the experiment began in August 1993, the experimental station subsequently experienced rapid and visible improvements attributed to the enhanced communication while the comparison station's error performance more closely matched the system overall (Taylor, 1995). For March through August 1994, nine to twelve months following the onset of the study, the experimental station continued to show a lower error rate than the comparison station and/or all stations combined. Thus, after the MRM interventions began there, the experimental station displayed a lower logbook error rate in both comparisons for every subsequent month available thereafter (Taylor, 1994; 1995).

By 1995, the experiment concluded that—not by plan, but by lack of momentum—the local managers and supervisors who supported the shift briefings and AMT participation in decision making left the station and/or the company. Their successors were encouraged to support another (and department-wide) program in non-safety related employee communication and participation.

The QA, IAM, and FSDO partners to this company's cooperative MRM relationship continued their efforts to reduce errors. In 1993, these three partners created an on-going human-centered error investigation process which was designed to analyze specific cases of maintainer mistakes using a participative process and to apply what is learned to system-wide solutions (Marx, 1998).

In general, such second-generation programs, although participative, are reactive to prior problems. Thus they are in part focused on the past.

Generation 3: AMT Maintenance Training for Individual Awareness and Readiness

In 1994 the curriculum for a different kind of maintenance training program was developed and distributed through Transport Canada. The

program, called Human Performance in Maintenance (HPIM) is based on a two-day training course designed specifically for AMTs. It soon became widely known because of the maintenance-oriented nature of its training materials and its ready availability. Among HPIM's most popular innovations is a set of safety posters—the Dirty Dozen posters—one for each of twelve major causes of maintenance errors (Taylor & Christensen, 1998, pp. 145–6). As evidence for the strength of HPIM influence, all reported MRM programs implemented in North America since 1994 have included the Dirty Dozen as a core set of concepts. The purpose of HPIM training as described in the prototype participants' workbook is “to create an awareness of the human aspect of aircraft maintenance and develop safeguards to lessen the ‘human cause’ factors in maintenance” (Transport Canada, 1996, p. 7).

In several ways HPIM has had a direct impact on the development of the third generation of MRM programs. First is the emphasis on awareness. The HPIM purpose differs from the purpose of the CRM-based maintenance training in Cases 1 through 3 above. HPIM focuses on awareness and coping mechanisms or safeguards, while the MRM of Cases 1 through 3 focuses on skills such as communication and assertiveness. Second is the emphasis on the individual. The objectives of the initial 1994 HPIM course emphasizes three of the Dirty Dozen—lack of communication, stress, and fatigue—two of which are primarily personal issues that can be best managed by the individual. Third is the emphasis on internal and passive change rather than interpersonal and active change. In HPIM both its curriculum and workbook illustrate this. The workbook includes a section on communication that emphasizes listening (passive rather than active communication) as a major technique. This trend that maintenance was taking on an awareness training orientation has been noted by others (Kanki, Walter & Dulchinos, 1997).

Although the several cases of third generation MRM described below differ in significant detail from one another they all share a training purpose focused on awareness as well as resulting overwhelmingly in intended and reported changes which are passive, individual, coping adaptations rather than active changes in communication.

Case 5: AMT awareness leads to improved performance.

In 1996 a large airline undertook to provide MRM training for all of its AMTs.

Program purpose. The purpose of the program, stated in participant's workbook is to create an awareness of the impact of human performance on maintenance-related errors and personal safety. The learning objectives for

the course were as follows: a) relate how AMT characteristics and personal behavior can impact the maintenance process, b) identify 12 performance factors (dirty dozen) and their role in the chain of events leading to maintenance-related errors, c) develop personal techniques to minimize risk and maximize performance, and d) give and receive feedback with coworkers related to personal safety.

The company trained over six thousand employees during a two and one-half year period. It addressed its MRM training exclusively to AMTs (supervisors and managers account for less than 1 percent of the total trained in that company). The AMT union and the company's management cooperated to initiate the training. Training materials were adapted from the HPIM package and the company standardized them for its own use—including the use of local case illustrations. In addition to the three of the dirty dozen emphasized in the HPIM syllabus a fourth dirty item, complacency, was added to the core curriculum. Training then continued at the local level with facilitators coming from the ranks of both AMTs and their first-line supervisors. This group of facilitators represented excellent use of local operations experience and leadership abilities. The training was coordinated and supported by the company's training and education department.

Likelihood of voluntary change. Enthusiasm was positive immediately following the training even if some participants hedged a little on their interpretation of substantial change. Over sixty percent of the participants said there would be a moderate or large change in their on-the-job behavior (Taylor & Christensen, 1998). Although a clear majority believes that the training will affect their actual behavior, this level of enthusiasm does not approach the high ratings—between 80 percent and 90 percent—reported for the earlier three MRM cases.

Specific intentions to change. These AMTs also responded to the question: "How will you use this training on your job?" Content coding of those answers resulted in the bulk of the responses divided into several categories including "interacting with others," "being more assertive," "being more aware of other's behavior," "being a better listener," and "fighting complacency/being more careful at work." The first two categories—active communication intentions—can be compared with the more passive coping behaviors that can be done alone. As shown in Table 1 below, 27 percent of the AMTs' responses were coded in the active category while nearly 46 percent were coded in the passive category. This result is substantially lower for active communication than the AMT sample described in case 3. This tendency toward passive coping behaviors is consistent with the purpose and objectives of the case 5 program.

Table 1. Case 5 Post-training Behavior Intentions (n=4,613)

Total Passive Intentions	45.9%
Total Active Intentions	27.3%
Other	21.5%
No Change Intended	5.3%
	100.0%

Attitude changes. Statistically significant improvements were found in attitudes about sharing responsibility, communication, and stress management immediately following the training sessions. The change in the value of stress management was particularly striking. Furthermore, those same three attitudes remained stable for months after the training. Attitudes toward assertiveness did not improve as a result of the training (Taylor & Christensen, 1998).

Performance changes. The AMTs' positive attitudes following MRM training leads to enhanced performance as well. In particular, the marked increase in appreciation of stress management two months after training showed the strongest correlations with low rates of injury and aircraft damage (Taylor, 1998a). Two years later, we found that line maintenance stress management six months after training also shows correlations with the six-month periods of improved ground damage rates—mainly coincident with the two month survey (Taylor, 2000b). Stress management is primarily a passive coping activity and its improvement following the training and its relationship to safety performance improvements is entirely consistent with this company's MRM purpose.

By 1999, the higher the line mechanics evaluated goal sharing and safety practice in their units six months after their MRM training, the lower the incidence of LTI in those units both before and after the survey (Taylor, 2000b). These results emphasize that if line maintenance share goals and experience a responsive safety practice, their injury rates will be lower.

For base maintenance in Case 5, correlations are found between six-month measurement of communication & coordination attitudes and aircraft ground damage. This pattern is quite strong and regular—it suggests that the more value that is placed on meetings and briefings and other communication six months after training, the better is ground damage performance in the following year (Taylor, 2000b).

Figures 1, 2, and 3 below show performance data for the expanded five-year period 1995–1999. All figures show linear trend lines (obtained using the Least Squares method) for the before, during and after-training periods superimposed over the actual monthly data points.

Figures 1 and 2 show the trends before, during, and after MRM training for occupational injuries and aircraft ground damage for line maintenance

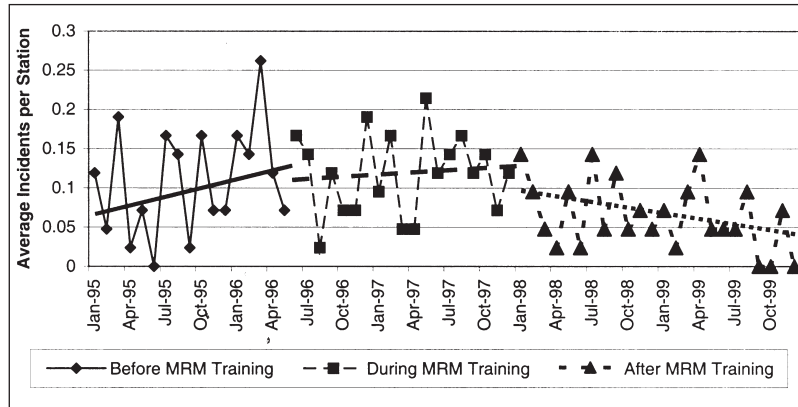


Figure 1. Five Years of Line Maintenance Aircraft Ground Damage (n = 42 stations)

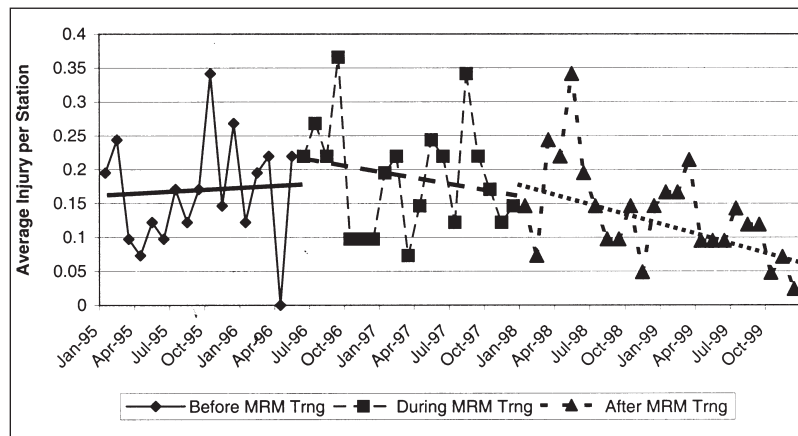


Figure 2. Five Years of Line Maintenance Lost Time Injuries (n = 42 stations)

performance. Figure 3 shows similar trends for occupational injuries for base maintenance.

It is clear from the trends in Figures 1 and 2 that a dramatic improvement took place for the line stations taken together. Furthermore, this improvement directly after the onset of the MRM program and its rate of change continues in the two years following the completion of the MRM training. This strongly suggests that the awareness program works, through its effect on stress management and situation awareness—at least in this company’s line maintenance organization.

For the Base Maintenance organization the effect is also encouraging. Figure 3 shows that the trend for lost time injuries remains low during the

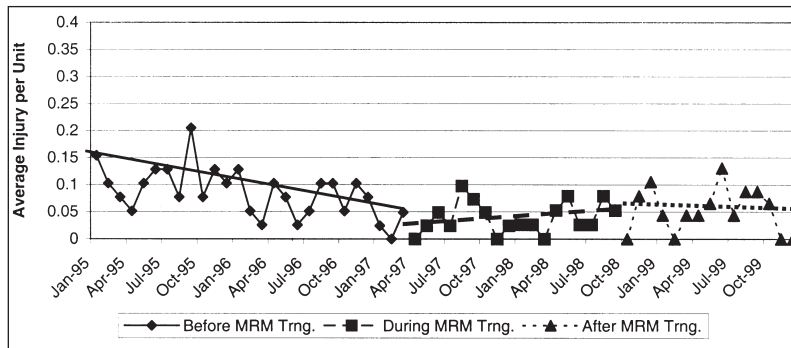


Figure 3. Five Years of Heavy Maintenance Lost Time Injuries (n = 40 units)

period of MRM training and that it rises and falls only gradually in the 15 months after the training was concluded. However, because of the sharply downward trend before the training began we must question whether the lower rates during training and after are a continuation of some previous program to lessen injuries in the hangars or they are the result of the MRM training.

An unplanned liability of the individual change model. It is ironic—given the apparent success of this MRM program as expressed in long-term safety outcomes—that AMTs' enthusiasm for the program turned from positive to negative. Earlier reports examining the attitudes and opinions of line maintenance employees in the months following their MRM training have described the apparent frustration and anger these individuals voiced (Taylor, 1998a). They expected more support by their managers and co-workers in fulfilling the promise of the MRM program to improve communication and collaboration (Taylor, 1998b). Subsequent interviews and observations in the company's repair hangars confirm this backlash exists in heavy maintenance as well. AMTs and inspectors reported discouragement waiting for some management safety initiative that was based on the content of the MRM course.

This company's individual-based awareness training, with its emphasis on building individual's coping skills, does not give AMTs subsequent information about whether or how much the MRM program is working, or whether other people value the lessons of the training like they themselves do. Months after the training many AMTs reported still being careful, fighting complacency, and managing their own stress levels. But many also did not think the MRM program would be very useful in the future (Taylor & Christensen, 1998). Many said they did not know or could not tell if others were using the lessons learned from the training—they rarely talked

about MRM informally and were never encouraged to do so by their leaders.

Case 6: Distributing Third generation MRM training.

Another company's adaptations to the MRM third generation have been to train all maintenance personnel, and to divide two days of training over several months. That company created its own MRM training after reviewing the HPIM training model. The AMTs' union and the company's management cooperated to initiate and design the training. Training materials were inspired by the HPIM package, but the most of the exercises and cases were created specifically for this application.

Program purpose. To provide participants with specific human factors principles and techniques to help them work more safely. The definition of MRM, stated in the participant's workbook, "...is the process where we work together, using available resources, to reduce errors and to promote safety." The statement goes on to say, "MRM addresses human factor errors and problem resolution through open and honest communication between all maintenance operations personnel, and with the FAA."

The training topics for the first day are: a) identify human factors elements, b) recognize the dirty dozen error causes, c) identify the chain of events in accidents, d) effective written communication, e) identify norms, f) establish safety nets, and g) recognize safety mechanisms.

Although the MRM definition quoted above is more active and interpersonal than is typical for the HPIM (third generation) model, the supporting topics are largely awareness or conceptual issues—with written communication as the active skill exception.

At the beginning of the second training day (Phase 2) the definition of MRM is reiterated. The training topics in the participants' workbook for the second day are as follows: a) recognize the nature of errors and how they affect participants; b) focus on how to manage errors, where dirty dozen topics: of lack of assertiveness and lack of awareness are emphasized; c) introduce tools to use in error reduction with an emphasis on situation awareness.

Likewise these topic labels for phase 2 training seem more conceptual than behavioral. The module on lack of assertiveness is, however, focusing on active communication. On the other hand, the main tool in the final phase 2 topic list, "situation awareness," is an individual, passive mechanism. This MRM program appears to be bridging between the third generation model of individual AMTs coping with safety hazards and issues and the interpersonal communication techniques of the original MRM maintenance safety training. By design, phase 2 (the second day of

training) is conducted about two months after the first one.

The course is designed for all maintenance employees and each session is expected to include management and hourly employees from a variety of functions within maintenance. Initially, the training took place in a large line station and both phases 1 and 2 were completed there before the program was moved to two cities containing both base and line maintenance stations. Eventually all 8,000 maintenance employees throughout the system are expected to attend the training.

Phase 1 training for the first city (line maintenance station "A" with some 500 maintenance employees) was finished in July 1998. Phase 2 was completed during August and September 1998. The second city ("B") to begin the MRM training included both a large line station and a major heavy maintenance base. City B began phase 1 training in September 1998 and completed it with about 1,000 maintenance personnel in April 1999. Phase 2 began in city B during June 1999 and was about 50 percent completed by December 1999. A third city (also both a large line station and a major heavy maintenance base) began phase 1 training in July 1999 and, with over 900 employees attending, had not yet been completed by December 1999. Results from cities A and B will be used below to illustrate the effects of distributed training and the modified course purpose and topics.

Likelihood of voluntary change. Enthusiasm for city A is moderate when compared with past MRM experience described for the cases above. Slightly over 60 percent of the participants following phase 1 said there would be a moderate to large change in their on-the-job behavior. Following phase 2, 65 percent city A participants said there would be at least a moderate change in their at-work activities. This modest increase in encouraging, but statistical tests of this result, or the change between the associated phase 1 and 2 mean scores, do not show significant differences. For city B the enthusiasm following phase 1 is also moderate with some 69 percent saying there would at least a moderate change in their behavior. Following phase 2, 85 percent in city B say they expect moderate to large change in their at-work activities. With only half of the phase 1 respondents having attended phase 2 training these results are incomplete, but they are certainly promising.

Attitude changes. Figure 4 shows the mean scores for attitudes and opinions for city A, the first station to complete the two phase MRM program. Immediately following the phase 1 training, participants' attitudes reveal significant improvement in attitudes toward communication, stress management and assertiveness. Following phase 2 training all three attitudes increased again significantly. Although attitudes

toward sharing command responsibility increase slightly over this time, the differences are not statistically significant.

Opinion changes. Figure 4 also shows city A participants' evaluation of their station's goal setting and sharing remained unchanged between phases 1 and 2. However their evaluations of the station's safety climate decreased significantly ($F = 8.29, p < 001$) between phases 1 and 2. Field observation at city A some 60 days after phase 1 training and again four months after phase 2 confirm these survey results. AMTs, leads, and foremen reported that safety standards and program seemed to be deteriorating. Apart from their own individual care and awareness, they said, little was being done to support maintenance safety in the station.

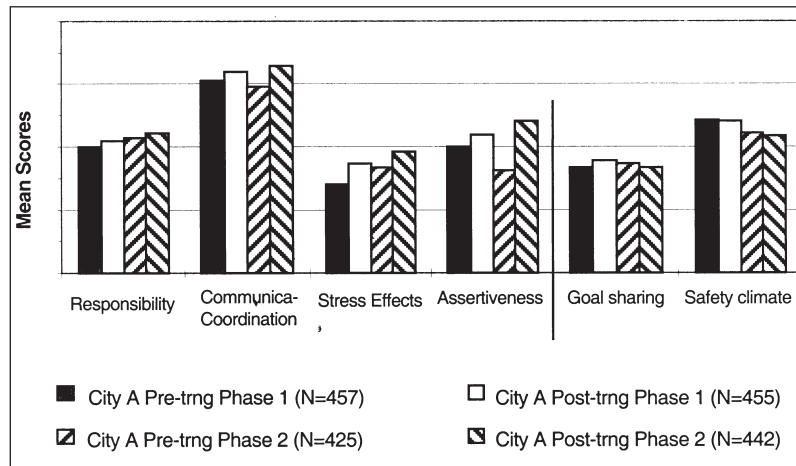


Figure 4. Distributed MRM Sessions: Attitude & Opinion Changes

Specific intentions to change. The question, "How will you use this training on the job?" was included in the surveys that followed both phase 1 and phase 2 training. City A participants' answers to that question were coded for intentions to begin active communication with management and coworkers, as well as for intentions to apply more individual, passive, coping behaviors. If respondents said they were not intending to change at all, that was coded separately. Those answers that did not fit any of the categories were coded other. Answers to the same question from city B's MRM participants were similarly coded and can be compared with city A's results.

Self-reported changes between MRM phases 1 and 2. The post-phase 2 survey asked the question, "How have you used the MRM training on your job?" The answers received were coded the same as those for the

question of intention. Thus both intention to change and the subsequent changes can be compared over time. These data are presently available for city A in its entirety as well as for first half of the city B participants who have completed phase 2 training.

Figure 5 presents the expected behaviors at the end of both phase 1 and 2 training. The figure also shows the actual behaviors reported by participants at the time of the phase 2 training. Although 11 percent in city A said they intended to communicate actively following phase 1, only eight percent reported having done so when they returned for phase 2 training.

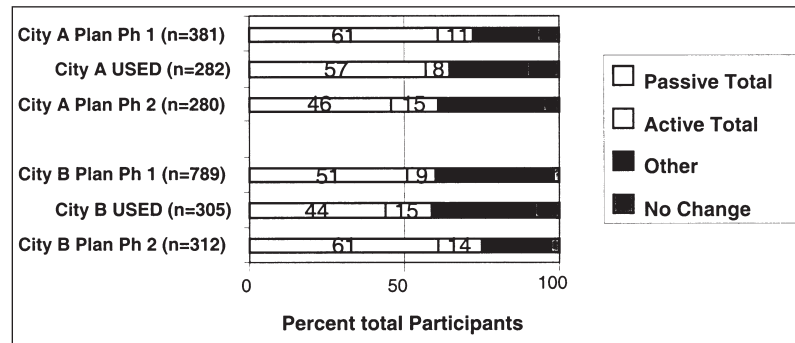


Figure 5. Planning for and Using the MRM Training

Fifteen percent expected to actively communicate after attending the second day. For city B a larger percentage (nearly twice as large as city A) reported having been more active communicators when they returned for phase 2, and that proportion again, further expected to actively communicate with others about safety. These results, even though they shift slightly more toward active intentions following phase 2 training they do not favorably compare with the proportions of active to passive intentions found in cases in the first generation of MRM training. This ratio in figure 5 (generally about 15 percent active to over 45 percent passive) is much less than the 40 percent active to 45 percent passive intentions in the earlier programs (Taylor & Robertson, 1995; Taylor, et al., 1997).

Performance changes. Four years (1996-99) of aircraft damage incidents charged to city A maintenance are compared with all line stations in Figure 6. The overall pattern of ground damage incidents for all (n = 45) line stations in the system remains steady with a flat trend line during this four year period. The results for city A, however, show an increasing incident rate before the MRM training began. That trend reverses following the phase 1 training and it continues downward for 16 months after the

second training phase concluded. The initial ground damage results for city B are not portrayed here, but they track a similar pattern of increasing incidents before the onset of the MRM training followed by a marked decline after the program begins.

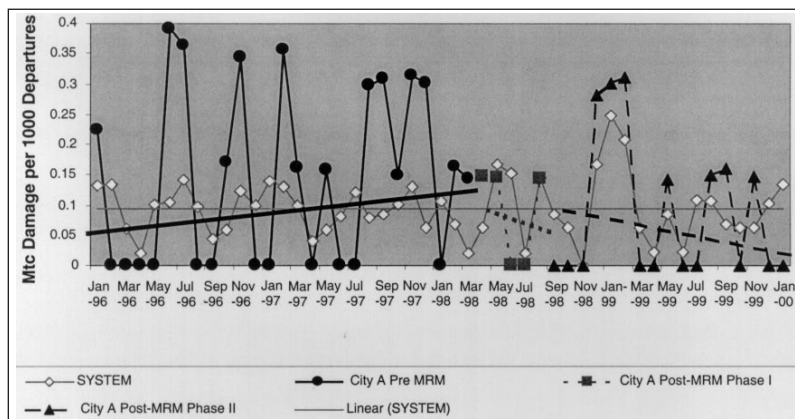


Figure 6. Ground Damage & 2-Phase MRM Training

This improvement in safety results is further evidence for the effect that MRM awareness instruction can have on maintenance performance. This, coupled with sustained enthusiasm following more than a year from the completion of the training, suggests that the distributed, two-phase training program may avoid some of the frustration and anger caused by a perceived lack of support by their managers and co-workers to improve the safety climate (Taylor, 1998b).

This two-phase MRM training appears to provide several additional advantages over the one-shot training model. First, it provides the opportunity for program facilitators to follow-up and elaborate the lessons from the first session. For example, some changes to the phase 2 curriculum for city B were made after the program had been used at city A.

Second, the subsequent session begins to demonstrate management's commitment to an ongoing MRM program. Unlike the experience in Case 5 above, where interest in changing behavior declines steadily in the months after training, some enthusiasm for the program in the present case continues months after the initial training.

Third, it should begin to satisfy those participants who want recurrent training on these topics. Typically some 10 to 12 percent of participants in previous MRM programs have said that recurrent MRM training would make an improvement to the one-shot model. In this case however the expectation for further MRM training may be heightened with a two-phase

program. In this regard nearly 20 percent of the participants' following the Case 6 two-phased training said even further recurrent training would improve this model. Another 20 percent are eager to see more management and employees from other maintenance groups experience this MRM training.

Despite the successes reported for Cases 5 and 6, together with the added advantages of the distributed awareness training, they remain programs to influence the values and awareness of individuals. These programs do not create the structure and the process for improving safety at a systemic, interpersonal level. They also do not have clear safety goals, rapid feedback of results, or appropriate reinforcement for those who are behaving more safely. Without these systemic, organizational features, MRM programs like those illustrated in Cases 5 and 6 seem destined to suffer the irony of increased long term improvement coupled with participants' ignorance about that gain and greater pessimism about the quality of maintenance safety programs. The sheer professionalism of the AMTs themselves makes these present programs work. AMTs are reminded of the dangers of the dirty dozen causes of errors and accidents and they respond appropriately—on their own and apparently for a period of months, or years not weeks.

Generation 4: Integrated, behavior-based MRM programs

The fourth generation MRM programs are using the knowledge gained from the experience of the past three generations and from recent innovative processes to standardize communication and tactical decision making. For the first time, these programs are being designed and implemented from a systemic perspective. Data from the past three generations of MRM programs shows that different MRM programs usually achieve different results. Therefore, airlines are now adding a skills training module to their classroom instruction and making it a true training program that is more likely to result in more open communication (Patankar & Taylor, 2000). These airlines are also aware of the limited interpersonal trust that impede self-disclosure, and they are striving to incorporate a maintenance error investigation (MEI) module in their training, and in their larger program, so that the participants understand the goal and the procedure of such investigation. In the skills training module, the airlines are beginning to train their maintenance personnel to use simple, standard processes to detect and resolve differences in information through third-party validation. The airlines are now better informed about the capabilities and limitations of MRM programs, and they are embarking

on a new result-oriented approach to safety through strategic, system-wide, changes.

Understanding the human factor in unanticipated events. Real time knowledge of what human factors lie behind classes of maintenance errors is important to obtain, and central to the long-range and comprehensive success of MRM. Processes for a human-centered maintenance error investigation (MEI) are becoming objects of serious interests in aviation maintenance organizations (Allen & Marx, 1994; FAA, 1999). However, full-blown maintenance experience with such programs is limited. A recent expert assessment of MEI in the U.S. shows that there has been little commitment yet by either the air carriers or repair stations to see such error investigation and analysis become a new way of doing business (Marx, 1998).

Trust within the maintenance system. Informal reports from users suggest that AMTs limited trust of the MEI process creates an obstacle to its widespread diffusion. Why should an AMT cooperate with management in investigating his/her own mistakes? Unless a strong culture for open communication and assertiveness already exists in their organization, relatively few AMTs will voluntarily or willingly disclose what they believe to be the real story. AMTs' individualism (Taylor, 1999; Taylor & Patankar, 1999) and self-reliance (Taylor & Christensen, 1998) can limit their trust in others.

