

CONCLUSIONS AND RECOMMENDATIONS

The present state of the U.S. air carrier industry can only be viewed with ambivalence. There is much to praise; at the same time, there are genuine causes for concern. Had Charles Dickens written his famous opening line from *A Tale of Two Cities*, "It was the best of times, it was the worst of times" some one hundred and thirty-three years later, he might well have been speaking of commercial aviation in the United States.

The recent performance record of U.S. commercial aviation carries some impressive statistics. In 1991, over 450 million passengers were carried in almost seven million departures. All of this was accomplished with an outstanding safety record. For this same year, there were only six accidents with fatalities. A total of 39 deaths occurred in these accidents, an unfortunate but nonetheless minuscule number when compared with that for highway transportation.

The contribution of U.S. airlines in meeting national transportation needs, combined with a commendable safety record, certainly is praiseworthy. Yet, expressions of concern can be heard. Safety continues to be a topic for two reasons. First, an airline accident draws attention. Even though more people may be killed in highway accidents on the same day, the aviation accident receives the press coverage and gains national interest. Second, older aircraft continue to fly as airlines delay earlier retirement plans for these aircraft.

Another topic of concern centers on maintenance personnel. The availability of an adequate supply of maintenance candidates over the next decade, the extent to which these candidates will be qualified for entry positions, and the training systems necessary to develop and maintain appropriate skills are continuing questions. As new aircraft, new airframe materials, and new avionics systems appear, these questions grow in importance.

A final, and quite serious, concern is over the financial condition of the air carrier industry. Last year, three major airlines stopped operating. Others continue to operate under the oversight of bankruptcy courts. As one can imagine, control of operating expenses is a matter of great importance for airline management. Maintenance costs must be considered here inasmuch as these costs have risen from \$5.5 billion in 1986 to almost \$9 billion in 1991. Maintenance represents a major cost item.

Issues of airline safety, personnel utilization, and operating costs all are directly affected by maintenance. Over the coming decade, maintenance can make a positive or negative contribution to airline viability depending on the extent to which issues impacting maintenance are understood and managed. The objective of this meeting is to define the issues and problems likely to be faced by air carrier maintenance in the coming decade. The goal of this meeting was to review all topics that would ensure over the next 10 years:

- Continuing improvement in the quality and effectiveness of air carrier maintenance.
- Productive and efficient utilization of maintenance personnel.
- Incorporation of new technologies beneficial to the air carrier maintenance industry.
- Adherence to rigorous cost control procedures.

Those attending this meeting represent all segments within the air carrier industry, including airline operators, manufacturers, maintenance managers, union representatives, regulators, information management and computer scientists, and others. Formal presentations given during the two days covered a variety of topics related to trends in maintenance today and new technologies likely to impact maintenance performance during the coming decade. Recommendations concerning the management of major issues likely to be faced by maintenance in the future were offered during formal presentations, during ensuing discussions, and during a final closing session. The following recommendations represent a grouping and synthesis of broad topics considered important by attendees, with specific recommendations included within each topic.

The Maintenance Workforce

The viability of the air carrier industry is dependent on an effective maintenance workforce, available in adequate supply and well-trained to meet the demands of maintaining the complex airliners of today and tomorrow. Considerable attention has been given to the availability of candidates for jobs as aviation maintenance technicians (AMTs) in the year 2000. This was a major topic in the Fourth Human Factors Conference entitled "*The Aviation Maintenance Technician*", held in December 1990. Since that time, many pros and cons concerning the seriousness of the maintenance manpower problem in the future have been expressed.

Growth of the air carrier maintenance workforce has been steady. [Table 1](#) shows this growth in the five years from 1986 to 1991. Only the final year (1991) shows a decline in workers and this can be attributed to the demise of three air carriers during that year. Other than 1991, manpower growth has been relatively constant. In fact, during the ten years from 1981 to 1991, the number of AMTs employed in air carrier maintenance operations increased by almost 30 percent.

