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Report to the Chairman, Subcommittee on Aviation, Committee on Public Works and Transportation, House of Representatives

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AIRCRAFT MAINTENANCE

Additional FAA Oversight Needed of Aging Aircraft Repairs (Vol. I)

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The Honorable James L. Oberstar, Chairman,
The Honorable William F. Clinger, Jr.
Ranking Minority Member
Subcommittee on Aviation
Committee on Public Works and Transportation
House of Representatives

In response to your September 19, 1989, request and subsequent agreements with your offices, this two-volume report provides information on the U.S. aircraft repair industry. Volume I describes that portion of the industry that performs heavy airframe maintenance on large transport aircraft. Specifically, it examines increases in demand for heavy airframe maintenance; constraints on supply, including parts, skilled mechanics, and hangar space; and air carriers' efforts to comply with the new requirements for aging aircraft and the Federal Aviation Administration's (FAA) oversight of air carriers as they attempt to comply with the new rules.

Volume II provides the questionnaire responses of the 48 air carriers and 35 independent repair stations participating in our review on the issues we examined in Volume I.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 15 days from the date of this letter. At that time, we will send copies to the appropriate congressional committees, the Secretary of Transportation, the Administrator, FAA, and the Office of Management and Budget. We will also make copies available to others on request.

This work was performed under the direction of Kenneth M. Mead, Director, Transportation Issues, (202) 275-1000. Major contributors are listed in appendix IV.

Kent O. Fulton for

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Executive Summary

Purpose

To ensure that the oldest portion—about 1,400—of the nation's 4,100-transport aircraft fleet remains airworthy, the Federal Aviation Administration (FAA) is requiring these aircraft to undergo extensive structural modification. Aircraft operators have until mid-1994 to finish the work; if they do not, FAA could ground the planes. Because of the pressure these requirements are placing on the aircraft repair industry, the Chairman and Ranking Minority Member of the Subcommittee on Aviation, House Committee on Public Works and Transportation, asked GAO to determine the industry's ability to cope with the approaching demand by airlines for repair services. Based on a survey of U.S. airlines and independent aircraft repair stations, this report examines

- the factors causing demand for aircraft repair to increase,
- the constraints on increasing the supply of repair services, and
- the air carriers' efforts to comply with FAA's new rules and the agency's approach to monitoring that compliance and overseeing enforcement.

Background

On April 28, 1988, 18 feet of the skin ripped from the fuselage of a 19-year-old Aloha Airlines Boeing 737 while the plane was in flight. The accident's probable cause was the carrier's failure to detect structural damage to an aircraft that had exceeded the manufacturer's expectation for its economically useful life—about 20 years for most models. This event led to industry recommendations to structurally repair or modify aging aircraft to extend their useful lives while retaining their original level of safety. FAA incorporated these recommendations into airworthiness directives (AD)—FAA's means of mandating changes to the carriers' maintenance programs. The 1,368 oldest members of the fleet—such as Boeing 727s, 737s, and 747s; and Douglas DC-8s, -9s, -10s, and MD-80s—are to have the AD work done before the 1994 deadlines. This creates substantial additional demand for aircraft repair.

Results in Brief

Although the current recession and the recent war with Iraq have decreased air travel demand and, in turn, airlines' demand for repair services, GAO believes that demand for repairs eventually will rebound. However, on the basis of the following factors, some of the U.S. fleet may not be repaired before the 1994 deadlines:

- The 1994 deadlines may not provide enough time to do the AD work.
- Some replacement parts are still scarce, airframe mechanics are in short supply, and hangar space has been marginally sufficient.

- Although 13 of 17 carriers GAO visited had written plans for complying with FAA's new rules, lack of action by 9 carriers—4 of which are major airlines—shows that they may not comply by the deadline.
- Almost 30 percent of the U.S. airline market is under financial stress due to debt, the recession, and high fuel costs and cannot afford to repair or keep many of their older planes in service.