In order to develop a strong safety culture a maintenance organization must first recognize its own organizational and occupational culture, and it must appreciate the interplay between these two with the effects of national origins and cultures of its individual members (Taylor, 1999; Patankar, 1999).

Now, at the beginning of the 21st Century, MRM is being seen as more than mere awareness training, or coping skills for individual AMTs—it is the conscious process of increasing trust among maintainers, their managers, and their regulators that enable them to learn from present behaviors in order to improve future quality and efficiency. MRM is now a process of cultural change.

Direct focus on behavior change. The focus of contemporary MRM programs is now moving toward active error reduction through structured communication. Patankar and Taylor (1999) describe a case from the corporate aviation environment that uses a behavior-change first approach instead of the prevalent attitude-change first of MRM. In the earlier MRM generations 1 and 3, companies simply provided classroom instruction and hoped that the desired change in attitudes and behavior would take place automatically. This strategy focused on changing the participants' attitude

toward safety through education and persuasion, and sometimes skill training. Its developers hoped that participants' behavior would change as a consequence of the classroom experience alone. Unfortunately, the evaluations of such training programs for improving communication revealed that the subsequent behavior change is limited—either in scope or duration.

At the same time there were companies that began to provide a simple structure and process for communication among all departments associated with aviation operations: flight crew, maintenance, and administration. These companies assumed that if they provided a simple, consistent communication and decision making process, and the outcome of this process was promptly acted upon and continuously supported, their employees would continue to use it and could eventually change their attitudes. The immediate interest of these companies was in changing their employees' work-related communication behavior, they did not use the better known attitude change approach taken in MRM generations 1 and 2.

The Structured Communication Process. Basically, there are two aspects to achieving new communication behavior: first, a structure which requires connected parties to communicate, and second, a process that is followed consistently—regardless of the outcome.

Structure: An example of structure might be an organization policy for line maintenance which requires that for each flight an AMT act (either by direction or discretion) as its liaison AMT. This person is expected to meet with the flight crew and discuss the maintenance issues with them. The pilots are expected to remain after arrival to discuss maintenance discrepancies with the AMT. During such discussions, both the flight crew and the maintenance AMT(s) are required to follow the pre-agreed communication process described below. Another example of structure is a policy requiring that maintenance shift turnovers take place face-to-face; and that among other standing agenda items is the expectation that AMTs leads and foremen briefly review the outgoing shift's use of the pre-agreed decision making process.

Process: A process for enhanced aviation communication has been observed and documented (Lynch, 1996; Patankar & Taylor, 1999). Its originators (CMR, Inc. of XX, VT) have titled it the Concept Alignment Process (CAP). According to this process, a concept is an idea or a piece of information presented by an observer of, or a party to, a technical decision. All members are expected to present their concepts. If the members present differing concepts, they must validate their concepts from a third party source such as a flight manual, air traffic controller, maintenance manual, or company policy. If only one concept can be validated, it is executed; if

none of the concepts can be validated, the most conservative concept is executed; and if multiple concepts can be validated, the senior ranking person has the authority to choose any one of the valid concepts. Additionally, when multiple concepts are stated, whether valid or not, the members are required to investigate the reasons for the existence of multiple concepts. Such an investigation is aimed at providing systemic feedback to minimize the occurrence of multiple concepts, at least not the non-validated ones.

The Concept Alignment Process addresses the following causes of human error accidents: (Lynch, 1996) nonadherence to procedure, incorrect tactical decisions, inattention or complacency, and failure to challenge another member's error.

The CAP provides objective procedures, thus making the use of the process observable to all. It provides team members with decision-making and conflict resolution methodology. It reduces chances of acting on incorrect concepts for forcing collaborative task completion and decision making. It reduces interpersonal conflict and defensiveness through the understanding that what is challenged is the concept and not the individual. All of these benefits have been observed in the use of the CAP in the maintenance environment. The following description of Case 7 highlights those benefits.

Case 7: The Concept Alignment Process to facilitate crew communication and consistent decision making among all members of a corporate aviation department.

The aviation department of a large U.S. corporation trained all of its flight crew and maintenance members to use this system. The management used it as well.

Purpose. The CAP, a communication and decision-making protocol, was implemented to enhance systemic safety through early identification and management of risk. With this approach, management intended to impact behavior and did not aim to directly or immediately change attitudes toward interpersonal relations at work.

The management required that all aviation employees use the CAP actively and held them accountable for it. Therefore, the use of the system was not voluntary. This is consistent with the behavior-first strategy discussed earlier. However, Patankar and Taylor (1999) observed that once the employees (both flight and maintenance crew members) experienced successful implementation of the process and consistent support from the management, even if it meant making policy changes or confronting the local FAA, their belief in the process grew and their attitude toward safety

and toward the use of this process changed over time. Most maintenance employees agreed that it took some time for them to really understand the process and be able to apply it consistently. The flight operations personnel had been using, the CAP for almost three years before the maintenance manager began learning the process. He customized the original flight-oriented program to a maintenance-oriented program and called it Error Reduction & Decision Making Process.

Likelihood of voluntary change. A year after the Maintenance Error Reduction Program began AMTs were surveyed for their attitudes and opinions about it. Only 40 percent of the AMTs said the program had at least moderate effect on their behavior, but nearly three-quarters of them reported that the program had been useful to others. Regardless of how they may discount the program's effects on themselves, these AMTs could see the effects on the others around them.

Attitude and opinions. Compared with our standard dataset (Taylor, 2000b), the survey for this aviation department showed favorable attitudes toward sharing command responsibility, and for assertiveness. These people do value speaking up and making decisions. Their attitudes toward communication however, were substantially below our standard benchmark. That is, they appear not to value or enjoy communication for its own sake. Their assessment of goal setting and sharing is at the benchmark norm, while their evaluation of the department's safety climate was higher than the norm.

Behavior changes. The behavior changes were almost immediate. Because the change was mandatory and the employees were evaluated based on their ability to use the process, everyone tried to use it. Although some did not believe in it as much as others did, they all used it. There were a few product champions who consistently used the CAP process and more assertively addressed the concepts of others. Self-reports of how the process was used and stated intentions to continue using it are encouraging. Two-thirds of the AMTs reported that the program caused them to communicate actively while only one member described behaving passively as a result of the CAP process. Reported intentions to further use the process were weighted toward active communication vs. passive reaction in a ratio of two to one.

As the AMTs observed that the management supported the process, regardless of the outcome, they started to trust this new communication protocol and continued to use it. There were times when the flight crew and the maintenance crew had disagreements and each party was able to validate its concept (Patankar & Taylor, 1999). Under such circumstances, the department manager was able to step-in, validate the application of the

process, and determine an outcome that was consistent with the CAP protocol. Consequently, all parties emerged trusting the process more.

Performance changes. As a result of the CAP process, the maintenance personnel, the flight crew, and the management were more actively engaging external vendors, aircraft manufacturers, and their local FAA for more accurate and acceptable solutions to problems. Additionally, the maintenance manager was able to follow-up on several information discrepancies, determine their root cause, and make the necessary structural or procedural changes so that the same discrepancy would not arise in the future.

Processes such as the CAP focus on behavioral outcomes rather than attitudinal change by providing a simple structure and process for communication among all parties involved in aircraft operations. The consistent use of this pre-agreed process, regardless of the outcome, in genuine pursuit of systemic improvements toward safety builds trust among all parties. Through consistent use of this process, the corporate aviation department was able to raise the performance standards at an individual as well as organizational level. Such an approach shows strong potential for long-term changes in the aviation safety culture.

Organizational safety culture and management support. Assuming that organizational culture has the potential for the greatest impact on safety, Helmreich and Merritt (1998) present strategies to unify and strengthen the organizational culture and aim to introduce safety as a shared value. Management's commitment, Helmreich and Merritt suggest, is prerequisite to successful implementation of new process or protocol because although an organizational culture is shaped by all of the employees, an organizational change is defined by the upper management. "Senior Management is a part of, not apart from, the culture; that is, it does not look down upon the organization and direct it by edict, rather it influences the culture as a participating element within the culture" (p. 124). The change has to be top-down, through concrete and consistent examples.

In Case 7, the CAP communication protocol worked as an outstanding strategy to unify and strengthen the organizational culture because the top management agreed to manage risk through team decision making. On the flight side, the pilots were required to conduct preflight briefings and post-flight debriefings for every flight. Similarly, in the maintenance department, the AMTs were required to conduct regular briefings with the flight crew and follow the approved protocol. In addition maintenance personnel agreed to discuss the recent use of the CAP during their daily shift turnover meetings. The management fully supported these briefings

and agreed to act on the subsequent recommendations in a timely manner.

By visibly supporting these activities, the management created an environment which expected everyone to follow the CAP protocol in making decisions and that all the employees base these decisions on safety concerns as well as on scheduling. Every employee does not need to believe in this communication process, but they are required to practice it. Rewards and penalties are based on the employee's ability to follow the process. With a demonstrated consistent support to the process, regardless of the resulting recommendations, the employees gain confidence and build safety as a shared value.

Case 8: MRM combining direct behavior change with awareness instruction and error investigation.

A large airline has recently designed an MRM program based on the best practices from the industry, together with innovative ways of adapting those practices to their own company culture.

Program purpose. To expand the view of MRM providing participants with awareness of human factors principles, to include skills training and techniques to help identify and correct mistakes, oversights, and lack of knowledge. Dirty Dozen issues initially emphasized are lack of communication, lack of knowledge, and lack of teamwork.

The MRM program topics are: a) training for awareness and basic safety skills, b) incident/error investigation, c) resolving differences in knowledge and information for improved decision making, and d) baseline metrics for trust, for errors and incidents, and for attitudes toward safety and teamwork.

A one-day training session is planned for employees and managers in all maintenance locations and functions. The syllabus is based on the topics above, and contains the following six 45-minute modules.

1. Introduction to human factors concepts
2. The Dirty Dozen
3. Maintenance errors
4. Ways to eliminate errors
5. The company's MRM program
6. Where to get more information

Maintenance error investigation (MEI) process. The company does not currently have either a standardized information gathering process for

maintenance errors and incidents. As part of their MRM program they expect to provide maintenance leads and managers with a standardized process to follow in error investigation, which will provide a means to gather information about errors and how they occur. It will help determine where to concentrate efforts for error reduction and prevention in the rest of the MRM program. And it will reduce fear of unknown for those that may have committed errors.

They expect to complete implementation of the awareness and skills training before implementing their MEI process. Currently they expect to obtain more training in MEI methods and to prepare an ASAP memo of understanding (FAA, 1999). They will develop a process that will work best for them.

Their MRM program will contain much of the best of MRM development over the past decade—it is designed to be systemic, integrated, data-based. Their experience with the process and its outcomes will be monitored and assessed.

The Balance of Change

Based on the experience of the first three generations of MRM programs, the fourth generation programs, such as the one described in Case 8, are starting to address the issue of balance among individual and organizational changes. In theory, both the individual and the organization must change in order to effect a long-term change in the safety culture. The first generation MRM program customized the concepts from CRM training to maintenance by focusing on teamwork—communication between two or more individuals—but it was still personal change and little attempt to support it through organizational structure or process was made. The second generation MRM programs used focus groups to solve specific problems resulting in some organizational changes and some individual changes, but because these programs were focused at specific problems, once problems were solved and to continue the process proved difficult, the programs were discontinued. The third generation MRM programs focused on individual awareness resulting in mostly passive individual change.

Now, as illustrated in the figure below, the balance of organizational change (cases 4 and 7) together with individual change (Cases 2, 3, 5 and 6) is becoming an idea in good currency. This balance provides structure and processes for individuals to practice the desired behaviors, as well as the encouragement and personal support for individuals taking a positive attitude about safety, as well as knowledge and skills for how to do it. Strategy or purpose guides the balance. If either the organization or the individual does not perform the requisite function, the resultant behavior

will be unbalanced and not achieve the higher levels that are possible through planning (Patankar & Taylor, 2000b).

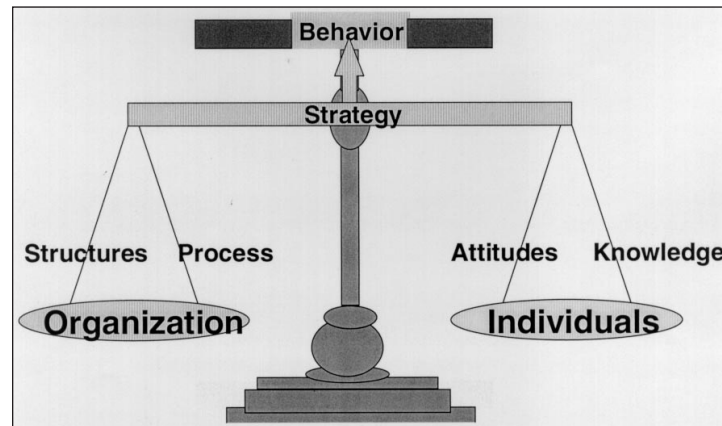


Figure 7. The Balance of Change

CONCLUSION

Awareness programs as illustrated in Cases 5 and 6 raised the safety consciousness among maintenance personnel and improved their attitude toward safe practices. These programs achieved considerable success in causing individual changes in coping with safety hazards. However in these most recent programs there has been little change in communication. In cases 2 and 3, where open and assertive communication was improved through training, the positive results were not sustained. The behavior-based programs, such as illustrated by cases 4 and 7, focused on promoting the desired behavior rather than changing attitudes toward safety. Consequently, the behavior-based programs achieved a more readily observable change in behavior. This body of research has illustrated the ability of MRM programs to influence several different areas ranging from injuries and aircraft damage to paperwork error reduction. The fourth generation of MRM programs appears to be based upon improving on these successes as it moves toward an integrated, behavior-based philosophy. Programs in this fourth generation, such as that described in Case 8, can be expected to effect significant improvements in aviation safety. The fourth generation MRM programs will be among the first to truly satisfy the interactive part of the 1999 ATA definition of MRM programs. But this success will depend on developing a process that builds interpersonal trust—assuring the AMTs that they will be treated fairly—because the

AMTs will have to be actively involved in identifying individual and organizational errors to accomplish the next higher level of aviation safety.

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LEARNING STYLES OF PILOTS CURRENTLY QUALIFIED IN UNITED STATES AIR FORCE AIRCRAFT¹

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ABSTRACT

Kolb's Learning Style Inventory was used to identify the predominant learning styles of pilots currently qualified in United States Air Force aircraft. The results indicate that these pilots show a significant preference for facts and things over people and feelings. By understanding the preferred learning styles of the target population, course material can be developed that take advantage of the strengths of these learning styles. This information can be especially useful in the future design of cockpit resource management training. The training program can be developed to demonstrate both that there are different learning styles and that it is possible to take advantage of the relative strengths of each of these learning styles.

INTRODUCTION

The purpose of this study was to determine the learning styles of pilots currently qualified in United States Air Force aircraft. How students learn is impacted by how the material they are to learn is presented. Studies have shown that more effective learning is achieved when programs take into account the learning styles of the target population (Wooldridge, 1995). Increasing student learning, the desired outcome of all instruction, requires developing an ability to recognize students' learning styles and use techniques that increase the probability of achieving success (Anderson & Adams, 1992).

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The study of learning styles has its roots in the field of psychology. There have been two main paths for study as research has moved forward from these roots. One path has followed the classic Pavlovian stimulus-response approach, using reinforcement of successful completion at each step in a sequential learning process. The other path has focused instead on the cognitive processes in learning. Researchers conducting current studies of learning styles have mainly chosen this second path, focusing on the cognitive processes of the learner (Sims & Sims, 1995).

The Myers-Briggs Type Indicator, field dependence/field independence, and brain hemisphericity studies are all examples of measures for cognitive based learning. Another example is the Kolb Learning Style Inventory. There are many other approaches to measuring learning styles, with diverse terminology and measurement instruments. The common ground for all of these approaches, however, is that they attempt to describe the learning styles of the individual by measuring the individual's behavior during the learning process. Through this measurement, each instrument attempts to describe how the individual takes in and processes information. Sims & Sims (1995) provide an apt summary, stating that "...regardless of how that process is described, it is dramatically different for each person" (p. 194).

Kolb's (1984) approach to measuring this learning process is through the experiential learning model. The experiential learning model proceeds from the assumption that all learning is influenced by the prior experiences of the individual learner. Because of this assumption that prior experience influences each new learning event, learning can be viewed as a continuous process. How the learner progresses through this process, or uses this process, becomes the focus for defining that learner's learning style.

The experiential learning model describes four phases of the continuous learning experience. Concrete experience is involvement with the learning event, absorbing the surroundings and activities as they happen. Reflective observation is reviewing the experiences and attempting to determine what is new and different about the experience, and what is similar to previous experiences. Abstract conceptualization is the process of integrating these experiences and reflections into a modified view of the learner's environment. Finally active experimentation is the process of testing this new world view (Kolb, 1984).

The "perfect" learner would use all four modes of learning equally, and would shift around the learning model smoothly with each new learning situation. The "normal" learner, on the other hand, develops a preferred mode of learning. Whether this preferred style is adopted as the result of

positive reinforcement in earlier, similar situations (Schmeck, 1988) or rises from deeper, personality based roots, the effect is that the learner tends to “specialize” in a specific style of learning. Identifying this preferred style of learning is the focus of learning style research.

Kolb’s (1985) Learning Style Inventory uses twelve sentence stems with four endings each to measure preferred learning style. Each of the sentence endings indicates a preference for one of the four learning modes associated with the experiential learning model. Summing the responses for each of the twelve sentences yields a set of numbers between 12 and 48 which represents the degree to which the learner emphasizes each of the four learning modes. These scores provide an indication of the balance between the learning modes for the learner.

Because the four stages of the experiential learning model represent polar opposites of two learning scales, it is possible to use the individual element scores to derive a number which represents the individual’s position along each of these scales. In Kolb’s (1985) Learning Style Inventory this is done by subtracting the score for concrete experience from the score for abstract conceptualization and subtracting the score for reflective observation from the score for active experimentation.

The range of 12 to 48 on each individual learning mode yields range extremes of plus or minus 36 for the active experimentation minus reflective observation and abstract conceptualization minus concrete experience scales. These formulas provide a numerical representation of a learner’s relative emphasis for the types of learning represented by each axis. There is no qualitative differentiation between the learning modes; rather this process provides a way to display the results in a linear presentation showing the relative strength of a specific style for an individual.

The quadrant of the graph, formed by these two scales, which contains the combined score for the individual defines that learner’s predominant learning style.

Within the experiential learning model the quadrant formed by concrete experience and reflective observation is called divergent learning. The diverger prefers being a part of the learning experience, and thinking about what has happened during that experience. The opposite preference lies in the quadrant formed by abstract conceptualization and active experience and is called convergent learning. The convergent learner takes multiple observations of many events and brings them together into the answer to a specific problem.

The other two quadrants produce assimilative and accommodative learners. The quadrant formed by reflective observation and abstract conceptualization is called assimilative learning. The assimilator is the inductive reasoner who can put together coherent theories based upon observations, integrating multiple observations into a cohesive explanation of the events. The active experimentation/concrete experience quadrant produces the accommodative learner. The accommodator gets things done and is part of the action.

Knowing which learning style the learner prefers provides important information for course design. There is disagreement among researchers over whether it is better to match the preferred learning style to ease the learning process, or to mismatch the style to force the learner to “stretch” into another style. Regardless of which method is preferred, however, there is agreement that this decision must be designed into the course as opposed to being the result of ignoring the possibility that differences in learning styles exist (Sadler-Smith, 1996).

PILOT LEARNING STYLES

The emphasis in pilot training has followed the Pavlovian instead of the cognitive path. Courses for pilot training are based upon task lists which the student must master to successfully complete the training program. The task is presented, demonstrated, and then the student practices until the task is mastered. Appropriate feedback is provided by the instructor during the practice session. There is no effort spent on determining the cognitive based learning style of the student.

In this age of technology and information there is an effort to move some of this training into the classroom using computer based training and simulation (Thiesse, Newmeyer, and Widick, 1992; Treiber, 1994). It is in this effort to apply new technologies to pilot training that understanding learning styles can be helpful in course design. Once the learning style of pilots is understood, the decision to match, or mismatch, these styles can be a conscious one instead of being left to chance.

Currently the predominant learning style of pilots is not well understood. Three studies by Quilty (1995, 1996, 1997) have addressed the global versus analytical cognitive bias of pilots with differing levels of experience. Studies by the United States Air Force (Carretta & Siem, 1988) have focused on predicting the chances of a specific individual successfully completing the Undergraduate Pilot Training program. This study used Kolb's (1985) Learning Style Inventory to identify the predominant

learning styles of pilots currently qualified to fly United States Air Force aircraft.

METHODOLOGY

Initially developed in 1976, and revised in 1984 (Kolb, 1976, 1984), the Learning Style Inventory has been used, and validated, in such diverse studies as comparing learning styles between high school and college students (Matthews & Hamby, 1995), a cross-cultural comparison of the learning styles between Western and Oriental learners (Auyeng & Sands, 1996), and comparisons of the learning styles among European management training students (Jackson, 1995). Recent validation studies such as that conducted by Willcoxson and Prosser (1996) have proven the continued usefulness of the LSI as a measure of predominant learning styles. Based on this history of use no pre-test evaluation of the Learning Style Inventory was conducted for this study.

The sample for this study was generated by the data retrieval section of the Air Force Personnel Center (AFPC). According to S. Heitkamp (personal communication, April 13, 1998) the data storage system has a built in randomization process for extracting names from the master personnel file based on the specified sort criteria. Using this built in system a list of 600 pilots was drawn at random from the Air Force Master Officer Personnel File. Copies of the Kolb Learning Style Inventory and an accompanying demographic data questionnaire were mailed to these 600 United States Air Force pilots in March 1998. Two hundred thirty-three surveys were returned by the end of June 1998, with completed and usable instruments. Another 63 surveys were returned by the United States Postal Service as undeliverable. The return of 233 of 537 surveys provided a 43.8 percent response rate for the study.

The original sample size was chosen using methodology developed by Krejcie and Morgan (1970) to provide a 95 percent probability of matching the population of 14,000 pilots in the United States Air Force. The rank structure of the final sample very closely approximated this population, with slightly fewer captains than expected, and slightly more majors than expected. Table 1 shows the distribution of the sample relative to the population for rank structure, gender, ethnicity, and type of aircraft flown.

Sample distributions for gender and ethnicity also closely approximated population distributions. The sample held 5 percent females and 95 percent males compared to a population of 2.5 percent female and 97.5 percent male. Sample distributions for ethnicity were within two percentage points in all categories. The distribution of the sample based upon type of aircraft

flown was within 3 percent of the population distribution for all types of aircraft. Distribution comparisons for female pilots were not meaningful due to the small number in the sample.

Chi-square analysis of the expected distribution of the sample for rank, gender, and ethnicity produced a statistically significant match between the sample and the population. A Pearson product moment of 28.50146999, with 12 degrees of freedom returns a probability of < 0.005 of achieving the sample distribution by random chance.

Table 1. Sample vs. Population Distributions

	<i>Sample percent</i>	<i>Population percent</i>
Grade Distribution		
2LT	3.4	2.0
1LT	5.1	5.0
CPT	48.1	54.0
MAJ	27.9	24.0
LTC	15.5	15.0
Gender Distribution		
Female	5.2	2.4
Male	94.8	97.6
Ethnic Distribution		
American Indian/Alaskan	1.3	0.3
Asian/Pacific Islander	0.4	1.0
Black (non-Hispanic)	1.7	2.0
Hispanic	1.7	1.0
Other	2.6	1.0
White (non-Hispanic)	92.3	94.7
Aircraft Distribution		
Fighter/Attack/Reconnaissance (FAR)	27.5	33.7
Tanker/Transport/Bomber (TTB)	57.1	60.1
Helicopter (HELO)	5.2	5.3
Other/None	0.0	0.5
Both	9.9	0.0

FINDINGS

Kolb's (1984) norming process for the Learning Style Inventory produced median scores of 5.9 for active experimentation minus reflective observation and 3.8 for abstract conceptualization minus concrete experience. The sample result of 5.93 for the active experimentation minus reflective observation axis shows there is no greater emphasis placed upon active experimentation or reflective observation by pilots than is shown in

the general population. The sample result of 8.39 for abstract conceptualization minus concrete experience, however, is significant. Two-tailed t-test probability is less than .0001 for achieving this result at random. Pilots show a significantly stronger tendency to emphasize abstract conceptualization over concrete experience.

Based on this concrete experience and abstract conceptualization data, it can be said that the average pilot in the United States Air Force significantly emphasizes things and thought over people and feelings. The reflective observation and active experimentation data reflects a preference for active participation over observation; however, this preference is not statistically different from the preference shown by the population at large when compared to the norming sample (Kolb, 1984).

Descriptive statistics for the sample, showing the scores for each of the six learning style measurements, are shown in Table 2.

Table 2. Survey Results—Descriptive Statistics

	<i>Mean</i>	<i>Median</i>	<i>Standard Deviation</i>
Concrete Experience	23.85	20.00	10.28
Reflective Observation	28.98	28.00	6.47
Abstract Conceptualization	32.24	32.00	7.23
Active Experimentation	34.91	37.00	9.10
Abstract Conceptualization minus Concrete Experience	8.39	11.00	14.86
Active Experimentation minus Reflective Observation	5.93	9.00	12.41

LEARNING STYLES

Plotting active experimentation minus reflective observation and abstract conceptualization minus concrete experience as the “X” and “Y” axes of a grid forms a matrix which can be used to define the quadrants of the experiential learning cycle. Kolb (1984) used this graphic representation to plot the four learning styles (Figure 1). The median scores for active experimentation minus reflective observation (5.9) and abstract conceptualization minus concrete experience (3.8) define the intersection.