Table 1
Growth of the Maintenance Workforce

YEAR	MECHANICS
1986	47,651
1987	51,233
1988	55,001
1989	57,282
1990	60,952
1991	58,819

Source: *Air Transport Association* (1992)

Just how large a maintenance workforce will be needed by the year 2000? The growth of this workforce certainly will approximate that of the air carrier industry itself. Forecasts by the Air Transport Association, based on FAA projections, indicate that airlines will carry almost 650 million passengers in the year 2000. This is approximately a 45 percent increase over the passenger volume of 1991. If the maintenance workforce were to increase at exactly the same rate as the industry grows, an additional 26,500 AMTs would be needed by the end of the decade. Other projections are for an even greater increase. The Future Aviation Professionals of American (FAPA) estimated several years ago that the industry would need almost 46,000 AMTs in the next ten years.

Without doubt, the size of the maintenance establishment to support air carrier operations will grow in the coming years. The issue is whether there will be an adequate supply of qualified applicants to fill the needs of this industry. National demographic forecasts suggest a serious problem may be developing. Reports by the Bureau of Labor Statistics indicate that, while the national labor force will grow between 1988 and 2000, there will be a 3.8 percent decline in the 25 - 34 year old age group. This is the age group from which most entry-level AMTs typically originate.

Balancing the above picture of a possible manpower shortage are a number of other factors. The workforce at the turn of the century will include a higher percentage of blacks and other minorities than is the case now. Women also will be present in larger numbers. Until this time, aviation maintenance has not drawn on these groups to any significant extent. If aviation maintenance begins to employ more members of these groups, as anticipated, the manpower availability problem may be lessened.

Finally, there is another variable whose potential impact is not known. Last year, three major U.S. carriers (Pan American, Eastern, and Midway) went out of business. When these airlines stopped operating, a considerable number of maintenance personnel became unemployed. Will they gradually be absorbed by other airlines; will they be employed in some comparable but different technical industries; or will they simply retire? At the moment, there is no clear picture. However, these previous maintenance employees represent a well-trained group with known credentials on which the industry can draw.

Recommendation

1. Demands to be placed on U.S. air carriers in the year 2000 can only be met with a fully staffed and well-qualified workforce. Questions have arisen concerning the adequacy of a supply of maintenance candidates at the end of the decade. If problems are foreseen for that time, planning for solutions must begin now. An in-depth study should be made of factors likely to affect the maintenance workforce in the year 2000. Study coverage should include evaluations of (1) manpower projections indicating a shortfall in the 25 - 34 year old group, (2) likely availability of women and minorities in the workforce and (3) the impact of release into the workforce of maintenance personnel from airlines ceasing operations.

Personnel Capabilities

Maintenance practices are changing and will continue to change as the airline industry grows and as a host of new technologies are incorporated in the aircraft of tomorrow. The Boeing 777 airplane exemplifies the aircraft for which maintenance technicians will be responsible in coming years. The 777 airplane is different and more advanced in many respects than those flying today. It uses a fly-by-wire flight control system and has advanced high-bypass ratio turbo fan engines. The airplane also has folding wing tips to make it easier to move into loading gates and maintenance spaces.

Of particular interest for maintenance personnel are the Electronic Library System (ELS) and the On-Board Maintenance System (OMS). The ELS is part of Boeing's program toward a "paperless airplane." Displays on either side of the instrument panel will be able to call up items such as flight operations manuals, navigation charts, and maintenance documents. The OMS will provide maintenance monitoring data and will allow functional testing. It includes a direct maintenance access terminal for technicians and has direct connections through the airplane so that a portable access terminal can be used.

The Electronic Library System and the On-Board Maintenance system illustrate the direction in which the maintenance industry and the tasks facing maintenance technicians are moving. The capabilities required of an aviation maintenance technician are changing as maintenance becomes ever more complex and demanding. More and more, technicians must be comfortable working with computer-based diagnostic, training and information management systems. The move toward these systems is impacting airline management, technician training, and technician hiring. While the exact manner of this impact is unclear today, planning for the air carrier world of the next decade should begin now. The Chief Project Engineer of the 777 program was quoted recently (*Aviation Week & Space Technology*, 20 April 1992) on issues Boeing faces in developing the Electronic Library System:

"The airlines need to decide how they are going to use information in the future and how information will be integrated across their entire business, including the 777 and the rest of their fleet and ground systems. It is not a trivial task."

The technician required to maintain aircraft of the future, such as the 777, must be different than today's technician in terms of capabilities, skills, and orientation. This person must understand new information management and information presentation systems. The primary source of new technicians will be specialized technical training institutions. These institutions, working with the Federal Aviation Administration, are responsible for delivering a product that is as advanced over the technician of today as the 777 is over other aircraft of today.