FAA headquarters has asked its field inspectors to informally monitor carriers' progress in complying with the new rules. However, inspectors were not asked to determine why carriers will not meet the deadline. GAO believes that more definitive monitoring and data collection would enable FAA to determine whether problems with parts, personnel, and space will be overcome in time to achieve compliance and, if not, whether FAA's option of grounding all noncomplying aircraft can be tempered with alternatives that do not compromise safety.

Principal Findings

Aircraft Maintenance Demand Is Greater Than FAA Expected

The demand for airframe repair and maintenance during the 1990-94 compliance period will be much greater than FAA initially believed when it gave carriers 4 years to comply with the ADs. Although some carriers have not begun to complete the structural repairs—primarily because of financial problems—if air travel demand resumes after the recession, demand for aircraft repair should rebound. Therefore, the final 2 to 3 years of the compliance period could see heavy airline demand for maintenance services.

Air carriers believe that three factors contributed to FAA's underestimating the amount of repair work needed: (1) the estimates that FAA obtained from the aircraft manufacturers were based on ideal rather than actual conditions for making the repairs; (2) the time to repair substantial, unforeseen damage near the mandated repair was not included in the estimates; and (3) an additional maintenance workload is being created by other ADs—foremost are those related to airframe corrosion—issued several months after the structural ADs. Carriers told GAO that about 2,600 aircraft will be affected by the structural or corrosion ADs by January 1995, about twice the number affected by the structural ADs alone.

Shortages of Parts, Mechanics, and Hangars Threaten Timely Compliance

Although carriers should begin repairing their oldest aircraft immediately, resource shortages are causing airlines to postpone some AD work to the later years of the compliance period. For example, demand for some key parts is exceeding supply in the short-term because manufacturers may need up to 2 years to produce these parts. Boeing and Douglas are currently rationing scarce parts to the most needy aircraft; both manufacturers have taken steps to ensure that virtually all parts will soon be available. In addition, although the aircraft repair industry plans to increase its number of airframe mechanics by 35 percent by 1992, industry officials told us that the time needed to raise the productivity of inexperienced mechanics (2 to 3 years) could impair their ability to repair carriers' aircraft in the near term. Finally, a limited number of facilities have the hangar capacity to repair large transport aircraft. GAO found that current available hangar space is marginal; however, the industry plans to increase the amount of hangar space by 5.7 million square feet by the end of 1992 and by an additional 1.3 million square feet by the end of 1994—increases of 40 and 49 percent, respectively, over 1989 levels. Because much of the new space is for wide-bodies, capacity might be sufficient within a few years, provided the recession does not hinder construction plans.

Noncompliance Could Result in FAA's Grounding Planes

Air carriers' approaches to complying with FAA's ADs vary widely. In discussions with 17 carriers operating about 80 percent of the fleet, GAO found that 13 have written a compliance plan, 12 have secured hangar space, 10 have secured mechanics, 10 have planned to reduce their aging fleets, and 7 have ordered parts. Eight of the 17 carriers are engaged in four of the above five actions that GAO believes represent an adequate compliance approach and have made a creditable start on repairing their fleets. Six carriers have taken two or fewer actions. As of April 1991, 28 aircraft had been fully repaired and 705 had been partially repaired. On the basis of this progress, GAO believes the deadline may not be met. Moreover, many airlines that are slow to comply also are in poor financial health, probably because the high cost to repair aging aircraft deters financially weak airlines from complying.

Although FAA could ground aircraft not meeting the deadlines, other options include allowing an air carrier to continue inspecting an aircraft and fixing damage as needed, as long as airworthiness is ensured until AD modifications can be made. Grounding planes could affect air carriers' flight schedules and some carriers' financial survival; not

grounding them has safety implications. The best way to identify potential noncompliance and forestall its consequences is to stay abreast of air carriers' progress in completing the structural AD modifications.

Recommendations

To improve FAA's oversight of aging aircraft AD compliance, GAO recommends that the Secretary of Transportation direct the Administrator, FAA, to (1) require domestic air carriers to submit periodic reports on their implementation of FAA's new rules for aging aircraft, (2) submit to the Chairmen of the aviation authorization subcommittees in the House and Senate a semiannual report on the industry's progress in complying with FAA's aging aircraft mandates, and (3) explore options for extending compliance deadlines or granting alternative means of compliance when warranted by resource shortages and ensured airworthiness of each aircraft.