The mean values from the sample were 5.93 for active experimentation minus reflective observation and 8.39 for abstract conceptualization minus concrete experience. When plotted on the style grid these mean values fall on the boundary between Converger and Assimilator. Medians for the sample were 9.0 for active experimentation minus reflective observation and 11.0 for abstract conceptualization minus concrete experience. The

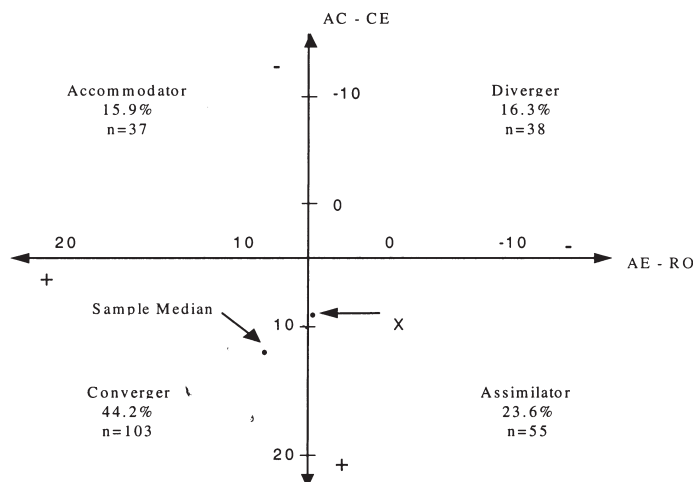


Figure 1. Style Grid

plot for these median values falls within the Converger learning style. When individual responses are plotted on this grid 15.8 percent ($n = 37$) are accommodators, 23.6 percent ($n = 55$) are assimilators, 44.2 percent ($n = 103$) are convergers, and 16.3 percent ($n = 38$) are divergers.

This distribution of learning styles is significant ($p < .0001$) relative to a hypothetical distribution of 25 percent in each style as would be shown in a random sample of the population at large. This significance corresponds to the predictive nature of the Learning Style Inventory (Kolb, 1984). In the case of pilots currently qualified in United States Air Force aircraft, the predominant learning style is convergence. A secondary learning style is assimilation. Divergent and accommodative learning styles are each used by significantly small groups of pilots within the study group.

The analysis of pilots' learning styles was based upon average data for the entire sample. Demographic data was collected for military rank, gender, ethnicity, type of aircraft flown, and number of flying hours. In all categories except ethnicity the convergent learning style was the predominant selection at a statistically significant level. Analysis of learning styles by ethnicity was not accomplished due to the small numbers of non-white ethnic groups within the sample.

CONCLUSIONS

The predominant learning style of pilots currently qualified in United States Air Force aircraft is the convergent learning style. This learning style fits within the predictive nature of Kolb's (1985) Learning Style Inventory as demonstrating traits which are valuable in specialist and technical fields. There are implications for future course design to match this learning style.

Learners with the convergent style prefer to know how it works as opposed to who says it works. These learners want to do it themselves rather than being shown how to do it, but they would rather be shown that it works than take an expert's word that it works. This will be especially important in the design of computer based training modules which introduce new equipment and technology to pilots during training courses. How the system fits together, and why it works, are more important to convergers than just being told that the system works.

The secondary learning style for pilots currently qualified in United States Air Force aircraft is the assimilative style. This style is included as a secondary learning style because of the relationship convergent and assimilative learning styles have relative to concrete experience and abstract conceptualization. Both styles show a preference for abstract conceptualization over concrete experience. The choice between a preference for active experimentation over reflective observation is the difference in learning preference which separates the converger from the assimilator. Although more individuals fell into the converger learning style than the assimilator learning style, the sample mean, very close to the dividing point between these two styles, was used in considering the assimilative style as a secondary learning style for the pilots in this study.

There are similar considerations for designing future courses for the accommodative learners in the class. They share the converger's desire to know how something works rather than who says that it works. Their preference for reflective observation, however, can lead them to look for all the available alternatives and overlook the fact that they have a workable solution already. Building into the training program justifications for limiting the scope of information will be important for the assimilative learner.

Taken together, the predominant converger learning style and the secondary assimilative learning style support the effectiveness of the current training program. The abstract conceptualization focus shared by these two learning styles works well with the demonstration/performance mode of teaching because of the focus on how things work as opposed to who says these things work. By seeing how things are done, and

understanding the implications, the abstract conceptualizer can work from the individual parts to create a whole.

The balance between reflective observation and active experimentation shown by the mean score of the sample also supports the current training program. This balance between careful observation and risk taking, and looking at problems from many angles and putting this information into action form the basis for sound decision making in the time-critical nature of aviation.

In short, the very things which are used to predict successful completion of Undergraduate Pilot Training (Carretta & Siem, 1988) are the factors which appear in the predominant learning style of current United States Air Force pilots. The sorting process coincides with two elements of the experiential learning model. The first element is socialization, where working in aviation tends to emphasize certain characteristics within the individual due to the requirements of the task. The second element is the process of the individual tending to gravitate towards a field where the requirements match that individual's personal characteristics. This process of specialization provides a basis for the predictive nature of the learning style inventory and the experiential learning model (Kolb, 1984).

One of the current areas of emphasis in aviation training is crew resource management. This training program emphasizes skills in relating to other individuals, both on the crew and in positions which interact with the crew focusing on team coordination, attitudes, behaviors, and communications (Driskell & Adams, 1992). Addressing learning styles within crew resource management training courses can provide an additional approach to defining the issues for all crewmembers. Understanding individual differences provides a critical stepping stone toward improvement within these areas.

Pilots with the predominant converger learning style "...would rather deal with technical tasks and problems than with social and interpersonal issues" (Kolb, 1985, p. 7). The focus of crew resource management training is these very social and interpersonal issues. The characteristics of the convergent learner, as well as the other learning styles, should be incorporated into course design for crew resource management training. Analyzing the different learning styles, including the differences between the styles and the strengths and weaknesses of each style, allows the group to make better use of the skills available through its individual members (Sims & Sims, 1995).

Incorporating learning styles into the design of crew resource management training provides an opportunity for better understanding of

the fact that there are different approaches to the same problem. Understanding the differences in the approach and bias associated with each learning style, and focusing on the learning style instead of the individual, personal conflict over differences and misunderstandings are possible (Sharp, 1997). This approach to the interpersonal issues associated with functioning as an aircrew member provides an opportunity to address these issues in a way that is compatible with all four learning styles.

IMPLICATIONS AND RECOMMENDATIONS FOR FURTHER STUDY

This study identified the convergent learning style as the predominant mode of learning for a statistically significant portion of currently qualified pilots in the United States Air Force. A statistically significant distribution of learning styles among these pilots was also identified. The information gained through this process provides a starting point into understanding how pilots learn. The convergent learning style is consistent with the technical nature of aviation, the decision-making requirements of flying, and the necessity to process large amounts of information during a flight.

Further study of the relationship among these three areas is appropriate. Such studies would be useful in determining if correlations exist between learning styles, cognitive biases, and successful completion of aviation training programs. It would also be informative to know where, if anywhere, within the training process the sorting for learning styles and cognitive bias occurs.

This study further examined only currently qualified United States Air Force pilots. A study comparing the learning styles of those individuals completing Undergraduate Pilot Training with the learning styles of those who failed to complete the course would be informative. Such a study would necessarily include observations of the cause for failure to complete the training program. Currently, qualified pilots exist who do not fall within the predominant learning style. Understanding why certain individuals do not successfully complete Undergraduate Pilot Training may provide information which will allow more individuals with these minority learning styles a greater chance of success in the training program.

The predominant learning style for all of the pilots in this study was convergence. This style held a statistically significant position regardless of gender, degree type, total flying experience, or military rank, which is also an indicator of age. Why pilots share a predominant learning style, regardless of other factors which indicate a tendency towards different preferred learning styles, is a matter for further study. Information on what

factors are shared by pilots, which become dominant factors in determining preferred learning style, could be correlated with success and failure rates for pilot training.

This study, and the above recommendations, applies to the training of pilots in the United States Air Force. With almost 150 colleges offering professional pilot degree programs (Schukert, 1995), and current interest in the requirements for a non-technical doctoral program in aviation (Johnson, 1997), the learning styles of students within these programs are appropriate for study. A study focusing on college and university participants would provide correlational data for comparison to pilots training in the United States Air Force training program.

In addition to the cognitive bias studies conducted by Quilty (1995, 1996, 1997) on college students in aviation, and corporate and airline pilots, studies of the primary learning styles of these groups of pilots are also appropriate. Correlational studies among these groups would also then be possible. These groups of pilots would also provide an opportunity for longitudinal studies to determine the stability of learning styles over the career of a pilot. Such longitudinal studies would be useful when comparing career changes within aviation.

Understanding how pilots learn has significant implications for effective training of current and future pilots. While learning style research has investigated many learning situations, aviation students have not been studied. The academic and personal benefits associated with matching, or intentionally not matching, learning styles have been identified in many areas. It is appropriate to bring this understanding to the aviation training and education community. Incorporating the findings of academic research into the training of pilots, academically and professionally, can provide this same opportunity to enhance the learning process in this field of study.

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AIRCRAFT OPERATIONS CLASSIFICATION SYSTEM

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ABSTRACT

Accurate data is important in the aviation planning process. In this project we consider systems for measuring aircraft activity at airports. This would include determining the type of aircraft such as jet, helicopter, single engine, and multiengine propeller. Some of the issues involved in deploying technologies for monitoring aircraft operations are cost, reliability, and accuracy. In addition, the system must be field portable and acceptable at airports. A comparison of technologies was conducted and it was decided that an aircraft monitoring system should be based upon acoustic technology.

A multimedia relational database was established for the study. The information contained in the database consists of airport information, runway information, acoustic records, photographic records, a description of the event (takeoff, landing), aircraft type, and environmental information. We extracted features from the time signal and the frequency content of the signal. A multi-layer feed-forward neural network was chosen as the classifier. Training and testing results were obtained. We were able to obtain classification results of over 90 percent for training and testing for takeoff events.

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INTRODUCTION

In this project we consider the development of a system for automatically measuring aircraft activity at airports. This would include determining the type of aircraft and the type of aircraft activity. The different types of aircraft considered in this study are helicopter, single engine, multiengine, and jet aircraft. An accurate count of aircraft operations is important to airport managers and aviation planners. These counts are difficult to obtain at non-towered airports.

BACKGROUND

A system for monitoring aircraft operations will likely include methods for directly counting the aircraft as well as the use of ancillary and statistical information to estimate total counts since it is unlikely that counters will be in constant operation at all airports (FAA, 1985). At airports without full-time tower facilities there are other indirect or ancillary indicators of aircraft operations. If this information is put in a database system, it will be useful in determining aircraft operations. The following describes some indirect sources of information on aircraft operations.

Many airports are associated with an approach control at a major airport giving the major airports information about operations at small airports. Some pilots do not use the services offered. Many airports have unicoms (local advisory service from the airport operator). This information is unreliable unless the operator is willing to log in arrivals and departures since there is no recording of the transmissions. Even then, hours of operation vary, and thus do not guarantee accurate information around the clock.

Other sources of information are flight plans filed with Flight Service Stations (FSSs). One disadvantage is that not every pilot files a flight plan when flying cross-country, and most rarely ever file a plan for a flight within the local area of their departure point. Another disadvantage is that it may be difficult to obtain this information on a regular basis from FSSs. Monitoring gas sales may also be considered, but this may be inaccurate because of the variety of sales that may occur. Another method to assist in assessment of aircraft operations would be to confirm the number and type of aircraft based at each airport and survey each aircraft owner to determine their normal aircraft use and flying patterns. Some pilots may use their aircraft purely for pleasure once or twice each month. Further, these pilots may perform touch and go maneuvers that will increase the airport usage.

Others who use their aircraft for business may only make one departure and one arrival each week. Another indicator is the category of airport. Some airports have shorter runways that are stressed for heavy loads, thus limiting the size and/or type of aircraft that operate at the facility. Additionally, airports that don't have any services or aircraft based at the airport will likely be used less and airport personnel may be able to accurately estimate the number of aircraft operations. While looking into different airports, interviews with airport managers or fixed base operators will give an indication of times that will assist the study such as "Peak Month," "Peak Week," "Busiest Day," as well as "Busiest Hour."

The above ancillary information may be useful in estimating aircraft operations and may be useful in determining where and when to monitor aircraft operations at different airports. Since the above indicators do not give direct counts, one still will need methods to directly monitor aircraft operations. The best overall approach may be to build databases with the above types of information and use statistical analysis and direct counts to increase the reliability of the analysis.

TECHNOLOGIES FOR MONITORING AIRCRAFT OPERATIONS

The following review of technical literature indicates the approaches taken for automatic aircraft detection and classification. Some of the issues involved in deploying technologies for monitoring aircraft operations include the cost of the monitoring operation, the reliability of the system, the system must be portable, the system must operate self contained in the field for two weeks, and the system must be acceptable at airports. The costs of the monitoring operation includes capital equipment costs, travel costs, labor costs, and overhead costs.

The technologies that have been considered are electromagnetic loops, radar, microwave, radiation, video, pressure counters, and acoustic technologies. Acoustic counters use a microphone located near the runway to record takeoffs that produce a strong acoustic signal (Dress & Kerchel, 1994). Total operations cannot be counted directly because landings are quieter and do not register on the systems. The systems by Larson Davis are used by a number of states to count aircraft operations. The aircraft counter system has a high accuracy for counting takeoffs as reported by users. These systems have the advantage of low cost, portable, and are a demonstrated technology for operating in airport environments.

Tamayo et al. (1993) developed a magnetometric sensor for detecting airport ground traffic with the goal of performing detection, discrimination and tracking of static and moving targets. The authors also reviewed other

methods for solving the problem of airport traffic control such as radar, microwave gates, radiation, pressure sensors, acoustic sensors and loops (electromagnetic). Radar was determined to be too expensive and can easily be interfered with by obstacles. Radar can interfere with airport operations and may be difficult to operate in this environment. Microwave gates could not be installed flush to the ground, thus creating a potential obstacle. Microwave gates can cause electromagnetic interference, which is not acceptable in an airport environment. Radiation methods consisted of detecting infrared signatures from the target. This approach was found to be too sensitive to environmental fluctuations and weather conditions. Pressure sensors such as pneumatic tubes were likely to break and require maintenance that would be invasive to the flow of traffic and thus undesirable. Acoustic sensors were thought to be unsuitable in noisy environments. Ultrasonic sensors were dismissed due to their short range and high power consumption. Electromagnetic loops were also dismissed by the authors due to their invasive installation, maintenance and the limited information that they deliver. The authors' solution was to develop a magnetometric sensor that would detect the magnetic fields produced by ferro-metallic components in the aircraft, such as landing gear and wings. The resulting sensor systems were able to detect cars at a distance of 10 meters and aircraft up to 20 meters from their axis (due mainly to ferro-metallic components in the wings). While this range may be suitable for controlling ground flow, it would not be sufficient for detection along the runway as the distance to the aircraft to the sensor can easily exceed 20 meters if the aircraft is airborne when passing the sensor. The magnetic signatures obtained from the sensors did provide clear discrimination between vehicles and aircraft, but no information was given as to the ability to differentiate between various types of aircraft.

Hudson and Psaltis (1993) investigated ways to identify a target aircraft from one-dimensional radar range data. It was found that the quality of classification depends not only on the aspect angle to the aircraft of the radar site but also the number of range images examined for a single classification. The usability of this method on airport traffic is questionable since precise control of the aspect ratio would prove to be very difficult. As such, one must consider the classification rates when no aspect angles were taken into consideration. With rates of 57 percent, 65 percent and 86 percent for single profile, frame, and encounter classification, respectively, we see that the classification rates are low. Couple that with the cost of obtaining required permissions, installing, and maintaining radar sites at strategic locations around an airport, and this method seems unfeasible.

Adams and Esler (1995) describe a number of issues related to acoustic recognition of aircraft events. It is noted that there is a change in the sound quality as the aircraft approaches and departs from the observer. There are differences between the sound emitted from the front and rear of an aircraft. There is also the Doppler shift associated with the speed of the aircraft. It was observed that for propeller aircraft (fixed wing and helicopters) there are recognizable components in the acoustic signal that can be used for Doppler analysis. Doppler analysis for jet aircraft is more difficult because the spectrum is less coherent. Their analysis concluded that frequencies above eight kHz could be ignored. Reported problems encountered were difficult in determining corresponding features in the approaching and departing signal, and one must make allowance for the angle of flight of the aircraft relative to the observer. Some differences between speech and aircraft signals are observed. Aircraft signals are continuous without breaks as opposed to speech. However, aircraft signals have high variability due to different environmental conditions, distances, and aircraft orientations.

Adams and Esler (1996) a recognition system based on a one-third-octave filter bank and half-second L_{eq} values from acoustic signals is described. A data reduction algorithm is applied to the spectra to extract 25 features. A neural network is used to discriminate between helicopters, fixed-wing propeller aircraft, jet aircraft, and background noise of uncertain origin. The reduced data from 100 aircraft and background noise events are used to train and test the classifier. Classification accuracy was reported to be better than 80 percent.

Cabell and Fuller (1989) developed a recognition system for the identification of helicopters, propeller aircraft, jet aircraft, wind turbines, and trains from acoustic data. It is based on a decision tree. The features are extracted from the Fourier spectrum and auto-correlation function of the noise events. The best design could correctly identify 90 percent of the recordings. Scott, Fuller, Obrien and Cabells (1993) tested an associative memory and a multilayer perceptron neural network as alternatives to the decision tree. On the same data set, results show that the associative memory classifier identifies 96 percent of the sources correctly and the neural network identifies over 81 percent of the sources correctly.

Two aircraft noise event detection systems based on one-second A-weighted L_{eq} time history of the acoustic signal are described by Wallis and Snell (1995). The decision of classifying a noise event as caused by an aircraft or not is based on a series of tests performed on the shape of the time history L_{eq} . In addition, an anemometer is used to provide supplemental information on the speed and direction of the wind during the

noise event. Special sensors located at the ends of the runway are used to provide timing and directional data on the takeoffs and landings of aircraft. Extensive field tests showed “excellent” performance.

Yamada, Yokota, Yamamoto, and Shimizu (1985) describe an aircraft classification system that utilizes acoustic data. It composed of a one-third-octave spectral analyzer combined with a modified Gaussian classifier. Nine features are extracted empirically from the output of the one-third-octave band real-time spectral analyzer. The features consist of one-third-octave band peak levels normalized with respect to the peak A-weighted level of the noise event. Ten classes are considered in the first experiment: three types of airplanes performing takeoff or landing, helicopters, jet airplanes, propeller-driven airplanes. Sixteen classes corresponding to sixteen types of airplanes are considered in the second experiment. Eight classes corresponding to eight types of airplanes are considered in the third experiment. The classification accuracy was 86 percent, 86 percent, and 90 percent, respectively, in the three experiments.

Some systems have been proposed for the classification (Cabell, Fuller, & Obrien, 1992, 1993) of helicopter operations from acoustic data. They are based on specific properties of the helicopter signal that is impulsive and strongly periodic. They describe Gaussian classifiers and neural networks applied to the identification of the type of a helicopter. Cabell and Fuller (1991) developed a pattern recognition system to classify acoustic signals from aircraft. Five classes of vehicles were defined for the purpose of identification, namely, jet plane, propeller plane, helicopter, train, and wind turbine. All sources taken together produced a recognition rate of 90 percent. The authors indicate that with classes such as jet planes, further discrimination within the class is possible if additional features are used to create more complex decision surfaces.

From the above review and our own experiences we note a number of issues that complicate the recognition process (Harlow, Bullock & Smailius, 1997). Aircraft acoustic signals have variability due to different environmental conditions and aircraft distances. Acoustic classification systems have difficulty differentiating other events from actual takeoffs and landings. Examples are preflight throttle tests, echoes from large buildings, vehicular ground traffic, and nature. Examples of vehicular traffic are airport luggage transport, fueling trucks, and tractors for cutting grass. Different airports and different weather conditions will affect the signals. Noisy environments and natural phenomena such as thunderstorms provide problems. Multiple signals from different sources will distort the signals. Finally, aircraft of the same type will produce somewhat different signals.

At present a satisfactory system does not exist. The different technologies have different advantages and disadvantages. Electromagnetic loop technology is expensive and maintenance can interfere with operations. Magnetic field detectors have difficulty detecting aircraft at a distance. Pressure counters are likely to break and maintenance can interfere with operations. Also, they cannot determine aircraft type. Radar is expensive, is sensitive to the location of the unit, and can interfere with airport operations. Radiation (infrared) detection units are sensitive to the environment and will have difficulty classifying aircraft types. It is difficult to determine the type of aircraft from video signals. Acoustic sensors have shown success as counters of aircraft operations. The units are low cost and portable. They have difficulties with quiet aircraft landings and may be sensitive to environmental conditions. At the present time acoustic technology has proven effective in counting takeoffs and is the most promising for future development. We decided to perform an analysis of the costs factors related to developing acoustic technologies.

For these comparisons, it was assumed that one would need to monitor aircraft movements at 50 different sites during a 168 hour period (1 week). Factors considered in the comparisons were costs for development of counting procedures, capital equipment costs, travel costs for moving equipment and personnel, labor costs for operation of the equipment, and overhead costs. Certain assumptions were made about labor, development, and travel costs that influence the results. Hence the cost comparisons are approximate.

Visual observations of aircraft by technicians is the simplest detection technology. However, this requires scheduling technicians to obtain complete 24-hour surveillance over a few days. During sunny and moderate weather, this is not a problem. However, this is an undesirable job during bad weather, extreme heat, and late in the evening. Furthermore, this requires paying travel costs to lodge technicians in nearby hotels. For visual observations it is assumed the crew visits 50 sites. It is assumed the travel is 100 miles to the site. The expenses are 100 miles of travel at \$0.25 per mile per person, plus 7 nights lodging at \$40 per night per person, and 7 days of meals at \$21 per day per person. The labor costs for each crew member is 40 hours per week at \$6 per hour for 52 weeks per year.

For the counter systems, we assume a one-person installation crew and two round trips to a site 100 miles away (50 weeks at 4 trips per week at 100 miles per trip at \$.25 per mile). Assuming one day for installation and one day for removal of the system, the labor costs are (50 weeks at 8 hours per day at \$6 per hour for 2 days plus 160 hours of trouble shooting installation

sites at \$6 per hour). The equipment costs for pneumatic tubes is estimated at \$1,000 with a life time of five years. The equipment costs for an acoustic counter is estimated at \$6,000 with a life time of five years. The next issue involves systems that require development. In this case the development costs must be considered. This might be required for acoustic or other systems that require additional development work. In this calculation, it is estimated that \$60,000 is required for development costs. We assume that 10 systems are acquired with a life time to five years. The development costs are prorated and are reduced when the number of units acquired is large. The cost of the units is estimated at \$10,000 with a life time of five years. The comparisons are shown in Table 1. One can observe from Table 1 that the technology based systems can be competitive on costs. Even if some development costs are involved, the costs can be mitigated if a number of units are acquired. For this reason it is advisable to have a vendor involved with any development.

Table 1. Cost of Different Technologies

	<i>Human Observers</i>	<i>Pneumatic Tubes</i>	<i>Acoustic Counter</i>	<i>Enhanced System</i>
Equipment Development Costs	\$0	\$0	\$0	\$600
Equipment Costs/Annual	\$0	\$200	\$1,200	\$2,000
Travel & Mobilization				
1 Person Crew	\$22,600	\$2,500	\$2,500	\$2,500
Labor Cost	\$12,480	\$5,760	\$5,760	\$5,760
Fringe (20 percent of Labor)	\$2,496	\$1,152	\$1,152	\$1,152
Sub Total	\$37,576	\$9,612	\$10,612	\$12,012
Overhead (0.4)	\$15,030	\$3,845	\$4,245	\$4,805
Total Annual Cost	\$52,606	\$13,457	\$14,857	\$16,817
Cost/Site	\$1,052	\$269	\$297	\$337

We decided to study the development of an aircraft monitoring system based upon acoustic technology. This decision was based upon our review of the technologies, a cost analysis of the different technologies, the feasibility and cost of implementation of a portable unit, and the compatibility of the technology with normal airport operations. Acoustic technology exists to operate at airports in a counting mode. This study was conducted to consider the issue of expanding the technology to include the classification capability. The study was needed in order to determine algorithms for classifying aircraft operations and to determine any problem areas in the development and deployment of a system.

AIRCRAFT OPERATIONS DATABASE FORMATION

In order to develop algorithms and evaluate the system for characterizing aircraft operations, a database of aircraft operations was created. The information contained in the database consists of airport information, runway information, acoustic records, photographic records, a description of the event (takeoff, landing) and aircraft type, and environmental information.

The equipment used in the field for recording aircraft acoustic signals, aircraft information, and the type of aircraft operation consisted of a digital camera, sound recording equipment, and a form to manually enter information related to the aircraft operation. The Kodak digital camera was used for a photographic record of the aircraft operation. Acoustic equipment was used to record the sound records of the aircraft operations. This equipment consisted of a Larson Davis Model 712 Sound Level Meter, Electro-Voice RE55 Microphones, and a Sony TCD-D8 DAT Walkman. The data were collected at 44.1kHz on the DAT tapes. We processed the data at 22.05 kHz since this proved sufficient for this application.

FEATURE EXTRACTION

Sound data are often processed in the root mean square of the sound signal pressure $p(t)$. The form is $p_{rms} = \sqrt{\frac{1}{T_2 - T_1} \int_{T_1}^{T_2} p^2(t) dt}$. The units are Pascals. The interval over which p_{rms} is computed is a function of the sample rate of the sound power meter. The term L_p refers to the logarithmic form $L_p = 20 \log_{10} \left(\frac{p}{p_o} \right)$ with units of dB or decibels. This is the sound pressure level (SPL). The quantity p_o is 20 micro Pascals, μPa , which is the perception threshold at 1000Hz (Couvreur, 1997; Crocker, (1998). The sound pressure level L_p varies too fast for interpretation and often generates too much data for storage. An averaging is performed over some interval to reduce the amount of data. The equivalent continuous sound level over a specified time interval is the equivalent steady level that would have the same RMS value over that time interval (Couvreur, 1997). It is defined as

$$L_{eq} = 20 \log_{10} \left(\frac{p_{rms}}{p_o} \right)$$

Because of the sensitivity of the human ear, often frequency weighting is used. The most common weightings are A-frequency weighting, C-frequency weighting, and LIN-frequency weighting. LIN-weighting is

no weighting (Couvreur, 1997). A-weighting is widely used because it correlates with the human response to sound. It is intended to simulate a human ear at 40 phons. Sound level meters, SLM, sound exposure meters, and noise dosimeters use A frequency weighting to measure the effects of noise on humans. It is widely used to measure community noise. B frequency weighting is meant to simulate the human ear at 70 phons. It is not widely used. The C frequency weighted filter is meant to simulate the human ear at 100 phons. It is flat over most of the audible frequencies. It is down 3dB at 31.6 Hz and 8000Hz. It is often used to measure the acoustic emissions of machinery.