Recommendations

1. Aviation maintenance technicians increasingly need to work with computer-based systems to obtain necessary work instructions and supporting data. The next generation of aircraft will be capable of providing much of this information through on-board systems which present both diagnostic data and maintenance materials through computer displays. The industry goal of reducing human error to the lowest achievable level requires that this man-computer exchange of information be accurate and expeditious. A considerable number of studies have been made, many reported in *Human Factors*, the journal of the Human Factors Society, which seek to determine the parameters of an optimized computer display for various classes of information. These studies should be reviewed systematically for their application to work requirements projected for aviation maintenance technicians with the advent of aircraft such as the Boeing 777. To the extent that information to define an optimum computer interface is not available, appropriate research should be conducted. When this computer interface can be defined, consideration should be given to establishment of an industry standard for air carrier maintenance operations.
 2. The Federal Aviation Administration is planning to conduct a job task analysis of the aviation maintenance technician (AMT) position. The goal is to define the manner in which job activities are accomplished, the knowledge and skills required, the manipulative capabilities necessary, and the training required after certification. While the principal output of the job task analysis will be a clear exposition of the current AMT position, one part should review projected task demands and, on this basis, offer a picture of the AMT position in the future.
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Cost Factors

The U.S. air carrier industry is facing severe economic pressures from global competition, alternative transportation industries, and inter-airline competition within the United States. As these economic pressures grow, so do the operating expenses of the industry. From 1986 to 1991, operating expenses increased by about 28 percent while the number of scheduled departures increased by only six percent. Although the cost increase can be explained in large measure by increasing inflation during that period plus the rise in fuel costs during the Gulf War, the fact remains that air carrier operations are becoming increasingly expensive. The cost of maintenance operations, which regularly falls between 11 and 12 percent of total operating expenses, must be as carefully controlled as any other cost item.

Maintenance practices can affect industry costs in a number of ways. Delays due to maintenance can be quite expensive. As reported during the meeting, if a departure from the West Coast to the Orient is delayed for a maintenance fix, total costs for those who are deplaned can run as high as \$47,000. The need to meet departure commitments is obvious.

Other maintenance issues, some rather surprising, also can affect departure reliability. For instance, one report at the meeting discussed the impact of new technologies on the latest aircraft in service today. These aircraft, which themselves have generally satisfactory reliability, incorporate a number of high technology monitoring and sensing systems. Interestingly, these new systems are operating to reduce aircraft dispatch reliability. The report was that "false or overly sensitive alerts and warnings at departure time in these technology-laden cockpits has made these aircraft only half as reliable as those carrying less sophisticated equipment." The information provided by these monitoring systems obviously has not been fine-tuned to meet the real needs of maintenance and operating personnel.

Yet another cost issue can be found in the training of maintenance technicians. One airline reports incurring large training costs to improve the skills of newly hired technicians to a point where they can work with the complex technical equipment now being used in maintenance. As newer aircraft come on line and as advanced diagnostic systems are used, this problem will only get worse. Ways are needed to reduce the on-the-job training requirements for new hires.

Airlines are facing great pressures today to control costs. Maintenance expenses represent one cost element to consider although no airline would jeopardize quality of maintenance and flight safety. However, ways to reduce maintenance costs must be examined. The most obvious way is in terms of personnel utilization. To illustrate, between 1986 and 1991, there was a 23 percent increase in employment of maintenance technicians by U.S. airlines. Over this same five year period, scheduled departures by the airlines increased by only six percent.

Recommendation

1. Airlines are continually examining ways to reduce costs. No additional recommendation to do so is warranted. However, cost control efforts must continue, with a measure of these efforts directed toward maintenance. Since the aging aircraft issue came into prominence, primary attention within the FAA and the maintenance establishment has been on quality of maintenance. This attention now should be expanded to include "cost control in maintenance," giving it a priority immediately beneath quality. This attention, possibly through a joint FAA/industry team, should address:

- Ways to reduce the airline in-house training effort as new and more complex maintenance equipment is used.
- Procedures for assessing the efficiency as well as the effectiveness of maintenance work teams.
- Ways to facilitate the incorporation of new technologies, such as non-destructive inspection (NDI), through the industry as a means of making maintenance better and at the same time less personnel-intensive.