Agency Comments

FAA officials said that although accurate information was used in the report, some areas needed clarifying. In accordance with their comments, GAO changed the report as appropriate. FAA officials also believed that carrier reporting would impose a burden on the industry that is not warranted by the safety implications of GAO's report. In view of the limited time for which this reporting would be required, the cost of the ADs to the industry, and the threat to safety posed by fatigue and corrosion, GAO continues to believe that industry reporting is warranted.

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Abbreviations

AD	airworthiness directive
FAA	Federal Aviation Administration
PMI	Principal Maintenance Inspector
SB	service bulletin
TCAS	Traffic Alert and Collison Avoidance System

Introduction

Every day, about 1 million passengers fly on scheduled commercial airline flights in the United States. The Federal Aviation Act of 1958, as amended by the Department of Transportation Act, states that the safe travel of U.S. air passengers is the responsibility of the Federal Aviation Administration (FAA), an agency within the Department of Transportation. Individual air carriers[1] are responsible for safely operating and properly maintaining their aircraft according to FAA-issued regulations setting minimum acceptable standards of safety and maintenance. FAA, in turn, monitors the industry's compliance with the regulations and enforces them with civil penalties and other administrative actions.

About 1,400 of the 4,100 large transport airliners registered in the U.S. are considered to be "aging aircraft." Within the next 3 years these aircraft will reach or exceed their economic design lives—that lifespan over which their designers originally believed they could be economically operated. Although an airliner's lifespan is generally stated in terms of a number of years in service, takeoffs and landings, or hours of service, experts say that an aircraft can be operated indefinitely if it is maintained properly. To prevent human errors in inspection or maintenance and to better ensure the continued airworthiness of the U.S. transport fleet, FAA recently mandated an aging aircraft modification program based on recommendations from an aviation industry task force. As we reported in October 1990, this program will significantly increase short-term demand for aircraft repair services. It also faces obstacles such as shortage of skilled mechanics in some markets, unavailability of certain replacement parts, and the long time required to bring new maintenance facilities into operation.[2] In that report, we cautioned that airlines may need more than the FAA-allowed 4 years to complete the modification program for their aging aircraft.

FAA Oversees Airline Maintenance Programs

FAA and the airlines are jointly responsible for ensuring the safe travel of U.S. air passengers. FAA promotes aviation safety by issuing regulations that stipulate certain requirements that airlines must meet to operate commercial aircraft. For example, FAA is responsible for both certifying an airline's initial operations (assessing an airline's ability to carry out its proposed operations and the airworthiness of its aircraft) and monitoring the operations and maintenance of an airline's fleet.

[1] In this report "air carrier" refers to scheduled commercial airlines and air cargo carriers.

[2] See Aircraft Maintenance: Potential Shortage in National Aircraft Repair Capacity (GAO/RCED-91-14, Oct. 31, 1990).

Scheduled commercial airlines operate and maintain their aircraft under the Code of Federal Regulations, title 14 part 121 or part 135. Part 121 regulations apply to large passenger and cargo aircraft—those that carry more than 30 passengers or a payload greater than 7,500 pounds. Part 135 regulations apply to smaller aircraft—those that carry 30 or fewer passengers and a payload not exceeding 7,500 pounds. This report covers Part 121 carriers only—those that fly large transport aircraft.

To help ensure that airline operations are safe and that carriers properly maintain their aircraft, more than 2,100 FAA inspectors review air carrier personnel, aircraft maintenance, and other aspects of airline operations for compliance with federal aviation regulations under parts 121 or 135. About 930, or 44 percent, of these inspectors oversee the maintenance programs of the major air carriers (part 121), and about half these inspectors have a specialty in examining the structural airworthiness of aircraft.