Sound level meters equipped with filters are called spectrum analyzers. Often data are collected in octave filters or one-third octave filters. An octave band pass filter is a filter such that the upper cutoff frequency is twice the lower cutoff frequency. An octave is a doubling of frequency. This filter can be subdivided into one-third octave filters with 3 bands per octave.

In the application of aircraft counting and classification, we are interested in identifying aircraft from one-dimensional (1-D) sound signals. This problem may be stated as an object identification problem where the objects are the different types of aircraft. An audio sensor can generate a significant amount of data in a few seconds. Hence, it is important to extract features from the sound signal. An important step in object identification is to obtain information suitable for modeling the object to the automated recognition system. This process of reducing the amount of data while retaining the ability to recognize the object is called feature extraction. The features are represented as vectors. Figures 1 and 2 show the sound signals obtained from a jet and a multi-engine propeller powered aircraft, respectively.

The L_{eq} acoustic signal has a characteristic shape that is reflective of the different types of aircraft events. The L_{eq} signal can be processed to reduce the number of measurements and extract features useful for classification, see Figure 3. One measurement of relevance is the “maximum” value. Some sound events such as jet aircraft are loud. Single engine propeller aircraft landing are very quiet. Other measures can be related to the shape of the curves. A fast aircraft such as a jet will have a curve that is steeper as the plane approaches as compared to a propeller aircraft. Other measurements extracted are “skewness” which measures the skewness of the curve and “symmetry” that measures the symmetry of the curve about the maximum value, see Figure 3.

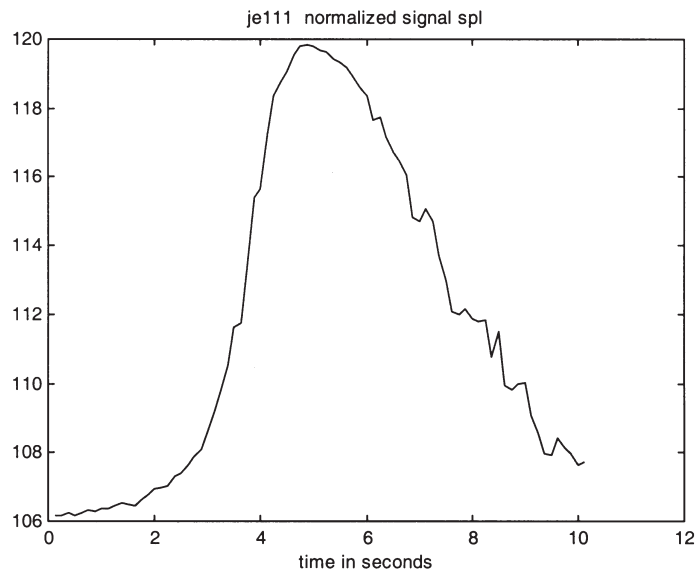


Figure 1. Sound Signal for Jet Aircraft Takeoff

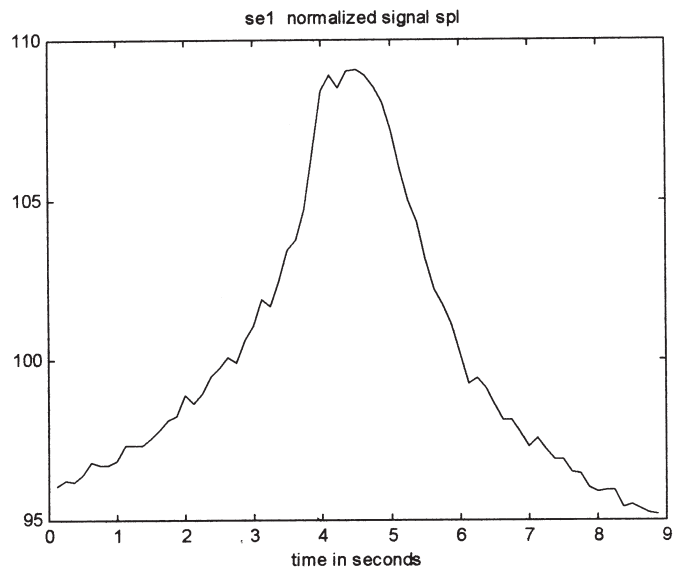


Figure 2. Sound Signal for Single Engine Aircraft Takeoff

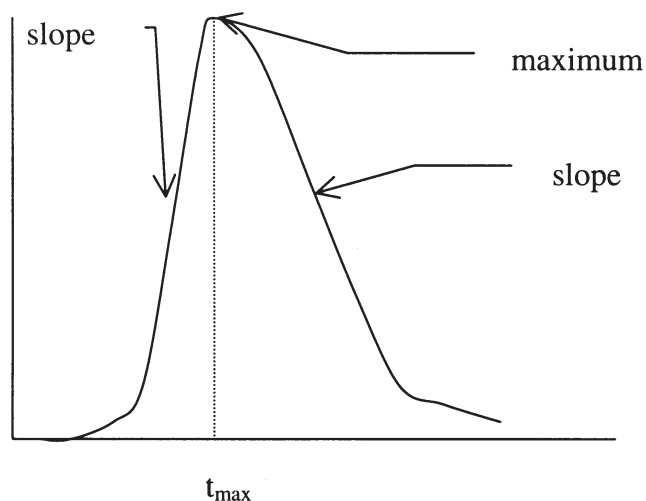


Figure 3. Measurements form Time Domain

One would expect frequency measures to reflect differences in the aircraft. These are readily obtained from portable spectral analyzers that can operate in the field for several weeks. The measures we considered are one-third-octave frequency measures since they are readily collected with spectral analyzers. We used sound data at a sampling rate of 22,050 Hz. This implies that we can estimate frequencies up to $22,050/2$ Hz without aliasing. For this reason, we limited our frequencies to 8,000 Hz. Therefore, 27 frequency measures are taken up to 8,000 Hz. We extracted these measures for the aircraft as it approached and departed the acoustic sensor. The speed of the aircraft is reflected in the shift of the frequencies. It should be noted that the frequency discrimination of the one-third-octave filters is not sufficient to obtain an accurate measure of the Doppler shift.

CLASSIFICATION

Let us now consider signal classification which is the process of identifying the object associated with a given input signal. Once the features have been extracted as described in the last section, we will have an n -dimensional feature vector that is the input to a classifier. Neural networks were selected for the classifier.

Artificial neural networks (ANN) can be grouped into simple-layer and multiple-layer nets (Fausett, 1994). There are two types of training—supervised and unsupervised training for a network. Supervised

training is accomplished by presenting a sequence of training vectors, or patterns, with associated target output vectors. Then, the weights are adjusted according to its learning algorithm. Backpropagation nets require supervised training. ANNs are “trained,” meaning they used previous examples to establish the relationships between the input variables and the output variables. Once an ANN is trained, the neural network can be presented with new input variables and it will generate the output classification.

A multi-layer feed-forward neural network was chosen as the classifier. It is very important to define the network’s structure properly. In our case, there are three layers in the neural network—an input layer, a hidden layer, and an output layer. It is sufficient to have one hidden layer because it reduces the complexity of the network. The number of input neurons depends on the number of features used in classification. Because 35 features have been extracted from the aircraft sound record, 35 input neurons are needed. The number of output neurons depends on the number of classes of the aircraft being separated. Four output neurons will be needed because four kinds of aircraft (helicopter, jet, multi-engine and single engine) are needed to be distinguished. Each output neuron represent two states—0 or 1. When it is active, the value is 1, so the aircraft belongs to that class. The number of hidden neurons is crucial for a network’s performance. If more hidden neurons are used, one gets a higher training accuracy, but a lower testing accuracy. After several repeated training and testing, we found that the performance is best for a network with a hidden layer with 8 neurons (Harlow, 1999). This configuration was used with the time domain and frequency measures of the approaching aircraft.

We had a total of 105 takeoff events for jets, multi-engine, and single engine planes and helicopters. We used all of the available helicopter data even though they were not all takeoff events. Helicopters will fly in different paths to their landing area depending upon the traffic. They do not follow runways and will in general take a path that keeps them near the runway a short amount of time. One must be located near their landing area to obtain a good takeoff or landing signal. We used 12 of the samples for testing and the rest for training. The training results were 99 percent correct classification. The accuracy of testing was 100 percent classification accuracy. These results are given in Tables 2 and 3.

We conducted one final study. This study included 48 sound events that were not aircraft events. Various background sound events such as tractors, car, trucks, construction sounds, or natural sounds like thunder may occur at airports. We collected 48 sound events of vehicles such as cars and trucks

Table 2. Training Results

	<i>Helicopter</i>	<i>Jet</i>	<i>Multi-engine</i>	<i>Single engine</i>
Helicopter	13	0	0	0
Jet	0	11	0	0
Multi-engine	0	1	21	0
Single engine	0	0	0	47

Table 3. Testing Results

	<i>Helicopter</i>	<i>Jet</i>	<i>Multi-engine</i>	<i>Single engine</i>
Helicopter	2	0	0	0
Jet	0	2	0	0
Multi-engine	0	0	3	0
Single engine	0	0	0	5

for this study. We also implemented a binary tree classification method with a neural network classifier at each node of the tree. The tree classification system is shown in Figure 4. We used 153 sound samples consisting of 105 aircraft data and 48 vehicle events. Of these 133 samples were used for training and 20 samples were used for testing. The training results of correct classification were 100 percent. The testing results were also 100 percent. The results are given in Tables 4 and 5.

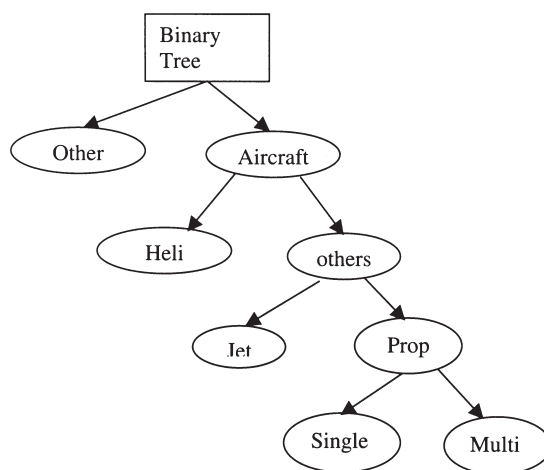
**Figure 4. Binary Tree Classification**

Table 4. Training Results

	<i>Non aircraft</i>	<i>Aircraft</i>
Traffic	41	0
Helicopter	0	13
Jets	0	11
Multi-engine	0	22
Single engine	0	46

Table 5. Testing Results

	<i>Non aircraft</i>	<i>Aircraft</i>
Traffic	7	0
Helicopter	0	2
Jets	0	2
Multi-engine	0	3
Single engine	0	6

The choice of features is an important problem in the development of a classification system (Fukunaga, 1990). More features may allow one to perform better classification, but the feature set often contains redundant features. It is best to keep only the most effective features and remove the redundant features. A reduction in the number of features results in reduced complexity and computation time for the classifier. With a limited number of training samples one may also get better classification rates with a smaller number of features (Fukunaga, 1990).

We did some experiments to determine the most effective measures. We extracted the time domain measures and also frequency measures as the object approached and departed the acoustic sensor. For the aircraft vs. non-aircraft experiment nine measures were found to be significant. Five of these measures were frequency measures of the approaching object and four were frequency measures of the departing aircraft. In the aircraft category of helicopter vs. other aircraft, four measures were found to be significant. These were a time domain measure (the slope of the curve), two frequency measures of the approaching aircraft, and one frequency measure of the departing aircraft. For jet vs. propeller aircraft, the most significant measure was a frequency measure of the approaching aircraft. For multiengine vs. single engine propeller the most significant measures were a time domain measure of slope and two frequency measures of the approaching aircraft. These results indicate that a reasonable subset of the features can be extracted for classification. These results are not conclusive, since additional data would need to be collected under a wide

variety of environmental conditions in order to determine the best measures.

In order to provide for updating the system, a flexible software system has been developed. The system allows one to process, display the raw data, and perform classifications. The software also provides for retraining the classification network as one experiments with the system and new data becomes available. The software is programmed in Matlab (MathWorks, 1998).

DISCUSSION

Our discussion in the “Technologies for Monitoring Aircraft Operations” section indicates that there are issues related to the deployment of the different technologies for monitoring aircraft operations. Acoustic technology was determined to be the best developed and the most feasible technology upon which to develop an aircraft operations monitoring system. This study considered the development of a classification system to determine the type of aircraft involved in aircraft operations.

The results of the classification studies indicate that automatic classification of aircraft takeoffs can be accomplished at acceptable rates. Operations such as landings that are quiet events may not be detected. Also, the monitors will have to be located near runways with aircraft operations. If there are several runways or operations are occurring on the runway far from the sensor, then the acoustic signal may be very weak at the sensor. Several sensors may be needed to cover all the areas of operation. For smaller airports, this should not be a problem. Since the automatic classification of aircraft operations will not cover the operations at every airport all the time, the automatic counts will need to be augmented with statistical models as discussed in the “Background” section.

These results demonstrate the feasibility of developing an automated aircraft operations monitor. Current hardware exists for portable operation that will record the time and spectral information required for classification. The system needs further testing with data collected under varying environment conditions. It is difficult to obtain data under adverse weather conditions due to the risk to personnel near runways under adverse conditions. The next stage in the work would be to place an automated data collection system in the field to collect data under adverse conditions. In addition, studies need to be conducted on the best manner to incorporate automatic aircraft operations counters with statistical and ancillary information in order to obtain the best estimate of aircraft operations.

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THE AIR TRANSPORTATION POLICY OF SMALL STATES: MEETING THE CHALLENGES OF GLOBALIZATION

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ABSTRACT

The air transport policies of small states are currently at a crossroad. Policy makers in these countries are facing a difficult dilemma: either follow the general trend of liberalization and pay the high cost of the resulting restructuring or maintain the existing regulatory and ownership structures at the risk of isolation thus undermining the viability and sustainability of their air transport sector and their economies in general. This paper proposes to explore the broad issues raised by this difficult dilemma, to outline its special significance in the context of small states and to delineate the options opened to the economic policymakers in these states. After a brief note on the method of research, we sketch the main elements of the international air transport industry in which the airlines of small states are called upon to act. We then propose to review the main features of the analytical framework of this debate as it pertains to the special circumstances of these states. Then we focus on the challenges facing the airlines of Small States, while the next section proposes a number of the alternative policy options open to the policy makers in these states. The main conclusions are drawn in the final section.

INTRODUCTION

Small states¹ are especially vulnerable to exogenous shocks and are facing the increasingly difficult task in meeting the challenges of globalization. The international community has long recognized this fact and several multilateral institutions and donor countries have taken a number of initiatives to assist these states to overcome this handicap. The economies of these states are often dependent on a single industry that is often their main, and sometimes the only, source of foreign currency.

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Furthermore, because most of these small states are geographically isolated from their main trading partners, air transport is often the main link to the outside world both for the transport of passengers and freight.

At the same time, many states have embarked on a major effort to overhaul and liberalize their air transportation markets. Some countries, inspired by the relative success of similar policy changes in other countries such as the U.S. and the EU, have done so willingly, although not without painful sacrifices, while others maintained a (healthy) dose of scepticism and thus remain reluctant to move in the same direction. Small states are no exception, and their air transport policies are currently at a crossroad. Policy makers in these countries are facing a difficult dilemma: either follow the general trend of liberalization and pay the high cost of the resulting restructuring, or maintain the existing regulatory and ownership structures at the risk of isolation thus undermining the viability and sustainability of their air transport sector and their economies in general.

This paper proposes to explore the broad issues raised by this difficult dilemma, to outline its special significance in the context of small states and to delineate the options opened to the economic policymakers in these states. The research method adopted in this study, is primarily desk research, laced however with healthy dose of the author's access to, hitherto, unpublished primary information and informal private interviews. The next section outlines the main elements of the international air transport industry in which the airlines of small states are called upon to act. The main features of the analytical framework of this debate follow this section as it pertains to the special circumstances of these states and the challenges facing the airlines of small states. Based on these findings, alternative policy options and recommendations open to the policymakers in these states are discussed. Finally, the main conclusions are drawn.

A NOTE ON THE RESEARCH METHOD

This is a policy-oriented paper, rather than a theoretical or an empirical work, and as such its main objective is to evaluate the policy options confronting the aviation industries of small states, within the existing institutional framework, based on well-grounded economic principles. The main source of information regarding the institutional environment and the relevant analytical framework was desk research on the various key aspects of this, otherwise convoluted, subject involving several international agencies and different strands of literatures. However, as member of the Advisory Board to the Commonwealth/World Bank Joint Task Force (CSWB Task Force) on Small States for several years, the author was able to participate in several, panel discussions, study groups and seminars, as

well as have access to numerous published and unpublished original research material, involving several aspects of the economies of small states. In addition, as a discussant and commentator on several of the papers that were considered and/or commissioned by the CSWB Task Force, he conducted several informal interviews with key policymakers and had the opportunity to acquire first-hand experience on some of major globalization challenges facing small states. In fact, it is in the context of these activities that it became clear to this author that the formulation of a coherent air transportation policy, enabling small states to meet the challenges of globalization, has to become a major priority for them and a subject in dire need for additional original theoretical and empirical research.

SMALL STATES AND THE INTERNATIONAL AIR TRANSPORT INDUSTRY

In addressing the issue of the air transport policy of small states one is faced with a multifaceted reality covering a wide breadth of issues. These range from the sector-specific regulatory framework facing decision-makers, namely the system of multilateral agreements established within the context of ICAO (1992, 1993) and the various bilateral agreements currently in effect, as well as the wider nexus of regional and multilateral trade, economic and political relations. Clearly, therefore, anyone attempting to pinpoint and isolate the salient elements of this framework is facing a daunting and a somewhat arbitrary task heavily tainted by the idiosyncrasies of the analyst. It is, nevertheless, possible to identify the prominent global trends that are currently shaping the industry, and are likely to do so in the foreseeable future.²

During the last few years, the Commonwealth Secretariat and the World Bank (WB) undertook a sustained and concerted effort in recognizing and addressing the developmental needs of small states. As more Multilaterals and other International Financial Institutions (IFIs) are drawn into this process, new economic challenges and opportunities will become available for these states. Nevertheless, given the dominance of the U.S. economy on the world stage and the increasingly aggressive stance adopted by the EU in international economic affairs, it is safe to assume that developments in the international air transport field will, to a great extent, be determined by the policies of these two economic superpowers. In addition, and notwithstanding the demises of the Seattle meeting, the World Trade Organization (WTO) is bound to increasingly become the main forum in which nations will be attempting to sketch the broad institutional

framework that will shape future trade relations in general, and trade in air services in particular.

Small States: Meeting the Challenges in the Global Economy³

In 1985 the Commonwealth Secretariat (ComSec) published a groundbreaking report on the Vulnerability of Small States in a Global Economy (ComSec, 1985). Since then, ComSec has carried out a sustained advocacy and research effort addressing the special characteristics of these states which culminated in 1998 with the establishment of Commonwealth Secretariat/World Bank (CSWB) Joint Task Force.

For the purposes of the CSWB Joint Task Force, small states are the 44 developing countries with a population below 1.5 million people. Thirty-three of these countries belong to the Caribbean region, East Asia and Pacific and Africa while the remaining two are in South Asia, two in the Middle East and three in Europe (ComSec, 1985, 1997). Note that although there is some overlap, this is not the same group of 33 countries that are included in the United Nations' Conference on Trade and Development (UNCTAD) study on Small Island Development States (SIDS) (United Nations, 1994). Also note that although their population is over the 1.5 million threshold, for the purposes of the Task Force, Jamaica, Lesotho, Namibia and Papua New Guinea are included among the Commonwealth Small States "because they share many of the characteristics of smallness" (1985, p. 4). These characteristics, chosen for their important implications for development are: remoteness and insularity, income volatility, susceptibility to natural disasters, limited institutional capacity, limited diversification, openness, access to external markets, and poverty.

At the beginning the purpose of the CSWB Joint Task Force was to "assess the case for special treatment advanced by the Commonwealth small states at the Edinburgh Heads of Government Meeting and enable the [World] Bank to examine its instruments for assisting these countries..." (p. 1). After a series of consultations, conferences and the publication of an Interim Report, the agenda was widened and number of multinational institutions (i.e. the EU, the WTO, the International Monetary Fund, the United Nations, the United Nations' Development Program, and major regional development banks) and major donor countries were asked to submit frameworks.

The final report defines a measure of vulnerability and identifies the economic implications of small size and the emerging challenges. In addition, it addresses the policies, challenges and opportunities that these countries are likely to face in the immediate future. These include, inter alia, ways of tackling volatility, and mitigating vulnerability and natural disasters—such as catastrophe insurance and commodity risk management,

issues of transition to the changing global trade regime—such as the erosion of trade preferences, strengthening capacity and external assistance, and the new opportunities from globalisation—like international financial services, information technology and e-commerce.

The Task Force concluded that addressing these challenges successfully will take a combination of the following: correct domestic policy action; in some cases new approaches to regional co-operation; continued external support and assistance multilateral and bilateral development institutions; and improvements, where achievable, in the external environment (ComSec 2000, p. 3).

Although the Report does not make specific reference to international air transport as such, it is nevertheless clear to us that the issues tackled therein, and many of its recommendations as set out above, have immediate and direct relevance on this specific sector. In particular, we argue in this paper that the challenges that the airlines of small states currently face must be addressed in the framework outlined this Report and in particular as a combination of the “right” domestic air transport policy, coupled with new approaches to region co-operation in aviation policy.

International Air Transport Policy in the U.S. and the EU

The U.S. “Open Skies” Policy

The U.S. has traditionally advocated an “Open Skies Regime” in its negotiations with other countries, although with limited success. For Toh (1998), the decisive impetus came at the end of 1978 when the U.S. Congress adopted the Airline Deregulation Act and in 1979 with the passage of the International Air Transportation Competition Act. As a result, U.S. negotiators endeavoured to “trade competitive opportunities” in their bilateral negotiations, a strategy that best describes the policy stance that ensued. Indeed, Toh (1998) argues that the aim of this policy was

...to ensure that mutual concessions were to be of a liberalizing nature. It was expected that increased open competition will result in greater consumer benefits through increased travel options and reduced fares and rates, improved airline efficiencies through more extensive and rational routes structures, and general increase in economic welfare (pp. 62–3).

The repercussions of this policy were the negotiation of a series of “liberal” bilateral agreements between the U.S. and several Far Eastern countries, as well as with a number of “key” European partners. By and large, these agreements gave the U.S. airlines significantly greater pricing freedoms, enhanced market access through multiple carrier designation, unlimited freedom to set capacity and a curtailment of (host) government regulations. Several major European countries and Japan were, at first,

reluctant to follow the U.S. on its “Open Skies” policy, fearing the domination of their markets by U.S. carriers.

In fact, the choice of “consenting” partners was dictated by three key considerations. Contrary to large countries, small states generate relatively little third and fourth freedom traffic thus standing to gain more from greater access to the lucrative U.S. market and, through fifth freedom traffic, beyond. This prospect made them more willing to trade “competitive opportunities” with the U.S. Furthermore, there were also strategic considerations in the choice of these partners. McMillan (1989) argues that, from a game-theoretic perspective, in trade negotiations the bargaining power of a country is directly proportional to the concessions it is willing to exchange.⁴ In this context, it is clear that small (underdeveloped) states individually are “ideal” trading partners, with virtually zero bargaining power vis-à-vis the U.S.⁵ Furthermore, partners were also chosen on the basis of the stated “encirclement strategy”. Indeed, U.S. policymakers (correctly) anticipated⁶ that by signing a series of liberal bilateral agreements with minor alternative European and Far Eastern gateways, will bring pressure to bare on major competing partners (such as France, Italy, Britain and Japan), by diverting traffic to these alternative cheaper destinations.⁷

It is well documented and thus legitimate to argue that the world aviation industry has undergone major changes since the adoption of the “open skies” policy. These changes include, inter alia, the decline in IATA’s cartel-like tariff-setting ability,⁸ the gradual emergence of mega-carriers through airline consolidation, the proliferation of strategic alliances between major carriers, the drive towards privatization of national carriers and the deregulation of national markets. However, notwithstanding the declared pro-competitive aim of this policy, Abeyratne (1998) argues that

...it cannot be claimed incontrovertibly that an open skies policy...is not totally lacking in overprotectiveness. Most nations [including the U.S.] still give usually high priority to the marketing policies of their airlines, which are naturally geared to world protectionism and exploitation (p. 40).

In fact the author offers evidence suggesting that several developing countries view with certain suspicion this policy, considering the great reluctance by the U.S. (and other developed countries) to open-up their own domestic markets to market forces.⁹

In addition, according to Wassenbergh (1996), quoted by Abeyratne (1998), it would seem that the very concept of “open skies” is itself not unambiguous and appears to have evolved in the framework of successive bilateral agreements. Whereas it was first understood that a necessary and sufficient condition for its implementation was that the carriers of both signatories had a fair and equal opportunity to operate, it was later “re-

interpreted to mean *fair and equal opportunity to compete* and later still, *fair and equal opportunity to effectively participate* in the international air transportation as agreed.” (Abeyratne, 1998, p. 41). Although the “open skies” policy “a la U.S.” still faces major obstacles and strong opposition in many countries (Toh, 1998, pp. 64–66), there is no doubt that it has been the decisive factor in the general drive towards enhanced competition and greater efficiency in international air transportation and, as a result, “protectionism in commercial aviation should give way to some degree of liberalization in the least” (Abeyratne, 1998, p. 40).

The EU Common Air Transport Policy

The need for a Common Transport Policy is explicitly acknowledged in the Treaty of Rome (1958) as being an integral part in the construction of a Common European Market. But, the efforts for the definition of a Common European air transport policy began only in 1975 with the publication of a relevant European Commission (EC) Recommendation, followed by a 1979 EC Memorandum on bilateral agreements and state subsidies. Nevertheless, for Morrell (1998), and many other informed observers, it was the landmark 1984 “Nouvelles Frontieres” European Court of Justice (ECJ) ruling and the adoption of a Single European Act that were the decisive steps towards the formulation of a Community-wide aviation policy.

However, contrary to the U.S. one-shot-total-liberalization approach, the European model called for a gradual and protracted process going through successive packages/stages, spanning from 1988 to 1997 (Stasinopoulos 1992, 1993). The first two packages called for gradual “loosening” of intra-European bilaterals, while

...the third package of 1992 for the first time replaced the bilateral system with a multilateral system of air transport regulation. It established common rules for the award of an air operator’s certificate, open access to air transport routes within the Community, and the freedom to set airfares and rates according to commercial criteria. These rules moved away from the requirement of national ownership and control by creating the concept of a Community air carrier...open[ed] up traffic rights on all intra-Community air carriers (with full cabotage from 1997), with few exceptions, and remove[d] capacity restrictions (Morrell, 1998, p. 46).

In order to mitigate and anticipate some of the negative effects that U.S. deregulation has had on U.S. consumers, the EU decided to also include consumer protection in its Common Air Transport policy. For the EU Commissioner for Energy and Transport Ms. Loyola de Palacio the development of a “Passenger’s Charter,” “would establish in the clearest possible terms a set of consumer rights” (European Commission, 2000,

p.3). The Charter will be addressing issues "...such as the contractual rights of passengers, tariffs, comfort and health...financial protection of the passengers in case of air carrier bankruptcy, air carriers' commercial practices like code sharing and frequent flyer programmes and information to the passenger" (pp. 4–5).

In assessing the impact of these liberalization measures on EU consumers, Morrell (1998) argues that although several significant barriers remain—including administrative, infrastructure capacity constraints, imperfect input markets, economies of scale and lack of access to adequate finance—between 1992 and 1994, EU travellers benefited "...from air fares [that] were on average a little more than ten percent below the levels that they would have been without liberalization" (p. 59). Furthermore, Alamdari (1998) concludes that these measures also had beneficial effects on the labour productivity of EU carriers and that

...in the period 1991 to 1995, unit labour costs fell by approximately 38 percent as a result of the fast growth in productivity. In the same period, wages only increased 15 percent on real terms. It appears that the airlines were paying their staff only slightly more for proportionately greater productivity. This is possible because an increase in outsourcing has a tendency to increase the average unit labor cost by reducing the number of lower paid employees while boosting productivity (p. 82).

Air Transport Services Trade and the GATS

The Services Trade debate

Trade in aviation services is a prime example of services trade¹⁰ and as such were at the centre of the efforts to liberalise trade at a multilateral level during the early 1980s. The discussion on commercial policy in services trade has centred on the antagonism between the developed countries, under the leadership of the U.S., and the developing countries guided by India and Brazil. The controversy was sparked by the reluctance of developing countries to include services in the multilateral trade framework. This unwillingness was primarily motivated by two sets of concerns: economic and non-economic reasons. On economic grounds, developing countries believed, as argued by Bhagwati (1985), that industrial countries enjoy a clear comparative advantage in services and any liberalization would therefore compromise their own export in services. A number of countries suspected that the new focus on services was used by the U.S. to distract attention from the main issue at hand, namely the trade in goods for which they enjoy a comparative advantage, especially in labour-intensive goods. Sapir (1985) and Hindley (1988) argue that although both concerns had some empirical support, developing countries could also benefit from cheaper imports of services, especially

when they are used as intermediary inputs. However, there are other more profound economic reasons behind the stance adopted by many countries during these negotiations. National governments, especially in developing countries, will engage in the process of liberalization of international services trade only if this will be a net benefit for the development of their respective economies. Indeed, Sampson (1989) observes that the contribution of imported services to economic development is not merely limited to them being imported factors of production or consumption. Imported services could contribute significantly to the international competitiveness of an economy, the efficiency of domestic production, domestic relative prices, and the structure of production and the allocation of domestic resources.

Furthermore, it is a well known that services are prone to regulation for non-economic reasons. In particular, the liberalization of the trade in services often implies the substitution of internationally uncompetitive domestic services activities with services supplied by foreign producers. Thus trade in services often implies the importation not only of the service as such, but also of foreign labour and capital which could be contrary to national provisions. In addition, given that services include some of the most politically, militarily and culturally sensitive (infrastructure) activities, governments are often reluctant to surrender their provision and control to foreigners.

We note here that both these sets of arguments were particularly relevant to small states because they are especially sensitive to matters pertaining to their national sovereignty and economic independence. In fact one can argue that debate surrounding services trade epitomises many of the grievances of small states with respect to the emerging trading regime in a globalized economy (ComSec, 2000).

The eventual inclusion of services in, what is now commonly referred to as the Uruguay Round of GATT negotiations in Punta del Este was the result of a compromise brokered by the, then, European Community. The series of negotiations under the Uruguay Round eventually culminated in a framework agreement distinct from that on goods and known as General Agreement for Trade in Services (GATS).

Recall that following Bhagwati (1985) and Sampson and Snape (1985), it is useful and customary to classify the modes of delivery of services on the basis of the required physical proximity between Users and Providers. According to the typology of international transaction in services¹¹ there are four possible modes of delivering services. Mode 1, in GATS parlance **Cross Border Supply**, requires that neither the Users nor the Providers need to move (like in commodity trade). Mode 2, known as **Consumption Abroad**, implies that Users have the freedom to move (either temporarily

or permanently) but Providers do not. In Mode 3, also known as **Commercial Presence**, Users do not move while Providers have the freedom to establish or operate a branch, agency or subsidiary. In Mode 4, called **Presence of Natural Persons**, Users do not move but now Providers may enter and stay temporarily in order to supply the service.

In fact, Sapir and Winter (1994) argue that, as far as GATS is concerned, the most contentious issue has been the interface between these four modes of delivery and the participation of the developing countries. It is in this context that some industrial nations used the application of the principle of the **most-favoured-nation** treatment (MFN)¹² as a bargaining chip against granting freedom of establishment.¹³

Alternatively, some nations proposed a symmetric treatment of labour and capital as far the 'right of establishment' is concerned as a means of overcoming the developing nations' reluctance. Eventually, the GATS framework agreement signed in 1994 established, under Article II, MFN as a general obligation applicable to all measures affecting trade in services. Furthermore, signatory states submitted (schedules) of specific commitments pertaining to **market access**, namely the ability of foreign providers of services to penetrate domestic markets, and **national treatment**, an obligation prohibiting discrimination on the basis of foreign nationality. Although GATS offers only a partial coverage of air transport services,¹⁴ it is the only sector amongst the limited number of sectoral annexes to the Agreement where an explicit "positive list" of services covered is provided. These services are (a) aircraft repair and maintenance services, also known as maintenance, repair, and overhaul (MRO); (b) computer reservation system (CRS) services; (c) the selling and marketing of air transport services.

The GATS Annex on Air Transport Services

A recent WTO (1998) study looks at the trade in Air Transport in Services in the context of GATS. It notices that paragraph 2 of the Annex excludes the granting of traffic rights from GATS as well as the services directly related to the exercise of these rights. However, the above three services contained in paragraph 3 are excepted from the exclusion and are therefore covered under GATS. Furthermore, the study notices that while the above three services are the only services 'directly related to the exercise of traffic rights' that are covered, the wording of the Annex implies that those services that are not directly related to the exercise are also covered.

Looking at these sectors separately, starting with MRO, the study observes that recent estimates (based on 1996 data), value this market at

between U.S.\$23 and 28.5 billion, forecasted to reach by 2005 U.S.\$33 (WTO, 1998, pp. 2–3). Furthermore, it is customary to sub-divide MRO into different segments: upkeep of engines, representing 30 percent of turnover, heavy maintenance of airframes (27 percent), line maintenance (22 percent, not covered under GATS), and upkeep of components (21 percent).¹⁵ There are also different types of operators active in these markets, such as, airlines working on own account (“airline captives”), airlines working on behalf of other carriers (“airline third party”), after sales services by original equipment manufacturers (OEM). The WTO study notes that in recent years, there is a growing trend for joint ventures between these types of operators. Clearly though, the key issue as far as regulation is concerned is flight safety and quality. At the multilateral level, standards and regulations are determined within the framework of ICAO (1994, pp. 31-34), while national authorities and bilateral agreements may also have a significant impact on air safety.

Clearly the delivery of MRO’s fall under either Mode 2 or Mode 3 and are, respectively, determined by the freedom of consumption overseas and of establishment of foreign maintenance facilities in third markets. Referring to Table 1 in the Annex of the study (compiled by ICAO, not included here), the WTO notices that all except one WTO Members have MFN obligations on air maintenance and that there was, between 1995 and 1998, a “general increase in the number of new facilities established” (WTO, 1998, p. 4). It also notices however, that “this is more likely to result from market growth than from the effects of GATS, but...that six of the 13 newly created facilities have been in countries with GATS commitments in this sector” (p. 4). In the case of small states however, a slightly different picture seem to emerge. It would seem that, as far as MRO are concerned, for the period 1995–1998, these states have not benefited from GATS since none has had or has acquired any new repair and maintenance facilities.

Turning to the computer reservation system (CRS) services, GATS defines them “as services provided by computerized systems that contain information about carriers’ schedules, availability, fares and fare rules, for which reservations can be made or tickets may be issued” (WTO, 1998, p. 4). In the classic pattern of CRS operations, customers do not have direct access to the information provided by the CRS supplier.¹⁶ They use the services of an agent who acts as a broker between the customer, and the airline and CRS provider. Because CRS providers started as subsidiaries of major airlines, this segment of the market (with an estimated annual turnover of U.S.\$4 billion) is highly concentrated, with growth estimated up to 2015 varying between 3.6 percent to 5.5 percent annually. For the classic pattern, the main concern from the regulatory point of view was the danger of collusion between the CRS supplier and a specific carrier and the

need to ensure a non-discriminatory treatment of the all airlines in the system. This objective was by-and-large achieved through the adoption by the major aviation powers, the U.S. and EU authorities, of Codes of Good Conduct instituting on a neutral *quid pro quo* system. This amounted to reciprocity-based treatment, which of course were subject to MFN exceptions, also accompanied by the establishment of major suppliers. In fact the WTO study notices that in terms of the GATS mode of supply introduced earlier, trade in CRS services are essentially carried under Mode 3, namely through the establishment in each country of National Marketing Companies (NMC) with which the local airline or travel agents are associated. In some cases NMC are used as spring boards for export in neighbouring countries, which means that CRS services can also be supplied under Modes 1 or 2 or even mode 4. Looking at the effect that the existence of commitments has had on the export of CRS services, the study concludes that, "there seems to be no correlation between the development of the number of suppliers and the existence of commitments"(WTO, 1998, p. 11). Again focusing on small states it can be inferred from the same table, that, by and large, they benefited from the arrival of new suppliers of CRS services as a result of commitments.

Finally, in the case of sale of Marketing and Sales services, the WTO (1998) study notices that while the wording of the Annex restricts the definition of these services to those undertaken by the airline itself...

And does not cover these activities when carried out by CRS and ERSP [i.e. Electronic Reservation Service Providers] suppliers and travel agents...the Annex definition says nothing about those to whom sales are made. Potentially, therefore, it covers not only direct sales to private or business clients but also block sales of seats to travel agencies and tour operators (notably in the charter market (p. 12).

It estimates that the tickets sold directly by airlines on regular flights is about 20 to 30 percent of all tickets sold and represented in 1995 a figure of up to U.S.\$40 billion (twice the size of the MRO market and ten times that of the CRS services), about 16 percent of their operational expenses (figure that includes commissions).

THE ANALYTICAL FRAMEWORK FOR AN AIR TRANSPORT POLICY FOR SMALL STATES

There are two main strands of literature that have a direct bearing on the issues raised in this paper. To start with, airlines are a prime example of network-based business, others include banks, telephone companies, railroads, cable television, sewage system, inland water transport, postal and package delivery, oil and gas pipeline. As such these industries share a

number of characteristics that often lead to market failures and thus have attracted the attention of policymakers and business strategists alike. We will highlight some of the public-policy dilemmas and strategic issues that often attach to these industries as they relate to the airline industry. Next, as is convincingly argued in the ComSec Report and is clearly illustrated by the EU Common Aviation Policy, regional integration can be an effective policy to deal with the challenges of globalisation in the air transportation field. However, trade economists are still arguing whether regional trade agreements (RTAs) are, as Bhagwati (1991) put it, “building blocks” or “stumbling blocks” toward multilateral trade liberalisation. We will review the salient points of this debate.

International Aviation as a Network Industry

Broadly speaking, networks comprise links that connect nodes (Economides, 1996; White, 1999). The route system of a typical airline designed on the hub-and-spoke model is a prime example of a “simple-star-two-way network.” This means that all routes go through a central node while any non-central node can be the origin or destination of a trip. As such, route networks of airlines exhibit some special features that are especially relevant to economic policy namely, (positive) technological externalities, and economies of scale/scope, network compatibility and standards. Consider for example an airline with the smallest possible network: one central node C and a single destination A. Here there are only two possible origin-destinations (ODs), namely routes C-A and A-C. However, if we add a second destination, say B, then there potentially four extra ODs to the network: C-B, B-C, A-B, and B-A. Clearly, the addition of an extra destination to an n-dimensional network will create $2n$ new potential destinations thus enhancing the value of the network accordingly.¹⁷ In other words, the addition of a new route linking a new destination to the hub of an existing airline network will add value not only to the passengers between the two cities directly linked, but to all the travelers of the network. Thus, airline networks are a prime example of what economists call positive technological externalities,¹⁸ whereby “an individual’s actions convey uncompensated benefits to others, outside a direct market contact” (White, 1999, p. 14).

Notice that airlines are the kind of network-based businesses for which the value of the network to customers increases not only because there are more users, but also a substantial portion of that value is derived from size of the network per se (Coyne & Dye, 1998). That means that diversity increases the demand for variety and as such adds value to the network. Such externalities are known as consumption or network externalities. In addition, as Economides (1996) points out, the key precondition and main

source for the appearance of this type of externality is the “complementarity” between the pieces of the network. The value of a particular segment of the market increases as more of the other segments are sold. Therefore, there is a positive feedback loop at work here.

Turning our attention to the question of size as such and its effect on production, it is now widely recognised among air transport economists that airlines exhibit significant economies of scale and/or economies of scope and/or economies of density.¹⁹ Broadly speaking, economies of scale exist when the unit cost of production decreases as output increases (Baumol, Panzer & Wellig, 1982). When these economies are confined to particular route or city-pair economists speak of economies of density while if these are a result of adding new product lines or new markets we refer to it as economies of scope. These economies often find their origin in the indivisibility of infrastructures and the presence of excess capacity.²⁰ The prime policy concern here is whether the entire network or parts thereof generate enough traffic to exhaust any economies of scale that may be present. Otherwise the network may not be able to sustain the presence of more than one efficient carrier, thus leading to what is also known as “natural monopoly.”

Furthermore, it is clear that the degree of complementarity, and therefore the efficiency, of networks is enhanced when the links and nodes of different carriers are compatible with each other, namely when they use the same or sufficiently similar technologies and physical apparatus so as to minimise transaction costs. Notice that “compatibility need not be an all-or-nothing phenomenon: close technologies may permit transactions to proceed with some impairment of quality...or at a higher cost.” (White, 1999, p. 10). Of course an obvious way to achieve compatibility of networks is to define a commonly agreed set of standards that ensure technological and physical compatibility. The existence of commonly agreed air navigation standards and practices are of paramount importance for the orderly and safe development of the international civil aviation industry. Hence the pivotal role played by ICAO in developing and promoting International Standards and Recommended Practices (known as SARPs) and Procedures for Air Navigation Services (PANS) as Annexes to the Convention on International Civil Aviation.²¹

The key economic policy concern regarding these features is that, in one way or another, they constitute the root-causes of market imperfection inhibiting free competition, thus becoming the justification of government intervention. Given the dubious track record of governments in the effort of restoring competition, the fundamental policy dilemma raised here is whether the potentially negative effects of the resulting monopolies are sufficiently large to warrant enhanced government intervention.

Accordingly, the presence of market imperfections does not automatically justify government intervention. In the end, the choice between unfettered markets and a continuum of potential government interventions should rest on empirical experience and observation-guided by theory-and cannot be settled by pure theory or ideology alone (White, 1999, p. 14).

For Newbery (1997) though the choice is clear. Regulation of monopolistic (utility) networks has been and still is inherently inefficient. The way to improved efficiency and, eventually, to lower prices is a combination of privatisation and liberalization: "...introducing competition into previously monopolised and regulated network utilities is the key to achieving the full benefits of privatisation. Privatisation is necessary but not sufficient" (p. 358). However, the author cautions that the key problem facing policymakers in their drive towards greater efficiency in network utilities are the form competition to be introduced and the choice of appropriate restructuring.

The form of competition is strongly influenced by technology and initial endowments, and may not be sustainable in every utility, nor in all circumstances. Economists can play a key role in clarifying the determinants of successful liberalisation, and the risk of inappropriate restructuring. Opportunities for restructuring are rare and hard to reverse (p. 358).

Evidently, the airlines of small states have very limited potential for exploiting this kind of network externalities individually. This is because, by definition, their population is small, and therefore their domestic markets are often insignificant and the size of their route networks are very limited.

The presence of (positive) network externalities in conjunction with scale effects has two major implications as far as the airlines of small states are concerned. The direct policy implication of this attribute is that in a free market framework the size of the network will be smaller than what is socially desirable. It is also clear that network externalities also imply that the size of the network is a key factor

In the case of small states, where routes are thinner, networks less dense, and the ability of maintaining adequate technical standards uneven, these market imperfections become even more prominent and pressing. Furthermore the economic policy dilemma identified in the previous paragraph is also exasperated by the limited institutional capacity of these states acting individually. Clearly, if the recommendations of the CSWB Joint Task Force regarding the need for closer regional co-operation and increased bilateral and multilateral assistance were implemented, it would come a long way in alleviating some of these problems.

Commercial Policy: Regionalism vs Multilateralism?

There is an ongoing lively debate among economists on the merits of regionalism versus multilateralism. The key question at the centre of the controversy is whether regional trade integration schemes are “good” or “bad,” in the sense of promoting or inhibiting, the multilateral trading system. This question dates back to 1991, with the publication of two papers, by Bhagwati (1991) and by Krugman (1991). These papers sparked rich and burgeoning theoretical and empirical literature reviewed in a recent survey by Winters (1999). He defines regionalism, “loosely as any policy designed to reduce trade barriers between a subset of countries, regardless of whether these countries are actually contiguous or even close to each other” (p. 8); on the other hand, multilateralism, is a behavioural characteristic of a country relating to two aspects: “(1) the degree to which discrimination is absent—perhaps the proportion of trade partners that receives identical treatment; and (2) the extent to which the country’s trading regime approximates free trade.” (p. 8). Despite the numerous important contributions in this discussion, it would seem that the jury is still out on whether regional trade arrangements are “building blocks” or a “stumbling blocks” toward multilateral trade liberalisation and will remain so for a while yet. In concluding his survey, Winters (1999) notes that “the only categorical statement that can be made...is that one incident of regionalism is not sufficient to undermine a relatively multilateral system immediately” (p. 41).

First we note that although Sapir (1999) concurs with this assessment, he correctly points out that analysts often fail to distinguish between regionalism, as defined above, and regional integration. The latter refers “to a group of countries that wishes to opt for truly deep integration...with dismantled barriers to capital and labour mobility and aiming at common political such as parliament and even uniform foreign policy...,” (p. 51) which is considered to have unambiguously positive effects. McMillan (1993) takes a different more pragmatic approach:

Regardless of what economists think of them, RIAs [regional integration agreements], are here to stay. Regional integration can foster global trade; but it can also impede it. The relevant issue is not whether RIAs are a good thing per se, but how to design international laws that ensure that they are structured so as to avoid harming the global economy...the best test for judging whether a RIA is harmful is the simplest possible: does the agreement result in less trade between member countries and outsider countries? (p. 306).

Furthermore, it should also be noted that the discussion on the merits of the two alternative trade policies has mainly focused on goods trade and that trade services, as such, have remained largely outside the main thrust of this particular debate. Indeed, save some isolated exceptions, the

proliferation of RIA in goods trade in different parts of the world, have not had any counter part in services trade. Up to this point, there is no comprehensive regional trade agreement covering services trade in general between any set countries, except the European Union. In fact, overall services remain still the most heavily regulated economic activity in all parts of the world. Furthermore, even economies that have deregulated large sectors of their domestic services market such as the U.S., the EU, and Canada, governments remain extremely reluctant when it comes to liberalizing trade with others countries. This incredulous attitude can, in great part, be explained by the special nature of services trade, discussed earlier, but also because negotiations involving services tend to be notoriously complex, often involving complicated technical elements, exacerbated by the lack of adequate historical statistical data and reliable background information.

The paucity of RIA in services trade notwithstanding, the international civil aviation industry offers a number of remarkable exceptions. In particular, the successful operation, for several years now, of supra-national regional airlines such as SAS but also Air Afrique, Air Maghreb, Air Mano (Abeyratne, 1998), and the recent emergence of several, so-called, “mega carriers,” would seem to suggest that the potential economic benefits of greater integration could outweigh the difficulties discussed above. Reaping the benefits of international cooperation in the field of civil aviation is also the main driving force behind the emergence and growth of organizations such as ICAO and IATA.

CHALLENGES FACING THE AIRLINES OF SMALL STATES

Small states face several challenges which are either idiosyncratic to these states or although encountered in many developed markets take on a special significance in the context of these states.

Air Transport and Tourism

The fact that many small states are often geographically remote and isolated from major markets, especially in Africa and the Pacific, has significant economic and administrative implications. In particular, long routes coupled with “thin” markets due to limited domestic markets impose high transportation costs on most of these countries. These conditions imply that service providers are usually (natural) monopolies and “as a result, the economies of small states do not benefit from the effects of competition on improving efficiency, lowering costs, and spurring innovation” (Abeyratne 1999, p. 7).

In addition, most small states rely heavily on tourism as the main source of foreign currency. Indeed, in Table 3, of the CSWB Report (ComSec, 2000, p. 11) it is pointed out that in 1997 the share of tourism in export of goods and services in the Pacific, ranged from 7.3 percent (Marshall Islands) to 50.6 percent (Samoa). The situation is more dramatic in the Caribbean (Table 4, p. 11) where the share of tourism in exports of goods and services for the same year varied from 43.7 percent (St. Vincent) to 75.6 percent (St. Lucia).

The heavy reliance of the economies of small states on tourism has considerable developmental and environmental implications. In particular, as this was pointed out in our earlier discussion on the services trade debate, the export of services often implies import growth. This is especially true in the case of tourism development in small states where tourism expansion is accompanied by significant increases in non-indigenous food imports and inputs to construction of tourism-related infrastructure. In addition, linkages and spill-overs to the rest of the domestic economy are generally thought to be limited, as many types of tourism facilities are in effect “enclave developments” (ComSec, 2000, p. 11–12).

Nonetheless, the “symbiosis” of aviation and tourism has correctly been identified as the driving force behind the phenomenal growth of tourism as the “world’s largest industry” (Abeyratne, 1999, p. 63). Clearly, air transport plays an especially pivotal role in promoting the tourist industry of small states, especially in the case of SIDS. The fact that most of the airlines of small states are also “flag carriers” means that air transport has had a significant overall strategic economic importance for the development of these states. However, considering the drive towards multilateral liberalization of the air transport industry described earlier, “...it would not be unrealistic to expect that air carriers of the future would operate air services to tourism-based countries on the dictates of unpredictable and rapidly changing market forces rather than on sustained public services considerations” (p. 63).

Furthermore, given the well-established causal link between variations in National Income and demand for air transport, the high income volatility that characterises these states, coupled with the openness of these economies, places carriers in a very precarious financial position. In addition, the susceptibility of small states to natural disasters and environmental changes, their limited access to external private capital and financial resources, and their reduced institution capacity—especially in the provision of public goods and services (such as airports and ground facilities)—could transform mere challenges facing their airlines into major stumbling blocks in their overall economic development. Finally, while it is true that most of these problems are not small-state-specific, in

the case of these states they often appear simultaneously, thus having a cumulative detrimental effect on their economies.

Environment Effects and Airport Congestion

Another serious challenge facing the airlines of many developing nations, directly related to the earlier point is the environmental impact of air transportation activity on the economies of many small developing states.²² Indeed these economies are often confronted with a difficult dilemma between, on the one hand, maintaining a healthy level of socio-economic development—to large extent dependent on the hospitality industry (and in particular travel and tourism), and environmental protection on the other.

The pivotal consideration in sustainable development is that it has economic, social and environmental dimensions. Therefore, in considering the extent of control that needs to be exercised by SIDS [small island developing states] in the areas of tourism and air transport development in order that a balance be maintained between progress and sustainable development, all three factors have to be carefully addressed" (Abeyratne, 1999, pp. 64–5).

In fact, the thrust of the Report of the 1992 United Nations Conference on Environment and Development (especially Agenda 21), "was that environmental issues were the necessary corollaries to social process and should be addressed on the basis of equity, care for nature and natural resources and development of society. Environmental management is therefore to effective sustainable development" (p. 58). Clearly, the geography and geomorphology of these countries imposes severe limitation and binding constraints on their ability to achieve the necessary level of sustainable development.

Quality of Service and Fleet Renewal

Recent evidence suggests that the quality of service offered by airlines is to a large degree determined by the average age of the fleet (Abeyratne, 1998; Headley & Bowen, 1997). Indeed surveys confirm that flight punctuality, in-flight service, superiority of aircraft, cabin and seating configurations, and number of accidents regularly top the list of factors influencing customer satisfaction. Clearly all these elements are directly related to the quality of the fleet in general and the age of the fleet in particular.²³ It is also generally recognised that the fleets of the airlines of small (developing) nations are in dire need for major overhaul and that these countries face increasing difficulties in securing sufficient funding to undertake this onerous tasks.