Although FAA certifies new aircraft models as safe before the carriers use them commercially, it also issues airworthiness directives (AD) to address unsafe mechanical conditions that surface after the aircraft has been in use. ADs are FAA requirements for airlines to correct unsafe aircraft conditions that have occurred, or are likely to occur, in other aircraft of the same design. ADs also prescribe actions that airlines must take to correct identified problems in their aircraft. FAA becomes aware of most unsafe aircraft conditions through communications with aircraft manufacturers or reports of significant safety incidents such as landing gear or engine problems. Using engineering judgment, FAA decides if these conditions warrant an AD. The manufacturer usually prescribes the procedures needed to monitor and correct the unsafe condition, and FAA reviews and approves these procedures. FAA also establishes the time allowed for the airlines to comply with the AD. In determining the compliance time frames, which can range from a period for immediate action to several years, FAA engineers consider factors such as the severity of the unsafe condition, the availability of parts needed to correct the condition, and the potential economic impact the AD will have on the aviation industry.

Growing Demand for Air Carrier Services Results in Continued Use of Aging Aircraft

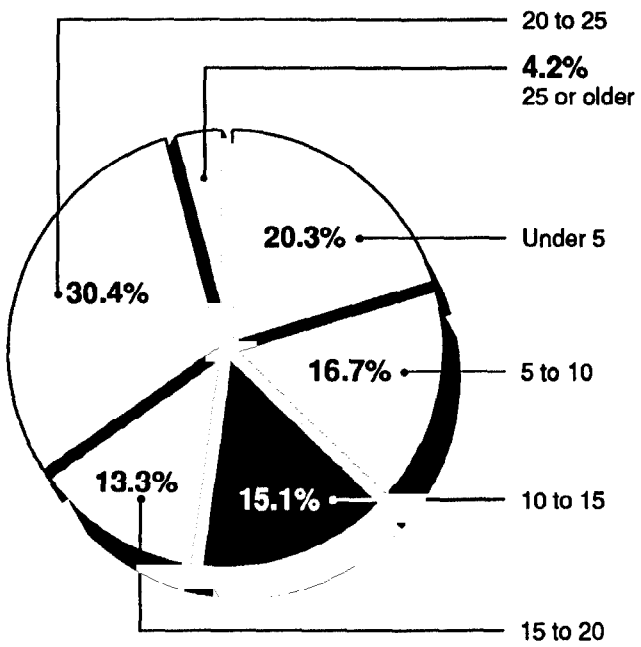
The demand for airline industry services has grown substantially in recent years, and FAA forecasts this growth to continue. U.S. passenger miles grew an average of 6 percent per year during 1970 to 1989. FAA projects that revenue passenger miles for U.S. airlines will increase from about 429 billion in 1989 to about 794 billion in 2002. The air cargo industry also has grown substantially. In 1987 the industry transported more than 11 times the number of shipments carried in 1977 with tonnage carried growing by more than 400 percent during the 10-year period.

This increased air traffic has led to an increase in the number of large transport aircraft operated by U.S. airlines—from about 2,500 aircraft in 1980 to about 4,100 in 1990, or 64 percent. These are the largest passenger planes, including the A-300, A-310, and A-320 made by the European consortium Airbus Industrie; the Boeing 707, 720, 727, 737, 747, 757, and 767 made by the Boeing Commercial Airplane Company; the DC-8, DC-9, DC-10, and MD-80 made by Douglas Aircraft Company; and the L-1011 made by the Lockheed Aeronautical Systems Company. Similarly, the number of jet freighters operated by U.S. cargo carriers rose from 76 in 1977 to 306 in 1987. By the end of 1989, the number of jet freighters had risen to 458—or 12 percent of the total U.S. transport fleet. Cargo carriers project that their fleet will total 745 by 1995.

In 1988 and 1989, world airlines ordered 2,936 large jet aircraft from U.S. and foreign aircraft manufacturers, with U.S. customers accounting for 1,236 of the total. At the same time, airlines have retired only a few transport aircraft over the last decade and, as of January 31, 1991, U.S. manufacturers had an order backlog of 3,658 aircraft. Producing these planes will take manufacturers many years. For example, deliveries of planes to U.S. customers totaled only 466 in 1988 and 1989. Thus, a backlog exists and, coupled with high demand for air travel, probably explains why carriers have retired very few of the older aircraft during recent years. However, with the recent financial problems besetting the airline industry, we can expect to see more aircraft being retired, and over time this could result in delayed deliveries, unexercised options to buy new planes, and postponed outright cancelled deliveries. For example, an official of one carrier told us how his company recently has accelerated the pace at which it has removed older, less fuel efficient aircraft from service and has pushed back delivery of 14 Boeing 737s and 2 Boeing 767s from 1991-92 to 1993-94 and 12 Boeing 737s from 1991-92 to 1995.