Market Access (Barriers to Entry, Slot Allocation and Airport Competition)

Several studies, in the U.S. and elsewhere,²⁴ have documented that while deregulation has had an overall positive effect on consumers in the respective economies, several important impediments to market access remain, especially for new entrants. In many instances incumbent carriers use existing exclusive gate use leases in major U.S. and European hubs, the so called “grandfather rights,” as barriers to entry, which result in heavily skewed allocation of landing rights, or slots, in their favour. Analysts and policymakers are concerned that these so-called “operating barriers” coupled with other marketing strategies, such as code-sharing agreements, booking incentives for travel agents, proprietary CRS and frequent flier plans strengthen the incumbents’ positions thus thwarting entry and significantly limiting competition. “As a result, competition suffers, leading to higher airfares. The effect of these strategies tends to be the greatest—and the fares highest—in markets where the dominant carrier’s position is protected by operating barriers” (GAO, 1996, p. 2).

In the case of small state airlines, the market access problem to large U.S. and European markets is exacerbated by the relatively small size of the home market which severely hampers their ability to effectively overcome these operating barriers. Furthermore, while airports in OECD countries are increasingly moving towards greater inter-airport competition, promoting profit-maximising objectives, thus offering incentives for more efficient allocation of take-off and landing rights, small state airports are facing a double handicap. In most cases, state ownership of airports coupled with strong vertical relationships between airports and airlines means that some form of regulatory control is inevitable (DECD, 1998, p. 8). In these cases, the OECD recommends, as a second best solution, that the regulatory arrangement and slot allocation should be based on the market process in both the primary and secondary markets, subject to competition law. The problem is that airport administrations in small states are not always able to perform the administrative allocation effectively. This is because often there are no primary and/or secondary markets for slots, meaning that the opportunity cost of slots is zero. This results in further “hoarding” and the socially inefficient allocation of landing slots.

Labour Productivity and Outsourcing

Greater competition at the global level has forced airlines to make a sustained effort to control costs, improve efficiency and hopefully increase profitability. Studies confirm that labour costs still represent a major component of the operating costs of international airlines and that their drive towards deregulation has forced companies to reduce labour costs and

increase productivity (Alamdari, 1998; Antoniou, 1992). One of the most popular strategies adopted by airlines in order to contain labour costs is by outsourcing some of their in-house functions (Rutner & Brown, 1999, p. 23). This reduces their fixed costs relative to their variable costs thus reducing the breakeven level of output. Evidence suggests that the functions more likely to be outsourced by airlines include ticket sales and distribution, aircraft leasing, airport gates, complementary limousine pick-up, food services, ticketing, baggage handlers, aircraft interior cleaning, engine overhaul or rework, maintenance training, information systems and technology, pilot training and advertising.

It is clear that small state airlines have a limited ability to outsource most, if not some, of these services. This is because small states, and especially islands, are typically geographically isolated thus making the entire effort pointless. Furthermore, even when surrounded by other states, outsourcing to suppliers of services in neighbouring countries will not necessarily have the desired effect, as costs do not vary significantly on a sub-regional basis. Nevertheless, considering that there may be significant economies of scale in the provision of these auxiliary services, we can not exclude the potential that there may be non-negligible benefits to be reaped from the joint production and distribution of these services, provided that countries are sufficiently physically close to each other.

Other Impediments

In a discussion of challenges and opportunities facing Asian airlines, Oum (Findlay, Sein, Singh, 1997) identifies several impediments that these airlines must face in order to effectively implement market liberalization. Some of these impediments are also applicable to small state airlines including, (a) the tendency to “self protectionism” due to restrictive bilaterals, coupled with small-network-single-hub structures; (b) the weak consumer influence exacerbated by the fear of competition; (c) the great variations in the political systems of these countries, associated with the cross-culture communication difficulties between them; and (d) the competition between the military and civilian use of their airports.

On the broader issue of the liberalization in international aviation Trethaway (Findlay et al., 1997) believes that the greatest remaining impediment is the system of bilateral agreements which, he argues, is both expensive to administer and inefficient. He believes that as a result of bilateralism, countries expect to share equally the benefits of freer trade thus forego mutually beneficial, therefore efficient, trade expanding agreements.

ALTERNATIVE POLICY OPTIONS AND RECOMMENDATIONS

There is no magic formula to overcome the numerous and often insuperable problems facing the airlines of small states. Furthermore, almost every state has its own idiosyncrasies thus making it almost impossible to produce a ready-made set of remedies that can be applied to all cases. Nevertheless, the institutional framework outlined in the second section and the economic characteristics of the international airline industry identified in the next section point towards two broad policy options available to small states in order to meet the challenges facing their airlines. These are the integration of their air transport services at a regional levels and the liberalization of their air transport markets in a way that will allow their airlines greater operational flexibility to meet the challenges of enhanced global competition. Clearly, these are not any different from the options open to the airlines operating in other states. However, given the vulnerability of small states to outside shocks, these states need to be especially careful in formulating an appropriate set of strategies better suited to their own particular needs.

Several alternative strategies have been suggested that will enhance the ability of African, Asian, or indeed any other developing country's, airlines to survive in a more competitive global market. However, all these strategies share a common, often undeclared, underlining objective: to define the appropriate policy environment that will ease the transition to a more liberal and regionally integrated airline market. The key element of this approach is the gradual liberalisation of national airline markets over a relatively protracted transition period, while at the same time setting-up the foundations for greater cooperation and eventual integration at the regional level.

At the global intergovernmental level, ICAO recommends to its members that the airlines of states that "are at a competitive disadvantage when faced with the mega trends of commercial aviation and market access" should be granted the following preferential measures (Abeyratne, 1998):

1. The asymmetric liberalization of market access in bilaterals with developed countries;
2. More flexibility for air carriers in changing capacity between routes in bilaterals;
3. Trial periods for liberal arrangements for limited periods of time;
4. Gradual introduction of more liberal market access for longer periods;
5. Use of liberalised arrangements;

6. Waiver of nationality requirements for ownership of carriers;
7. Allowance for more liberal leasing agreements for modern carriers;
8. Preferential treatment in slot allocation at airports; and
9. More liberal agreements for ground handling at airports, conversion of currency at their overseas offices and employment of foreign personnel with scarce skills.

Other preferential measures could include:

1. Long term low interest loans for the purchase of modern carriers;
2. Temporary exception from emission standards;
3. Collective use of air traffic rights through combined operations; and
4. Release from obligation to own and control their own airlines.

At the more regional level, Oum (in Findlay et al., 1997) suggests a number of short and long term initiatives to mitigate the impediments facing some of these airlines. His short-term recommendations include:

1. Open charter and freight markets between countries in the region;
2. Relax code-sharing rules between regional carriers;
3. Liberalize third and fourth freedom rights;
4. Relax rules on foreign ownership; and
5. Expand bilateral and multilateral agreements with “like-minded” neighboring countries.

In the longer term, Oum also recommends:

1. Intra-regional open sky agreements;
2. Expanded bilateral and multilateral agreements outside the region; and
3. The development of multilateral general trade agreement.

Forsyth (in Findlay et al., 1997) has looked at the issue of privatization of airlines with reference to the Pacific Asian region and has come to a number of extremely interesting conclusions. In particular he found that, to a certain degree, the privatization of carriers is incompatible with the liberalization of markets. Indeed he observed that during the period leading to and following privatization, governments are unlikely to embark on any major liberalization campaign that could put to jeopardy the profitability

and thus the chances of success of privatization. To the contrary, governments tend to increase protection immediately prior and after privatization for this very reason. In addition, the author argues that governments continue to attach great political significance to ownership of their carrier seen as “flag carriers” to serve the public interest. Of particular concern to governments is the likelihood that the ownership of the national carrier could fall in foreign hands. Furthermore, he also found a very strong positive correlation between per capita income of the country and privatization of airlines and that the majority of privatized airlines were large successful companies.

Finally, inspired by the Treaty of Rome, Tretheway (in Findlay et al., 1997) recommends that the remaining, air transport services i.e. those not already included in the GATS, should be included in a broader regional trade liberalization negotiation as part of the wider package of goods and services. Furthermore the author also suggests that countries interested in liberalizing their markets should endeavor to document consumer gains from open-air transport markets, especially for down-stream industries such as tourism and high tech. A good starting point is air cargo where potential gains are bound to be large, especially for the rest of the economy, with almost no “flag-carrier” effects. Lastly, Tretheway is also in favor of starting the liberalization drive by developing sub-regional agreements of “like-minded” nations.

CONCLUSIONS

In this paper we set out to investigate the policy options open to small states in their quest to modernize and restructure their air transport industries in the context of the new world trade order. We presented the main features of the international air transport industry, discussed the salient points of the analytical debate surrounding the efforts to liberalize the world aviation industry and analyzed the challenges facing the airlines of small states. We were then able to propose a number of alternative policy measures that could constitute the basic elements of air transport policy aiming at defining the appropriate environment that will ease the gradual transition to a more flexible, more efficient, and regionally integrate airline market.

ENDNOTES

1. For the purposes of this study “small states” refers to independent and sovereign developing nations, which excludes former colonial overseas territories such as Montserrat and Anguilla, but also countries like Leichtenstein or Faroa.

2. An important ingredient of any policy is the availability of adequate International Air Transport data and statistics collection, a point convincingly made by Button (1999).
3. This is the actual title of the actual Report published by the Commonwealth Secretariat/World Bank Joint Task Force on Small States (2000).
4. "... One's bargaining power is greater the more one has to offer than the other party wants (via reciprocal bargaining) and, conversely, the more the other party would be harmed if one withheld what one has (in retaliation for violation of the agreement)." (McMillan, 1989, p. 38).
5. It was to mitigate this particular bargaining handicap vis-à-vis that the EU adopted its own common air transport policy, see later.
6. See Toh (1998), pp. 66–7.
7. It is interesting to note that, ironically, the encirclement strategy also gave these alternative destinations some potential strategic leverage over the US., as suggested by McMillan, although there is no evidence that these countries used this (unexpected) bargaining power.
8. See Antoniou (1998).
9. Implicitly acknowledging this inconsistency in U.S. policy, Toh (1998) concludes: "But the *ultimate* goal [italics added] of international Open Skies is the mutual granting of the rights of cabotage, allowing foreign airlines to operate flights serving domestic city pairs." (p. 69).
10. Weisman (1990) offers a good discussion on the economic issues surrounding services trade and their application to international aviation.
11. For a full discussion on the economics of the trade in services see Sapir and Winter (1994).
12. Recall that the MFN is a basic GATT principle, Article I, whereby members are bound not to discriminate in their trade policy and to provide to all trading partners the same customs tariff treatment given to the so-called 'most-favored-nation'.
13. "The problem has centred around two topics: the most-favoured-nation (MFN) principle and labour mobility. In both instances, the problem relates to a major ambition of the industrial nations in the services negotiations, namely to obtain not only improved trade access but also rights of establishment for their services companies in the developing countries. These countries have been reluctant to commit themselves to granting such rights in politically sensitive infrastructure activities. As a result, some industrial countries have sought to deny the application of the MFN principle from the services agreement." (Supir & Winter, 1994, p. 296)
14. In particular, this coverage can be found in paragraphs 2 and 3 of the Annex on Air Transport Services. Note also that Article III and V of the GATT also cover air transport. For details see WTO (1998) and that the Annex is due for review in September 2000.
15. According to some estimates these costs can represent two-thirds of the sale price of an aircraft (Airbus 300–600) over a 15-year period and that if airlines could reduce maintenance time (and thus raise rate of use) by one hour per day, this could increase the turnover per aircraft of between US\$ 10 and 12 million per year (WTO, 1998, p. 4).
16. Alternative patterns are also considered in the study, see WTO (1998), pp. 5–10 for details.

17. Provided that the system in general and the central node in particular has enough capacity to accommodate the extra traffic without imposing congestion costs on incumbent users.

18. Namely, "These are different from pecuniary externalities that are price-related and are transmitted through the market mechanism.

19. In fact this has not always been the case. For many years the prevailing wisdom was that airlines are characterized by the absence of any scale effects, see Antoniou (1991) for a review of the relevant more recent (empirical) literature.

20. On a more technical economic level, Antoniou (1998) argues that indivisibilities could in fact be one of the reasons why this industry may not have equilibrium so that its core may be empty.

21. See the ICAO (1994).

22. See Abeyratne (1999) for the a discussion of this problem in the special case on small island developing states, and *idem* (2000) for the consequences of slot transactions on airport congestion and environmental protection, with special reference to the ICAO Airport Planning Manual.

23. In fact, Antoniou (1992) identified age of the fleet as one of the factors the determines the profitability of international airlines Furthermore it is also true that the aircraft noise level is directly related to the age of the flight, see Abeyratne (1998).

24. See in particular, GAO (1996,1998), NRC (1999), DOT (1999), Abeyratne (2000), OECD (1998).

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AIR CHARTER—THE BUSINESS AIRLINE OF THE FUTURE ...BUT, DOES THE BUSINESS TRAVELER KNOW?

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ABSTRACT

Historically, FAR Part 121 commercial carriers have provided efficient, economical and safe air transportation for corporate and business users. Recently, however, corporate and business travelers find their travel plans disrupted by delays, bankruptcies, poor service, lost baggage, fare increases, labor strikes and other systemic difficulties that degrade their travel experience to unsatisfactory levels. This article examines these Part 121 service delivery problems and, utilizing a tripartite investigative methodology, examines an alternative air transport mode: FAR Part 135 on-demand charter travel products.

This long extant segment of our national air transportation system is set prime to support increased demand for charter services. Corporate and business travelers are set prime to utilize viable, cost effective alternatives to commercial travel products. Two research questions emerge. First is whether corporate and business travelers are aware of Part 135 travel alternatives. Second is whether Part 135 charter service providers are aware of this latent demand and are effectively targeting this demand segment in their marketing efforts. The three-partsurveys employed to investigate these questions examined demand side

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awareness of how to access charter services and examined supply side marketing efforts targeted at this demand segment.

First, a survey of travel agencies concerning their knowledge of charter products found that 97 percent of those travel agents surveyed were not aware of how to sell or book charter products. Second, a survey of large and medium businesses regarding their interest in using charter products found that 84 percent would be interested. Third, a survey of magazine advertising of charter travel products to determine visibility levels of charter products in print media found less than one page of charter product advertising in 8,684 pages published in 62 magazines over a 2 month period in Fall 2000. The conclusions derived from the research are that business and corporate travelers appear willing to examine charter products as alternatives to commercial products. Travel agencies appear willing to offer and book charter products for their clients. Finally, charter service providers are not effectively marketing to this demand segment in print media. The resultant situation is that none of the parties know how to go about "closing the deal."

INTRODUCTION

Historically, commercial carriers have provided efficient, economical and safe transportation services to corporate and business executives. Recently however, commercial carriers operating under Federal Aviation Regulation (FAR) Part 121 certification are experiencing poor on-time arrivals, increasing boarding denials, passenger complaints, congestion around major hubs and business fare increases (Bowen & Headley, 2000). According to McCoppin (2000) and Boydston (2000) these factors cause many corporate travelers to desire better air transport alternatives.

Organizations and individuals seeking alternatives to commercial service have several options each with different cost structures. The first option is a personal or corporate aircraft. This alternative offers the greatest degree of travel flexibility, but requires substantial capital commitment and is viable only for financially robust organizations. The second is fractional ownership programs, whereby organizations purchase a percentage of an aircraft and receive a guaranteed number of hours of use. This alternative allows many smaller organizations to acquire the benefits of aircraft ownership at affordable levels. Under fractional ownership programs, the cost of owning and maintaining the aircraft are dispersed among the several owners. This alternative has proved exceedingly successful and beneficial to many firms, yet still requires a capital ownership commitment.

The remaining viable alternative to commercial products is the on-demand air charter product. Charter services have traditionally held a small, but stable share of the total U.S. domestic market. In Europe, however, charter services have accounted for a significant share (56 percent in 1996) of intra-European air travel (Button, Haynes & Strough, 1998; Doganis, 1992). One key definitional difference, however, is that associate the term charter services with operations involving 60-seat or greater jet

service to major vacation resorts, and the term air taxi services with what Americans associate with corporate type aircraft. This paper examines only on-demand charter operations utilizing the corporate jet or turboprop definition common in the United States.

According to Wells and Chadbourne (1994, p. 26), the primary advantage of charter operations is flexibility. Wells (p.26) further notes, use of charter service is attractive to firms that do not have consistently high levels of demand for point-to-point services. Total or fractional ownership programs better support consistent high demand for point-to-point requirements. Charter services are also cost effective solutions when supplemental or type specific lift is required to support existing flight operations. Utilization of charter operators providing both aircraft and crew, operating on flexible client-driven schedules and itineraries provide lower aggregate time valued costs for multiple traveler scenarios and represent a viable alternative to the current commercial travel dilemma.

Delivery failure rates by commercial carriers create tension within the carriers' prime revenue client base: the business traveler. This traveler base is increasingly intolerant of commercial service delivery failures. This growing intolerance creates tremendous demand for viable travel alternatives. FAR Part 135 charter products represent a robust and inherently more flexible alternative to commercial product offerings. These two observations drive several investigative questions. One key question is what market channels must charter service providers utilize to effectively reach this traveler base and what should the message be.

PURPOSE OF THE STUDY

This study investigated whether changes are occurring in business travel requirements due to increasing levels of service delivery failures inherent in commercial product offerings. This study investigated the role charter products could play in providing alternate travel services thereby eliminating commercial service delivery problems. Lastly, this study examined how that knowledge could be delivered. This study was limited in scope to business travelers and travel agencies in the Midwestern United States. Specifically the goals were to ascertain whether a market for charter products exist among business enterprises; whether the traditional travel distribution channel, travel agencies, have access to and knowledge of charter product marketing and booking methods; and the extent to which charter operators use print advertising to penetrate the business travel market.

Commercial Carrier Service Delivery Problems

The third quarter of 2000 on-time performance ratings reported in the U.S. Department of Transportation catalogue *Air Travel Consumer Report*, ranked United Airlines tenth with a 51.6 percent on time performance rating; American Airlines sixth at 75.3 percent; TWA fourth at 78.7 percent; and Delta second at 77.2 percent (2000b). Increased rates of overbook boarding denials jumped from .89 per 10,000 passengers in 1999 to 1.22 per 10,000 passengers in 2000. *The Airline Quality Rating 2000* by Bowen and Headley (2000) shows net decline in commercial carrier performance quality in 1999. This occurred in spite of the fact that during 1999 commercial carriers voluntarily created and agreed to an industry wide performance improvement policy statement containing a plan of action to improve service delivery performance (Bowen & Headley, 2000). According to the *Air Travel Consumer Report*, airline consumer complaints declined from 2,726 in 1999 to 1,410 in 2000 (Consumer Complaints Summaries Category, Table 1, p. 37). Bechard (1999) postulates this may be due to high degrees of self scrutiny by the carriers coupled with Congressional oversight hearings regarding the enactment of passenger bill of rights legislation (pp. 27–28).

Commercial carrier customer complaints were exacerbated by increases in both air-side and land-side airport congestion. According to the U.S. Department of Transportation (DOT), highway congestion around large metropolitan areas in FY 1999 caused an average of 9.2 hours of delay per person annually (USDOT, 2000a). DOT projects a decrease in delay time in FY 2001 to only 8.1 hours annually. DOT also predicts that current airport expansion projects will not have significant impact on airport congestion until 2006 or 2007. Still, Bowen and Headley believe the high rates of commercial carrier passenger complaints reflect an overall frustration with the industry.

Commercial carrier claims of rising fuel prices as a prime driver of fare increases runs counter to an Air Transportation Association study by Simat, Helliessen, and Eichner, Inc., 1989 (as cited in Abunassar, Wissam, Koford & Kenneth, 1994). This study indicated lack of competition as the prime driver of fare increases. Abunassar et al (1994) concurred with the ATA report adding both lack of capacity at major hub airports and lack of competition as prime drivers of fare increases.

Irrespective of which price discrimination model is used to justify escalating airfares, business travelers absorb a disproportionately high share of airfare increases. Inability of the business traveler to predict and schedule trips seven, fourteen, twenty-one days in advance and capture advance purchase discounts, coupled with the inelastic nature of business

travel demand allow carriers to price business products at maximum yield. One example of this maximum yield pricing ability is United Airlines. Business travelers make up only 9 percent of United Airlines bookings but generate 45 percent of carrier revenue, according to a United Airlines spokesperson (McCoppin, 2000). Interestingly, the 1989 Air Transport Association study, (cited in Abunassar et al., 1994) found high correlation between the number of business passengers and the size and frequency of fare increases. Increases in business ticket sales volumes led directly to increases in fares.

The *Airline Quality Rating 2000* report indicates most problems consumers face with commercial carriers result directly from lack of competition and airline policy decisions. According to Bowen and Headley:

These problems range from unfair business practices targeting new start-up airlines, temporary route structure changes, gate-lock practices, select incentives to travel agents, ability to tie up landing slots and book them as assets, rapid expansion of code sharing practices which in effect may reduce competition on many routes, and flight scheduling competition. (p. 7)

The Charter Alternative

Frustrated by decreasing performance levels and escalating fare levels, business travelers are seeking alternatives to commercial carrier products (McCoppin, 2000). Bowen and Headley (2000) conclude that flying a group of three to six company executives to three to four destinations in the same day and returning to company headquarters that evening with less than 14 days notice is cost prohibitive, productivity draining and virtually impossible to schedule using commercial carrier products. Conversely, charter products are able to support such multi-destination, multi-traveler itineraries with relative ease. Charter products, once viewed as executive perquisites, could become the sine qua non of medium to large businesses with consistently stable multiple traveler, multiple destination travel demand requirements.

On-demand charter service is defined as the rental of an aircraft and flight crew for a specific trip. Charter aircraft range in size from single engine piston powered aircraft seating two or three passengers up to and including large transport category aircraft seating thirty or more passengers. Wells & Chadbourne (1994) define charter services as:

Chartering an airplane is similar to hailing a taxi for a single trip. The charter operator provides the aircraft, flight crew, fuel, and all other services for each trip. The party chartering the aircraft pays a fee, usually based on hours flown or mileage, plus extras such as aircraft waiting time and crew expenses. Chartering an aircraft is particularly attractive for a firm that does not

frequently require an airplane or does not often need a supplement to its existing aircraft fleet.

Chartering can be cost effective for a group of executives traveling together or for an emergency. When the individual businessperson is traveling alone, the airlines, including regional carriers, would probably be more cost efficient, especially if the trip were between two cities well served by scheduled carrier's (p. 179).

Charter operations are flown on the traveler's time schedule and to the traveler's desired destination. Charter operators are generally located among the 5,400 general aviation airports, compared to the 580 airports served by commercial carriers. These airports are generally less congested than major hub airports, offer easier land side ingress and egress and can be considerably closer to the travelers' ultimate destination. FAR Part 135 governs charter operations and contains functionally equivalent standards of safety as those imposed upon Part 121 commercial carrier operations. The Federal Aviation Administration (FAA) estimates that between 1998–2010 the number of turbine powered business aircraft will increase about 60.0 percent with an 81.6 percent increase in flight hours (NATA, 2000). According to this report, over that same timeframe 806 general aviation airports will require runway expansion, runway and taxiway resurfacing and installation of uprated instrument approach and navigation systems. These improvements, estimated at \$3.3 billion, will be required to cope safely and efficiently with forecasted increases in the number of aircraft and the number of flight operations (NATA, 2000).

A recent survey of corporate travel managers, conducted by the U.S. National Business Aviation Association (NBAA), indicated that 72 percent of respondents said their companies were using corporate jets or charter services for non-executive level employees, up from 56 percent last year (Boydston, 2000). According to Jones (1999), time management, control, privacy and quality of life issues are some of the main reasons cited in driving charter utilization to lower levels of the organization. While making sales calls to corporate executives around the country, a Richmond machinery distributor explained that charter flights allow him to schedule an extra sales call each day, where formerly that time was spent in ground commutes out of and into commercial service airports (Jones 1999). A senior vice president at the National Business Aviation Association stated that in the 1980s, corporate jets were viewed as status symbols. Today charter products are about work productivity, corporate employee time value and quality of life issues (Boydston, 2000).

METHODOLOGY

A tripartite investigative approach was employed to obtain information concerning charter product knowledge levels of (a) end users of charter products, the business traveler, (b) agents of charter product distribution, travel coordinators and travel agencies; and (c) charter service provider marketing efforts in print media directed at these two groups.

First, a literature review was conducted to identify current trends in commercial, charter and travel agency service levels and to identify any gating issues. This was accomplished by reference to commercial carrier quality review information, charter industry publications and governmental industry publications.

Next, two data collection instruments were constructed for use in a telephone survey of select potential distribution channel organizations: travel coordinators and travel agencies and select potential end users, the business traveler. The intent of the first survey was to determine travel agency personnel knowledge of charter products. The second survey sought to determine corporate travel manager and business traveler knowledge of charter products. Once the surveys were developed, travel agencies and businesses were contacted by telephone for survey solicitation. Southern Illinois University at Carbondale (SIUC) graduate students conducted the telephone survey over a three-day period. Student solicitors were instructed to record all information. Copies of the questionnaires are contained in Exhibits 1 and 2.

Due to travel agency managerial requirements imposed by both the International Association of Travel Agencies Network (IATAN) and the Airline Reporting Corporation (ARC) only travel agency managers were asked to respond to survey questions. Travel agency owners were excluded from participation as well. Travel agency owners may or may not be qualified as certified travel managers.

The travel agency survey was designed to elicit specific information concerning knowledge of charter operators, charter operations, product familiarity, booking methodology and charter commission structure. The survey was given to full service travel agencies in three major Midwestern cities: Chicago, St. Louis and Kansas City. Full service travel agencies were selected due to their handling higher volumes of business requests compared to agencies catering to leisure or boutique clientele. Thirty-eight travel agencies of various sizes were selected for interview based on size and segregated by their annual gross revenues. Agencies were divided into four categories: small (annual revenues of less than \$1 million), medium (annual revenues of \$1 to \$5 million), large (\$6 to \$10 million) and very large (\$11 to \$25 million). Travel conglomerates such as Maritz Travel and

Carson/Wagonlit Travel, with revenues in excess of twenty-five million dollars per year were not considered. These conglomerate agencies have preferential volume pricing arrangements with commercial carriers that would artificially skew survey results. The survey included only agencies that commission payments under current commercial carrier commission schedules.

Agencies selected were randomly drawn from listings in *Sorkin's Business Directory*. The number of survey participants in each selected city was determined by metropolitan size. Thus, Chicago's target participation was fifteen agencies of various size; St. Louis, twelve; and Kansas City, eleven. Agency size classification results were three small agencies, twenty-one medium sized agencies, twelve large agencies and two very large agencies.

The second survey was simultaneously delivered to twenty-five medium to large businesses within the same metropolitan market areas. Businesses were again randomly selected from *Sorkin's Business Directory* on the basis of gross revenues. The number selected for each city followed the methodology for travel agency selection. Size determinations were consistent with North American Industry Classification System (NAICS) definitions for small, medium and large enterprises. Thus, seven selected businesses were very large corporations; seventeen mediumsized and one a small firm.

Selection of businesses tracked and coincided with travel agencies selections in each of the surveyed cities: ten in Chicago, eight in St. Louis and seven in Kansas City. Like the first survey, Chicago accounted for 40 percent of business participants, St. Louis 32 percent and Kansas City 28 percent. In the large and medium sized participants, questions were directed to personnel responsible for travel disbursements, generally either the Vice-President or Director of Finance. The remaining surveys were directed to either a partner or owner as named in *Sorkin's Business Directory*.

Lastly, this study examined the extent to which charter service providers were advertising to these target markets in print media focused on upper management decision-makers. Listings of the top one hundred national business and finance magazines targeted at corporate decision makers were obtained from Fortune 500's online ranking of magazine target audiences and gross advertising revenues. Morris Library at Southern Illinois University (Carbondale) and the Aviation Management and Flight Department Library (Howell) had a combined total of sixty-two magazines catalogued. These sixty-two magazines were examined over a two month period in the third quarter of 2000 for charter specific advertising. A partial listing of magazines identified and the range and breadth of business sectors targeted is shown in Table 1.

Table 1. Survey Magazine Range
Example of Magazines Included in Survey

Air Traffic Management	Financial Report Card	Plus:
Aircraft Economics	Forbes	Specific Trade Magazines
Air Finance Journal	Global Investor	e.g.:
Barron's	Global Telecome Business	Batteries International
Black Enterprises	Green Financial	International Glass
Business Traveler	Hispanic Business	International Plastics
International	INC.	Petroleum Economist
Business Week	Institutional Investor	PharmaBusiness
Corporate Finance	Trade Finance	
Entrepreneur	World Law Business	Total 62 Magazines
Euromoney		124 @ 2 months

THE SURVEY

Critical business decisions involving shifts in entrenched purchase habits, purchase psychology and paradigms require considerably more justification and support than purchase decisions executed within existing frameworks. This advanced justification model served as a backdrop for this survey. This survey focused on defining end user and traditional travel distribution channel agent knowledge, and perceptions of charter travel products.

For purposes of consistency all calculated survey percentages have been rounded to the nearest whole number.

Travel Agency Survey

The first question established a baseline scenario for comparing commercial and charter travel products. This baseline scenario consisted of the following hypothetical business trip. Company A needs to send seven executives from St. Louis, Missouri (STL) to Hartford Connecticut (BDL) three days from now. The company desires the group to travel together on a morning departure and, if possible, return to St. Louis the same evening. Each of the surveyed travel agents consented to providing a commercial carrier trip quote generated by their computer reservation systems. A variety of systems were used by travel agencies in developing a quote for this hypothetical trip including Worldspan®, Sabre® and Apollo®.

Virtually all commercial carrier trip quotes presented by the travel agencies agreed and resulted in the following: all passengers confirmed full fare, coach non-restricted space at \$1,900 per passenger. The total cost for seven passengers travelling on a weekday and returning, if possible, the same evening without at least seven days advance booking is \$13,300. The travel agency commission equaled \$350 due to airline commission caps. Each agency surveyed confirmed the same basic itinerary, timing and price.

Whether or not the travelers would be able to return to St. Louis that same evening depended solely on what time they would be able to get to the airport. It is quite possible that the travelers would have to spend the night in Hartford.

According to Donna Kaps, Manager of Holske Travel Consultants, recent airline commission reductions have set the upper limit of commissions payable to travel agencies at 5 percent of net ticket fare (Personal communication, March 21, 2000). Kaps also indicated airlines have taken one additional step to reduce commission expenditures by redefining the upper limit as 5 percent of net ticket fare or a maximum of \$50.00 per ticket. Thus, whether an agency sells a ticket for \$5,000.00 or \$1,000.00, the commission earned is capped at \$50.00. Net ticket fares below \$1,000 are paid at the 5 percent rate. Thus, in the hypothetical trip from St. Louis to Hartford, although 5 percent of \$13,300.00 is \$665.00, the maximum payable commission is \$350.00, or 2.6 percent of net ticket fare.

For comparison, the SIU Carbondale survey team, using the same hypothetical itinerary obtained a charter product quote from an online charter operator, AirCharter.com. The charter quote returned indicated using a Lear 35 with eight usable seats. The quoted price for the trip equaled \$11,437.00. The quote included estimated flight hours required from STL to BDL and same day return and all applicable aircraft and crew wait time charges. Because charter quotes are based on per hour or per mile usage fees, not on a per seat basis as with commercial carriers, Company A in this hypothetical can, if it desires, add an eighth traveler or drop passengers with no impact on the cost of the aircraft. A travel agency booking this hypothetical trip using a charter service provider would earn \$571.85 in commissions representing five percent of the charter quote. This hypothetical trip resulted in the following differences between commercial and charter travel products when booked through travel agencies. The charter travel product saved the client \$1,800.00 in total trip cost, provided almost double the commission earned by the travel agency and the hypothetical itinerary was easily completed in one business day. Table 2 demonstrates the comparison.

The above commission comparison is strictly relative to a five percent commission rate quoted by the airline and charter service provider. Many travel agencies are compensating for lost commercial commission revenue by adding in-house service charges to the price of tickets booked. With reference to the above charter quotation, however, an agency may consider the price quoted to them as net. In such instance the agency may reap not only the 5 percent commission rate but also any add-on they desired to apply. While savings to the traveler will still be present, the agency may

Table 2. Rate Comparison for Booking of Seven Passengers with Itinerary of St. Louis, Missouri, to Hartford, Connecticut, Departing on a Tuesday Morning with Return the Same Evening

	<i>Commercial Carrier</i>	<i>Charter Operation</i>
Booked Through	Trans World Airlines	Air Charter.Com
Type of Aircraft	MD-80	Lear 35
Number of Seats	113	8
Total Cost	\$13,300	\$11,437
Commission to Travel Agency	\$350.00	\$571.85
Capped by Airline @ \$50 per psgr.		
Net Commission Rate	2.63%	5.0%

convert some of the total savings over commercial carriage to their own benefit.

All respondent travel agencies indicated they are occasionally tasked with business client requests to book groups of employees' traveling together. With the above hypothetical itinerary comparison as a basis, 37 percent of surveyed travel agents indicated they positively would and 13 percent might be willing to discuss booking a charter flight for group business trips of the nature indicated, although they admitted not knowing how to go about booking charter products. Thirty-four percent indicated they would require more information before discussing charter products with their clients.

Travel agents were then questioned about charter products as alternate revenue source for the agency. Ninety-two percent stated they would consider selling charter products if the commissions were equal to, or than, capped commercial carrier commission structures. The remaining 8 percent were willing to book charter products only if someone would train agency staff. In essence, 100 percent of the surveyed agencies would sell charter products if they knew how. Conversely, 97 percent indicated they had no knowledge of how to inquire about availability or book a charter product. The remaining 3 percent indicated some level of understanding of how to determine availability and quote and book charter products. When further questioned these two managers indicated what knowledge they had regarding quoting and booking charter products was learned because a client had asked them about charter flights. Both managers indicated looking in the yellow pages to locate and then call a local charter service provider to ask about a charter trip. Practically speaking, no travel agent surveyed had any functional knowledge of how to book charter products.

When travel agency managers were questioned as to the best method of obtaining information about charter flights, the results proved enlightening.

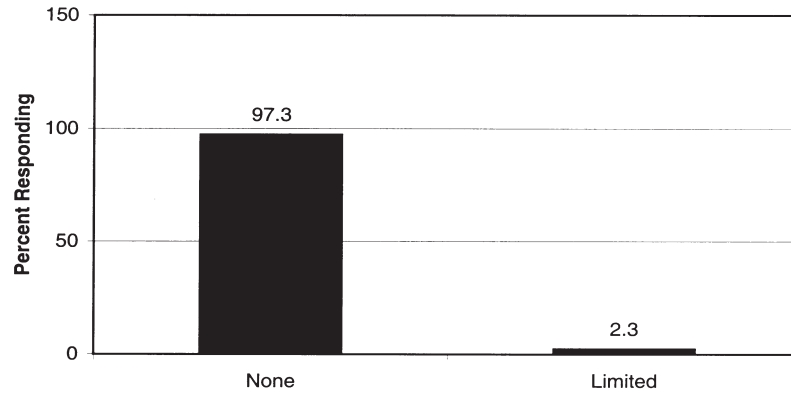


Figure 1. Travel Agent's Self-proclaimed Knowledge of Charter Booking Procedures

Fifty percent indicated they would recommend that their clients contact one of the commercial carriers for information. Thirteen percent would refer their clients to the Yellow Pages. The remaining agencies, 37 percent, indicated they had no idea of where to direct their clients, or how to obtain any pertinent information. One respondent, after long consideration, said she knew of someone who owned an airplane and maybe “he would know how to charter a flight.”

Although these results reinforce the fact that agencies have no methodology in place for querying, quoting or booking charter products, more importantly, they have no knowledge of where to look for answers. Figure 2 graphically highlights this informational dissociation.

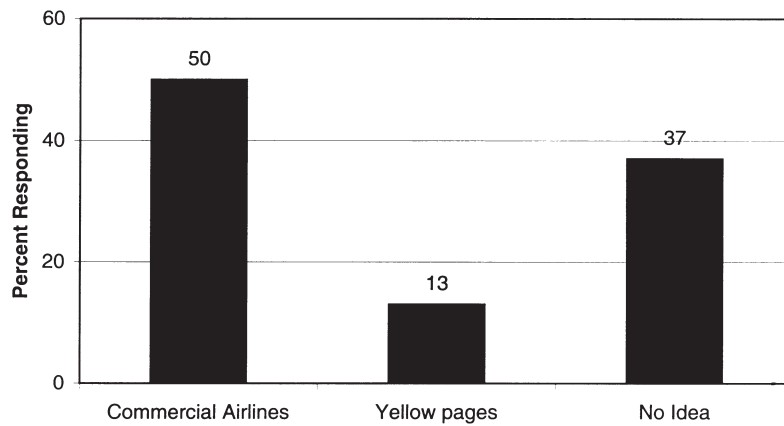


Figure 2. Where Travel Agents Would Seek Advice for Booking a Charter Flight

Travel agents were then asked if a sales consultant representing charter service providers, local or national, had ever called on their agency, made any type of presentation, or provided information or literature concerning charter travel products. Ninety-five percent responded negatively; 5 percent implied they thought so, but were not absolutely positive. After further reflection, one agency manager from the Chicago area said she thought someone might have contacted them, indicating “it was so long ago, I think it was about flying around the city.”

The responses of all travel agencies to survey questions regarding charter travel product knowledge and methodologies demonstrated a consistently significant void of expertise across all locations and agency sizes.

Business Survey

All businesses surveyed indicated frequent use of commercial carrier business products, including five participants who owned business aircraft and managed in-house flight departments. Business participants who did not have in-house flight departments indicated using commercial carrier business products exclusively. Eighty-eight percent of participants indicated a specific individual or department responsible for making all corporate travel arrangements. Eighteen respondents indicated having established policies and procedures for booking corporate business trips. Forty percent acknowledged having groups of four or more staff members regularly traveling together on commercial carriers.

Seventy-two percent of respondents indicated using travel agencies to book corporate travel requirements, while 16 percent indicated travel arrangements managed by an in-house travel manager. Twelve percent of respondents indicated allowing individual travelers to book their own trip arrangements.

Charter product awareness was higher among business participants compared to travel agency participants. Several companies indicated booking charter products for special occurrences. Twenty-eight percent indicated they had considered using charter products. Of these, three were from company’s operating their own business aircraft. In these three cases, two aircraft were chartered for temporary replacement of company aircraft down for maintenance. The other respondent indicated a charter flight had been booked to transport the Board of Directors to a special function. In all three cases, their flight departments established the bookings.

When queried as to how the company would go about booking charter travel products, 68 percent indicated they would direct their travel agency to make any and, all arrangements. Twelve percent indicated they would either use the Yellow Pages or contact a commercial carrier for advice.

Twenty percent indicated they would contact their own Chief Pilot for help with arrangements.

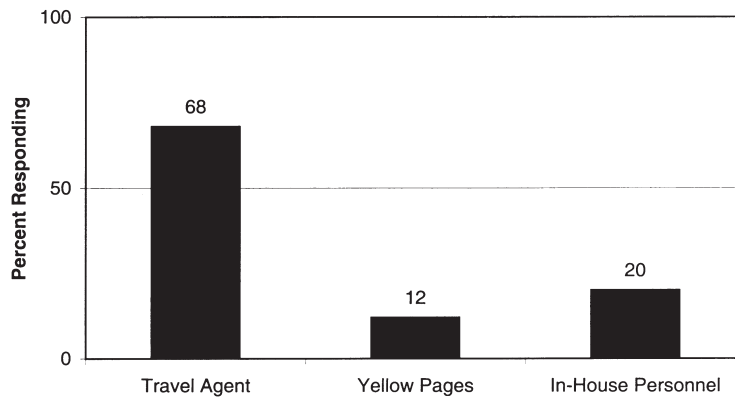


Figure 3. Where Surveyed Business Would Seek Advice on Aircraft Chartering

Despite the higher levels of awareness of charter products, 72 percent of business participants indicated never considering charter products for corporate travel requirements.

Business participants were asked how far in advance travel requirements could be predicted. Seventy-two percent reported usually having less than one week lead-time, while 16 percent reported, usually having two weeks lead-time.

Business participants were asked to identify reasons for not using charter products. Reasons cited in rank order were price, safety, lack of experience, lack of comfort, inconvenient schedules, negative impressions on stockholders and loss of frequent flyer mileage. The survey team then asked if cost/benefit analysis demonstrated that charter products could be competitive with commercial business products would the company re-examine charter products as alternative travel modes? Eighty-four percent replied positively, with 8 percent unsure and 8 percent replied negatively.

Of the seven topics cited as reasons for not considering charter products for corporate travel, one has true validity. The other six, when properly explained and understood are actually reasons supportive of charter product utilization.

The first reason cited, price, has validity. However, the price of a charter product represents only one evaluative factor when properly comparing charter to commercial travel. The other evaluative factor is time. By including the value of total time a traveling executive is away from the company, a very different “true cost” structure emerges. Commercial

carrier flight delays, coupled with route structures serving less than 10 percent of available airports require the business traveler to spend significant amounts of time in ground commutes. Point to point charter products often place the traveler much closer to the ultimate destination, resulting in significant timesaving. Meetings sometimes run late. A missed commercial carrier flight can result in an unnecessary overnight stay. Charter travel generally arrives and leaves when the client is ready. By accurately projecting the value of the traveling executive's time when combined with the "price" of a charter product; true cost savings can be captured through use of charter products for as few as two senior level passengers.

Safety, lack of experience, lack of passenger comfort and inconvenient schedules were the next most frequently cited reasons for not considering charter products by survey respondents. Ironically, the last three of these are in fact prime benefits of using charter products. Charter flights have no schedule. The aircraft departs when the client is ready, not when the aircraft operator is ready as with commercial carriers. On-board passenger amenities and comfort far exceed any commercial travel product. Charter operations safety and experience requirements mandated by the FAA under Part 135 are as stringent as those imposed on commercial carriers operating under FAR Part 121. The fact that these four items are cited as negative aspects of charter products indicates a lack of deep knowledge and information regarding the charter business segment.

The sixth reason cited for not considering charter products, negative impression on stockholders, can again be viewed as a benefit of using charter products. If a business is functioning properly and rational business decisions are being made, it is unlikely that a stockholder revolt will occur because management utilizes charter products in situations that save the firm time and money.

The seventh reason for not considering charter, loss of frequent flyer miles, although a potential valid reason for individual travelers to reject charter products, is incidental to business travel practices. When charter products are more widely accepted and charter service providers are effectively engaged in direct competition with commercial carriers, it is not unreasonable to expect charter frequent flyer programs to emerge.

Magazine Survey

Over a two-month period, in the third quarter of 2000, a total of 8,684 magazine pages contained in sixty-two independent magazines were scrutinized for charter oriented advertisements. Any page containing at least one paid commercial advertisement was counted as a page of text. During this time frame, only one magazine contained an advertisement

related to any aspect of charter activity. Interestingly, this advertisement was found in an aviation industry specific publication. The message was generic in nature, not addressing any advantage or convenience of charter travel products. This advertisement, less than full page in length, appeared only once during the two-month period.

Two other aviation-oriented advertisements were found among the 8,684 pages reviewed. One was placed by a commercial carrier and highlighted the carrier's schedules and destinations. The second aviation oriented advertisement was placed by a fractional ownership organization extolling the virtues and benefits of fractional programs.

Monitoring sixty-two magazines, whose collective readership focus was senior level decision-makers across a broad spectrum of industries, revealed one publication containing one advertisement offering generic charter information. This advertisement was found in a magazine that specifically targeted aviation industry decision-makers.

But for the existence of one advertisement placed by a well known fixed base operator, the market channel investigated was void of charter content.

CONCLUSION AND RECOMMENDATIONS

Commercial carriers seek to maximize yield per seat departure. Business clients are bearing a disproportionately high share of yield maximization efforts. Inability of most business travelers to predict and schedule travel in advance permit commercial carriers to price business products at exceedingly high yield levels, thereby bolstering system and route yield averages. Business traveler dissatisfaction with commercial carrier travel products has lead business clients to begin investigating alternative modes of transport. Charter products can represent fiscally sound time-weighted alternatives to commercial carrier product offerings.

Escalating business yields and fare structures together with poor quality ratings represent fundamental systemic problems inherent in the commercial carrier environment. These systemic problems detrimentally all passengers, but are most heavily felt by business travelers. These inherent systemic problems also provide a market entry point for charter products to compete effectively against commercial carrier products for business travel revenues. The primary concerns of any business traveler are time and productivity. Were it not so, business travelers would have long ago divorced themselves from the predatory pricing practices of commercial carriers. In fact, many large firms have done just that by acquiring and operating their own fleet of aircraft. Business travelers not having access to corporate fleets are beginning to examine charter products as viable options to commercial travel products. Itinerary flexibility

coupled with point to point service to vastly greater numbers of airports frequently closer to the travelers' ultimate destination are powerful marketing tools that can be exploited by charter service providers to capture business travel revenue. Two questions remain. First, are business travelers, business travel coordinators and travel agencies sufficiently informed, educated and knowledgeable of charter products and practices to be able to examine and correctly evaluate charter as an option to commercial travel? Second, are charter service providers offering sufficient educational and informational guidance to the business travel market segment to fill the informational gap and capture market share from commercial carriers? This study would seem to indicate not.

Businesses surveyed indicated they lacked comprehensive understanding of the charter marketplace. Businesses surveyed further indicated that should they desire to examine or purchase charter products as alternatives to commercial products, they would rely on travel coordinators and travel agencies to make the arrangements. Travel agencies surveyed indicated they also lacked comprehensive understanding of the charter marketplace as alternatives to commercial business products. This survey demonstrated a massive informational void among business travelers, travel coordinators and travel agencies regarding viability of and access to charter products.

For the charter business segment to compete effectively against, and capture market share from commercial business product offerings, any charter marketing efforts must be subordinated to charter educational efforts. Current situational analysis revealed by this survey indicates that all parties must first fund and engage in programs of informational and educational exchange before funding and engaging in targeted marketing programs. Failure to first educate and then market will comply with Gresham's law of throwing good money after bad. Business travelers must be given tools to properly evaluate cost/time comparisons of charter and commercial travel products. Travel coordinators and travel agencies must be given tools to access, query, book and track charter products. Charter service providers must be given tools to effectively interface and integrate product offerings with existing travel coordinator and travel agency systems and protocols. Conducting this type of focused mutual educational bootstrapping will also serve to define appropriate charter product distribution channels.

Charter Operators, acting individually or as a consortium, or through several national associations such as NBAA and, NATA can begin the process by working with local travel agencies. They teach the agency what charter products are, how they are priced, booked and conducted. The agency then teaches the charter operator how travel agencies function and

how client trip requests are managed. Once familiar with each other's functional requirements, the agency can then act as field representatives for the charter operators. There exists strong motivation for the travel agency to function in this manner. As one Chicago travel agent stated, "We are getting damn tired of what the commercial carriers are doing to us." His lament concerned the fact that commercial carriers are rapidly abandoning once powerful linkages to travel agencies by cutting commission structures in favor of alternate direct passenger booking systems. According to Wells (1996), travel agencies supplied commercial carriers with eighty percent or more of their bookings. Today direct passenger booking technologies are rapidly eroding the volume of travel agency bookings and commercial carrier commission caps are rapidly eroding travel agency revenue streams. These factors have led to dissolution of the airline-travel agency marriage. These factors also suggest the timing is right for the charter operations business segment to begin courting travel agencies. As was demonstrated by commission relationships on the St. Louis to Hartford itinerary, travel agencies see lucrative revenue gains available by entering the charter market.

The data indicated end users; business travelers are strongly receptive to obtaining deeper understanding of charter products as 84 percent responded they would like more information on cost-benefit comparisons of commercial carrier versus charter products. The data also indicated that distribution agents, travel agencies, are equally strongly receptive of obtaining deeper understanding of the charter alternative as 92 percent responded they would like more information on how to query, offer and book charter products. It is important to note that at this juncture, this apparent strong pent-up demand is not for charter products but for charter product information. Translating this demand for information into demand for the underlying charter product will involve a paradigm shift away from long standing business travel purchase patterns and psychology. The ability of the charter business segment to compete with and glean market share from commercial carriers is directly correlated to providing and disseminating sufficient information to allow end users and distribution agents to justify the paradigm shift.

Dissemination of meaningful and relevant charter product information to business travelers, travel coordinators and travel agencies can be accomplished in a variety of ways. Charter operator associations are one logical starting point. These associations could be called upon to develop informational programs specifically tailored to travel agencies. These programs could be administered as short course seminars conducted at key regional locations and/or presented at travel agency national conventions. These programs could also be delivered to individual travel agencies by

local charter operator sales forces. Web based distance learning technologies could also be employed effectively. A prime benefit of this association approach would be that all charter service providers would be presenting the same information in the same format.

Another informational dissemination channel available are charter marketing portals. Charter portals are organizations that market charter products directly to the end user and feed charter bookings to an inventory of charter operators who have contracted to supply lift to the portal. Portals are a relatively new construct. They function as charter specific travel agencies who coordinate all aspects of the client's trip. Inherent in the charter portal model is the necessity to educate the business traveler to the benefits of charter products versus airline products. It remains to be seen if charter portals are able to effectively compete with and glean market share from commercial carriers, but the educational nature of current portal marketing efforts is clearly a step in the right direction.

Irrespective of whether either or both of the above options are acted upon, each charter operator can, and must, call upon local travel agencies and establish dialogue. Travel agencies can be powerful allies in advancing charter product sales, but only if they are equipped with the tools and knowledge to act. Significant growth opportunities exist for the charter operations business segment. As John Maynard Keynes stated: "All that is required is a small, a very small amount of clear thinking."

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Exhibit 1

**Telephone Survey Questions
Business Survey**

Name of Business: _____

City: (Circle One): Chicago St. Louis Kansas City

1. Does your organization either own or operate aircraft for business reasons?
A. Yes B. No
2. Does your organization have its' own flight department?
A. Yes B. No
3. Is there someone specifically assigned the responsibility of making flight arrangements for personnel travelling for business purposes?
A. Yes B. No
4. Are personnel travelling for business purposes permitted to make their own travel arrangements (specifically airline bookings)?
A. Yes B. No
5. Does your organization have a specific policy or procedure that states how reservations and/or corporate business bookings are to be made?
A. Yes B. No
6. If your personnel are not utilizing a corporate aircraft how are most airline reservations made?
A. In-House Travel Manager B. Travel Agency C. Direct with Airline
D. Individual Traveler's Choice D. No Idea E. (Other): _____
7. With regard to business travel, does your organization ever have groups of 4 or more traveling together on commercial airline flights?
A. Yes B. No C. Don't Know
How Often?
A. Often (more than once/month B. Occasionally (once a month)
C. Sometimes (once a quarter) D. In-Frequently (rarely)
8. Generally, what is the lead time for booking most of the commercial flights?
A. Less than one week (7 days) B. Two weeks C. More than two weeks

9. Has your organization ever considered using an on-demand charter operator for your corporate (business) needs?
A. Yes B. No
10. If you would consider booking a charter, how would you make the arrangements?
(Record all responses, i.e. Call local FBO, contact airline and etc.)
11. If someone could show you a cost-benefit analysis that indicates chartering an aircraft may actually save your business money over commercial air travel, would you be interested?
A. Yes B. No C. Not Sure D. (Other): _____
12. Based upon your own understanding of the travel market, what in your estimation would be the most compelling reason to not consider using a charter aircraft for business purposes?
(INTERVIEWER: Do not give any alternatives, write down only those reasons given)

Exhibit 2

**Telephone Survey Questions
Travel Agency Survey**

Name of Agency: _____

City: (Circle One): Chicago St. Louis Kansas City

INTERVIEWER: After explaining the reason for the survey, how they were selected and determining their willingness to participate, tell them you would like to give them a hypothetical booking to see how fares and itinerary are developed with the aid of their computer reservations system.

1. "If time is permitting, could you please give me an itinerary and a fare quote for the following: I would like a flight that can accommodate seven people, all travelling together. The origin is St. Louis, Missouri and the destination is Hartford, Connecticut. They would like to travel on Tuesday morning and return that same evening from Hartford to St. Louis."

2. If in the above scenario I would ask you if using an on-demand charter we a viable alternative, what would you respond?
(record individual answers)

3. What would you consider as the best way to obtain information concerning a charter flight?
(record individual answers)

4. To your knowledge has the agency ever been called on or approached by a sales representative or agent representing charter operation/operator?
A. Yes B. No C. Possibly D. (Other): _____

5. To your knowledge has the agency ever had a formal presentation made by a representative or sales representative of a charter operator?
A. Yes B. No C. Possibly D. (Other): _____

6. To your knowledge has the agency ever received any literature, pamphlets or information concerning charter bookings or operations?
A. Yes B. No C. Possibly D. (Other): _____

7. To your knowledge has the agency ever sold a charter flight?
A. Yes B. No C. Possibly D. (Other): _____

8. If the commission provided by on-demand charter operators was equal to, or greater, than that given by the commercial air carriers, would your agency consider selling the charter product?
- A. Yes B. No C. Possibly D. (Other): _____
9. In the operation of your travel agency do you have client companies whose bookings you generate that have groups of employees travelling together for business purposes? In this regard we are talking of four or more people travelling on the same itinerary.
- A. Yes B. No C. Possibly D. (Other): _____
10. From the little we have discussed about the charter business, would you consider talking to your clients about booking a charter flight over a commercial carrier?
- A. Yes B. No C. Possibly D. (Other): _____

FUTURE OF COLOMBO AIRPORT (CMB) AS AN AIRLINE HUB

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ABSTRACT

Aviation throughout the world has seen profound changes within the last two decades. Today more and more airports are looking for hub operations. However, as the success of hub operation would depend on a number of parameters such as geographic location, route network, facilities available, passengers' acceptance etc. not all airports would be able to operate as successful hubs.

This paper investigates the possibility for the Bandaranayake international airport, Colombo, Sri Lanka (CMB) to emerge as a hub airport in the South Asian region. It is found that CMB is situated in a geographically advantageous position in the region with respect to the airline route network. Comparison of travel distances between CMB and prominent O-D pairs and evaluation of airline schedules at relevant established hub airports indicates that CMB could operate as a directional hub serving the South Asian market if the number of destinations with daily flights could be increased.

INTRODUCTION

Fifty years ago, air transport was a very small industry. Air travel was expensive and was restricted to a small segment of the population. However, in 1999, more than 1.5 billion passengers were carried on schedule airline services, equivalent to approximately 25 percent of world population as against an equivalent of 1/2 percent of world population carried on scheduled carriers in 1945. According to the International Civil Aviation Organization (ICAO 2000), the world scheduled airline traffic would increase at an average annual rate of over 5 percent by the year 2002.

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Asia/Pacific region is expected to grow at the highest rate among ICAO regions.

During the periods where governments exercised tight control and regulations, authorities had to find means of financing large scale investments required for the production of new aircraft and modernization of old fleets due to the growing demand for air travel, improved safety regulations and pressure for highest environmental controls. This resulted in the deregulation in airline industry in U.S. in late 1970s. The next wave of activities that followed the deregulation were part or total privatization of airlines and airports implementing open-sky policies to allow market forces to determine the destiny of the national carriers and the aviation industry.

Another development, which took place around the same time, especially in U.S., is the consolidation of few airports as collection centers for passengers and cargo. These types of airline route networks have become increasingly popular around the globe due to the economies derived by the airlines and airport authorities (Jemiolo & Oster, 1987). Airports that act as collection centers have benefited by the increased number of aircraft and passenger movements. Airlines that operated such schedules have benefited by dominating their presence at one location thereby creating an effective monopoly and deriving economy of scales by operating large aircraft. This phenomenon is called hub operation.

The objective of this paper is to investigate the viability of hub operation in the future at the Bandaranayake International Airport (CMB), Colombo, Sri Lanka which is located just South of India approximately 7° N and 80° E (Figure 1). CMB is just 20 km from the capital city Colombo and is the only International airport serving the Island's 19 million population.

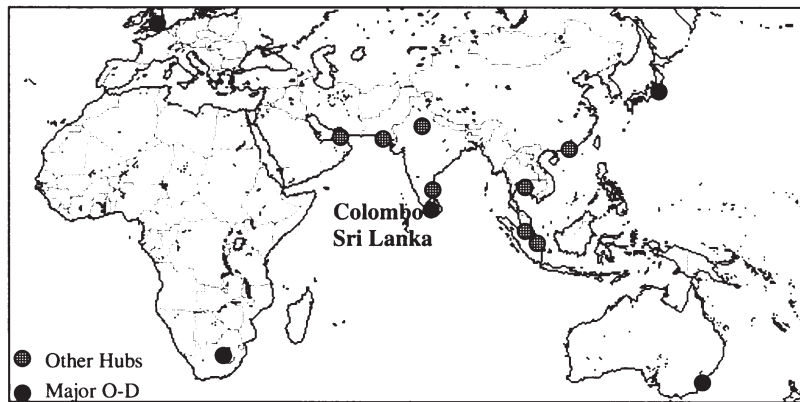


Figure 1. Location Map

Sri Lankan (formally Air Lanka) airline is the national flag carrier in Sri Lanka, which is based at CMB. At present Sri Lankan airline is a partner of Emirates Airlines and also managed by Emirates officials.

PROBLEM IDENTIFICATION

Airports world over make huge investments on capacity improvement and facility upgrading to meet the growth forecasts in passenger and cargo movements. International Civil Aviation Organization (ICAO) and other leading aircraft manufacturers predict the highest growth indices to emerge in Asia (ICAO 1995, 2000).

The hub concept is a phenomenon that can be considered on the rise in the air transportation system outside U.S. In a hub airport, a network of inbound and out bound flights are conveniently scheduled for efficient connections without having the need to have direct flights to several destinations from all regional airports.

In this backdrop, the need to upgrade the air transportation system in Sri Lanka seems appropriate. However, knowing the limited population of the country and its leverage on future capacity requirements at CMB, the need to evaluate other possibilities to benefit from the expected growth is in order. Management decisions on future strategic direction influences the infrastructure facilities and their capacities in the future airport. Due to the nature of the industry and the presence of different stake holders with varying influences on operations at an airport, such corporate decisions should be based on careful analysis of viability and its implications on all stake holders; airport, airlines, passengers, local community and the government.

HUBBING AND ITS IMPLICATIONS

A hub is an airport used by an airline or airlines, passenger and cargo, as a coordinated point, with several flights arriving in a short time period from several origins, allowing time for connections, and departing in a short time period to several destinations. Hub operations expanded mainly because of the carrier's need to derive economies of scale by operating larger aircraft and the need to monopolize its presence at one airport by offering higher schedule frequencies (Rubin and Jeng, 1993).

Hubs provide passengers with the preferred time of day slot for travel with increased schedule frequency, which eventually reduce the schedule delay time. Schedule convenience, is the prime reason for most passengers to choose between airlines. Airlines in exploiting economy of scale at the hub airport, offer passengers the convenience of flying in larger more

efficient aircraft in more comfort (Kanafani & Ghobrial, 1985). Another convenience for the passengers looking for one stop shopping is the ability to find most of the preferred destinations within the network of one carrier which eventually helps to keep the transaction cost to a minimum (Dempsey & Gesell, 1997). Ghobrial (1991) showed that increased emphasis on hubbing alone would not guarantee airline profitability unless it is associated with airline dominance at the main hub used for its operations.

Airport authorities have benefited from the increased traffic at the hub airport and its potential to reduce dependency on aeronautical revenue as the main source of income. In Asia, this trend will continue for some time due to the growing demand for duty-free shopping. But with the increased emphasis on reducing the turnaround time at hub airports, the future of commercial revenue expected of franchises, rentals, concessionaires may not be lucrative. Kanafani & Ghobrial (1985) in studying implications of hubbing on airport economics, revealed the negative impacts of congestion at hubs and a potential trend to impose hub penalties such as increasing the fare and raising breakeven load factors to secure adequate returns on increased investments required to support hub operations. They have also given increased congestion as a reason for major hubs to lose attractiveness and as an opportunity for new hubs to emerge.

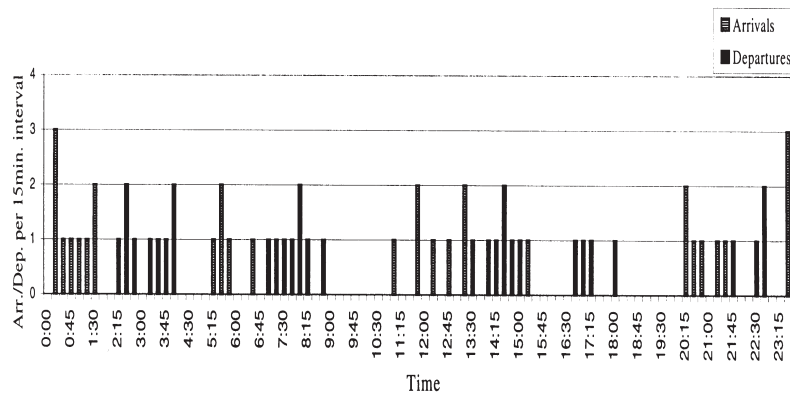
METHODOLOGY

The geographic location of Colombo with respect to the possible catchment area and the established hub airports in the region was studied based on route lengths between prominent origin-destination pairs. Airline schedules at established hub airports in the region (Singapore, Changi [SIN] and Dubai [DXB]) and well established European hub airports that have direct connections to the study region (London, Heathrow [LHR] and Amsterdam, Schipol [AMS]) were analyzed in detail to identify characteristics of schedules of major carriers at their respective hubs. These were then compared with the present schedule at Colombo (CMB). Data collected from a questionnaire survey carried out among frequent airport users were used to identify the passenger preferences at a hub airport and their attitude towards the facilities available at CMB. Passengers who have flown at least 3 times during an 18-month period were interviewed with the help of airline ticket agents.

SCENARIO TODAY

Aircraft sizes changed over the years and will continue to grow as long as it can bring economy of scale to all stakeholders in air transportation.

With the present trend to develop mega carriers, the need to have collection centers to consolidate and collect passengers will continue. The degree of concentration of airline’s operations at a particular airport will be the primary indication of hubbing. Any flag carrier will enjoy this status by concentrating its operations at the country’s international airport and contribute the primary element in creating a hub. Analysis of airline schedules at the selected airports clearly shows the basic premise at hub airports arrivals feed departures. For example, Emirates Airlines’ movements at the Dubai international airport on a Saturday shows how the departures are scheduled after a set of arrivals (Figure 2). Emirates offers schedule convenience by limiting the connection time to a maximum of 3 to 4 hours as evident from the hub duration.

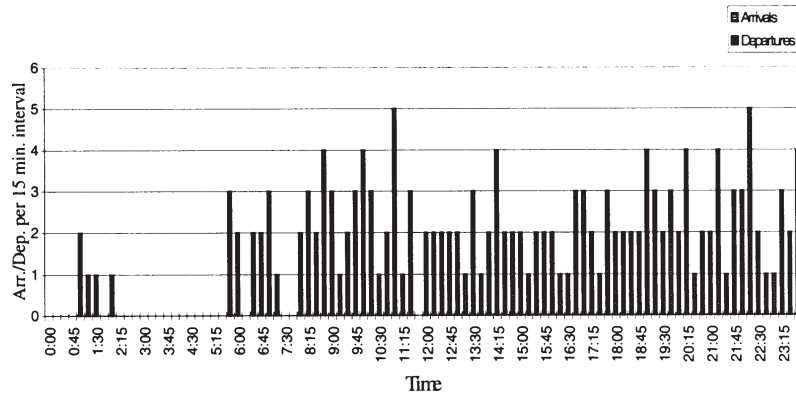


Source: Emirates Airlines Timetable, June/October 1998

Figure 2. Emirates—Movements in Dubai on a Saturday

When several airlines present at a hub, airlines prefer the prime slot with many flights to collect more connecting passengers. This eventually results in severe peaking of facilities and services, which airport authorities would like to spread over the entire period. Figure 3 indicates an attempt to spread the demand while maintaining a hub schedule pattern at Singapore Changi airport. A similar pattern can be observed on all seven days of the week.

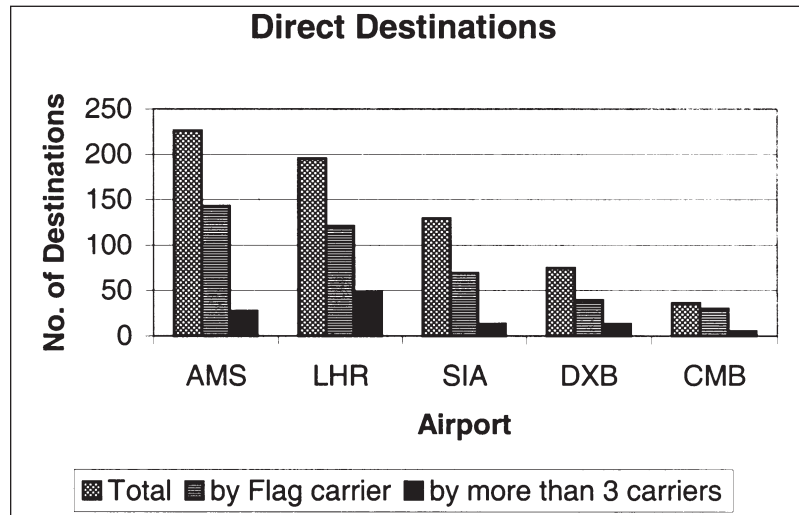
Analysis of published schedules (Official airline guide) at few major European, Middle East and Asian hub airports indicate a relatively higher number of direct destinations offered as compared to less hub networks. These schedules also show the presence of one strong carrier sharing the lion’s share of these destinations, which in this case was the country’s flag carrier. Another factor that indicates successful hubbing is the degree of schedule convenience. One measurement of this could be the ratio between the number of destinations with daily frequency to the total number of



Source: Singapore Airlines Flight Schedule, October 1998.

Figure 3. Singapore Airline Aircraft Movements at Changi Airport on a Sunday

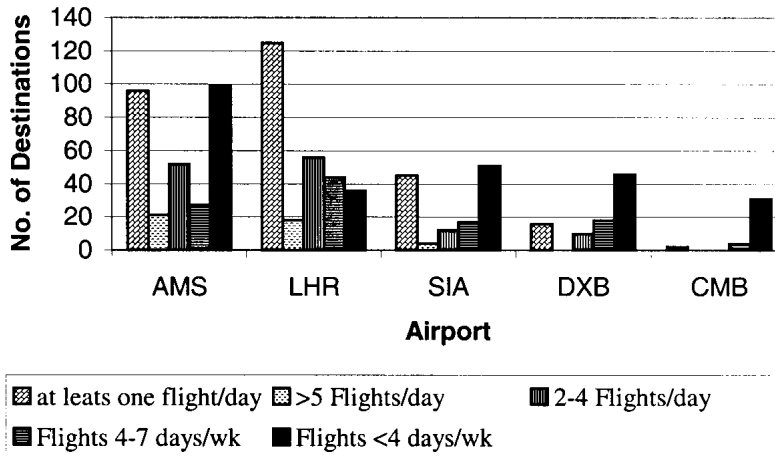
direct destinations offered at the airport. Another indicator of schedule convenience is the share of destinations that offer a choice of carriers (more than three different carriers) out of the total number of destinations offered at the hub airport. Comparison of airline flight operations between destinations with direct flights and flight frequencies at the above selected airports are given in Figures 4 and 5, respectively.



Source: Official Airline Guide 1997

Figure 4. Flight Operations at Selected Hub Airports

Flight frequency

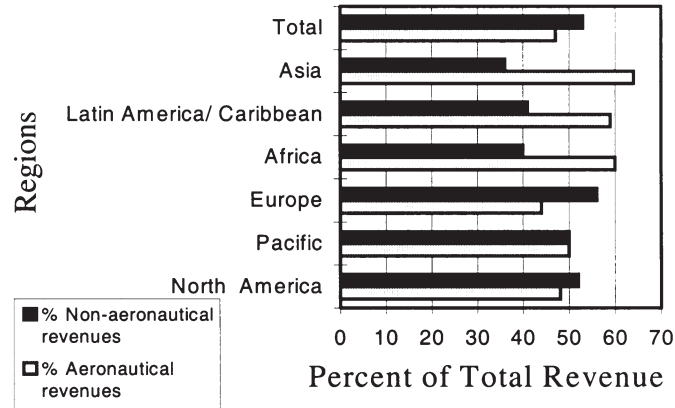


Source: Official Airline Guide 1997

Figure 5. Flight Frequencies at Selected Hub Airports

It can be seen that the National carrier dominates schedules at the CMB, which operates to 30 destinations out of the 36 direct destinations offered. However, at present only 2 of the 36 destinations offered through CMB have daily flights. At Schipol (AMS) and Heathrow (LHR), nearly 50 percent of the destinations have daily flights. Close to 10 percent of the total direct destinations offered have more than 5 flights per day by one single carrier and approximately 10 percent and 15 percent of the total destinations are served with three to four different carriers respectively.

Revenue to an airport mainly consists of the aeronautical revenue and the commercial revenue. Landing, parking and over flying charges for aircraft are considered as aeronautical revenue of an airport. Commercial revenue constitutes the moneys received from duty-free, concessionaires, rental, fuel throughput, airport tax and vehicle parking. With the development of air transportation and increased emphasis on hubbing, the historic view of the primary source of airport revenue is changing from aeronautical to commercial. While hubbing tends to increase the passenger enplanement at the airport, the best way to gain the full benefit of this trend should be evaluated, for an inter-regional and intra-regional passenger. Figure 6 shows the distribution of total revenue among aeronautical and non-aeronautical (commercial) sources in each region. It can be seen that the potential to increase the non-aeronautical revenue in the Asian region.



Source: Air Transport World (1997)

Figure 6. Airport Revenue as per Region

COUNTRY'S VIABILITY TO EMERGE AS A HUB

The survey on passenger preferences in selecting a transfer airport was done to identify what attributes passengers do expect from a hub airport and on what grounds they are willing to change their transit airport choice. Since this was done with a predominantly local market there is little relevance to the viability of hub operations. According to the responses from passengers who have flown at least 3 times during a 18 months period, majority preferred a direct route in spite of any offers attached to other options via a hub airport. If several offers were available to a passenger to encourage travel through a hub, the priority order of selecting a particular route is as follows; i) cheaper fare than flying direct, ii) reliable schedules at the hub airport and iii) one night stay free of charge.

In selecting a transfer airport out of several equal cost options, lowest transit waiting time appeared to be the first choice. With respect to terminal attributes of a hub airport, quick and convenient check-in facilities, user-friendly passenger guidance, clean and tidy buildings and reliable baggage handling system have been identified as the top requirements of a good transfer facility.

Runway and Taxiway facilities at CMB have the capacity to handle the expected aircraft movements for next 15–20 years. There is no restrictions and night curfew. Hardly any situations where the runway had been closed due to bad weather. The passenger movements at CMB have increased from 0.15 million in 1972 to 2.65 million in 1999. During the last 10 years the CMB has recorded annual growths of 10 percent, 6 percent and 13.5

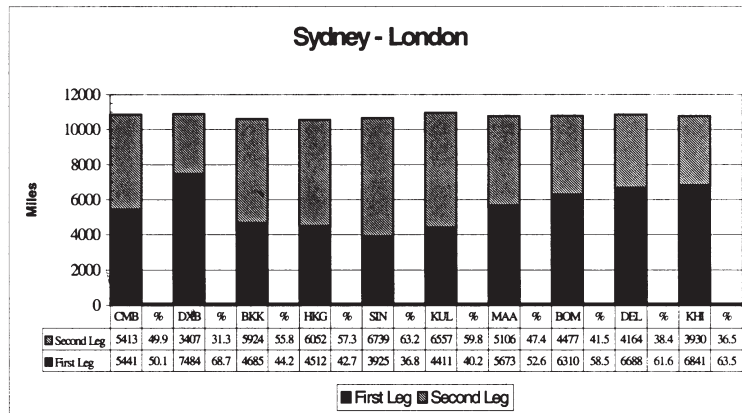
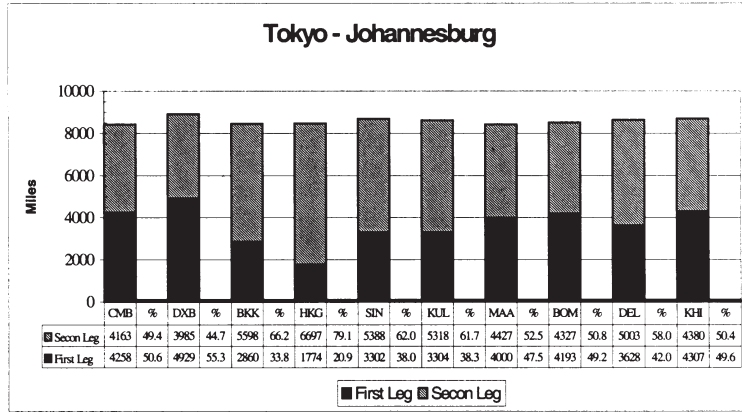
percent of passenger, aircraft and cargo movements respectively. CMB has already started the development of its terminal building and the air navigation system with the help of external funding (AASL, 1997).

Despite the terrorist activities in the northern part of the island Sri Lanka has shown a healthy and steady increase in country's economy. This is evident from the average annual increase of 5–6 percent in Sri Lanka's GDP during the last 7 years and steady increase in per capita income (Central Bank, 1999). The above shows that CMB has a potential to grow and will be able to accommodate any increase in aircraft traffic in the near future.

The primary characteristic of a hub airport can be considered as its geographical location that allows flights from several directions. According to Dempsey & Gesell (1997), the main direction for business traffic is from East to West. Accordingly, the biggest comparative advantage Sri Lanka has over the other established hubs in the region in terms of its potential to develop and sustain hub operations is its geographic position in the cross roads between N-E to S-W and S-E to N-W traffic. The approximate travel distance between prominent O-D pairs through established and potential hubs in the region shows that CMB is located closer to the direct route between the O-D's, specially with respect to N-E to S-W traffic (Table 1 and Figure 7).

Table 1. Distances between Selected Hub Airports

<i>Hub Airport Selected</i>		<i>Distance (Miles)</i>					
		<i>Tokyo-Johannesburg</i>			<i>Sydney-London</i>		
		<i>1st Leg</i>	<i>2nd Leg</i>	<i>Total</i>	<i>1st Leg</i>	<i>2nd Leg</i>	<i>Total</i>
Dubai	DXB	4929	3985	8914	7484	3407	10891
Bangkok	BKK	2860	5598	8458	4685	5924	10609
Hong Kong	HKG	1774	6697	8471	4512	6052	10564
Singapore	SIN	3302	5388	8690	3925	6739	10664
Kuala Lumpur	KUL	3304	5318	8622	4411	6557	10968
Madras	MAA	4000	4427	8427	5673	5106	10779
Bombay	BOM	4193	4327	8520	6310	4477	10787
Delhi	DEL	3628	5003	8631	6688	4164	10852
Karachi	KHI	4307	4380	8687	6841	3930	10771
Colombo	CMB	4258	4163	8421	5441	5413	10854
Direct				8420			10562



Source: <http://www.indo.com/distance/>

Figure 7. Distances through Selected Hub Airports

It can also be shown that Colombo (CMB) and Madras, India (IXM) more centrally located as a secondary hub in the region with respect to the airports selected in the Asian region (Table 2). There is the possibility of Madras (MAA) developing its airports to benefit from their geographical position. However, the very strong local market in India and the present marginal level of international traffic originating from MAA, it will not be necessary for the authority in India seriously look to exploit hubbing at MAA in the near future.

Table 2. Route Lengths between Selected Airports

<i>From</i>	<i>Distance (miles)</i>									
	<i>DXB</i>	<i>BKK</i>	<i>HKG</i>	<i>SIA</i>	<i>KLIA</i>	<i>CMB</i>	<i>IXM</i>	<i>MUM</i>	<i>DEL</i>	<i>KHI</i>
DXB		3026	757	3615	3431	2048	1821	1196	1363	735
BKK	3026		1099	885	740	1479	1367	1867	1816	2298
HKG	3757	1099		1593	1561	2555	2371	2734	2404	3033
SIA	3615	885	1593		187	1619	1801	2419	2578	2930
KLIA	3431	740	1561	187		1527	1620	2235	2394	2744
CMB	2048	1479	2555	1619	1527		415	951	1518	1493
IXM	1821	1367	2371	1801	1620	415		638	1110	1180
DEL	1363	1816	2404	2578	2394	1518	1110	737		679
KHI	735	2298	3033	2930	2744	1493	1180	547	679	

From the viewpoint of passenger convenience, this positioning offers another remarkable advantage that most airline passengers prefer. This is the central location of the country. Most passengers flying in excess of 14-15 hours prefer a stop halfway to break the journey than to fly for 3 to 4 hours and then to set in for a journey in excess of 12 to 13 hours (Hill, 1999). Figure 7 shows how Colombo is centrally positioned with respect to other regional airports for traffic from N-E to S-W and S-E to N-W.

CONCLUSIONS

The geographic position of Colombo in the crossroads between N-E (Japan, Korea) to S-W (South Africa) and S-E (Australia) to N-W (Europe) is the most favorable comparative advantage it has for viable hub operations. Other factors include the availability of a strong home based carrier with a well connected network of destinations, a huge catchment area in South India and in the South Asian region, and year-round favorable weather conditions. However, for Colombo to develop as a secondary hub in the South Asian region, it is necessary to have an increase in flight frequencies. The number of destinations with daily direct flight should be increased to maintain viable load factors and to provide attractive schedule frequencies.

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