We have previously reported that FAA does not know the repair status of older aircraft in the U.S. fleet because the agency does not keep records of individual aircraft.[3] However, the number of aging aircraft—those that have exceeded their design life in years or flight cycles—are an increasingly larger portion of the whole. More than 1,400 of the planes used by the nation's air carriers have exceeded their economic design lives in terms of years in service—20 years—450 of these also have exceeded their design lives in terms of flight cycles (number of take-offs and landings), ranging from 20,000 for a 747 to 100,000 for a DC-9. Figure 1.1 shows that by the year 2000, if all the U.S.-manufactured planes flying as of March 1990 are still in service, 63 percent will be 20 or more years old. While some aircraft retirements are inevitable, the exact number will depend on trade-offs between retaining older aircraft to meet the demand for air travel and retiring them because of their higher costs. These costs for fuel, maintenance, crew, and necessary modifications to make them quieter could outweigh the cost to replace them with new aircraft.

Figure 1.1: Age Profile of U.S. Transport Fleet in the Year 2000 (As of March 1990)



[3]See GAO testimony entitled Observations on H.R. 3774, "The Aging Aircraft Safety Act of 1989" (GAO-T/RCED-90-82, May 23, 1990).

The average age of planes in air carrier fleets varies considerably. For the nation's 18 largest airlines, the average fleet age varies from about 6 years to over 22 years. For the three largest overnight express cargo carriers, the average age ranges between 18 to more than 21 years. The expansion of air cargo companies has been facilitated by the availability of low-cost used aircraft. Air cargo companies' expansion plans have depended heavily on acquiring used jets at reasonable prices. As of December 31, 1989, 442 of their 458 aircraft were older models, such as Boeing 707s, 727s, and 747s; and Douglas DC-8s, DC-9s, and DC-10s.

Factors such as expectations about future demand—based on air travel forecasts, potential for new air routes or markets, and ticket pricing strategies—interest rates, the price of jet fuel, and the prices of new aircraft can affect air carriers' decisions to buy or lease new aircraft or continue operating their older ones. And because older aircraft require more maintenance than new ones, acquiring new aircraft can directly influence an airline's operating cost by reducing the amount of maintenance needed. Higher purchase, lease, and financing costs for new aircraft, combined with stable and reasonable fuel prices for the less efficient models, could cause air carriers to retain rather than replace their older aircraft. On the other hand, the recent increase in the price of jet fuel—if sustained—as a result of instability in the Mideast could be a major impetus behind a movement to replace older aircraft, which need more maintenance. Moreover, older aircraft also are likely to be louder and may have to be phased out by the year 2000 as a result of recently passed noise legislation.

Aloha Airlines Incident Changed Maintenance Approach for Aging Aircraft

On April 28, 1988, 18 feet of skin ripped from the fuselage of a 19-year-old Aloha Airlines Boeing 737 while the plane was in flight. FAA marks this incident as triggering a change in the prevailing industry and FAA philosophy regarding airframe maintenance, a philosophy that relied heavily on inspections. This philosophy called for airline maintenance organizations to inspect for damage during periodic heavy maintenance visits and replace only the portions of the airframe where the damage exceeded manufacturer-specified tolerances. Because fatigue damage is highly predictable, when inspection found it to be negligible, it was allowed to remain until subsequent inspection found that it exceeded the limits.

Inspection of the Aloha plane's fuselage revealed many fatigue cracks and a great deal of corrosion.[4] At the time of the accident, the aircraft had accumulated 89,680 flight cycles (take-offs and landings), the second highest number of cycles in the worldwide 737 fleet. Inspections of other Aloha 737s with more than 60,000 flight cycles revealed that two of them had fatigue cracking and corrosion extensive enough for them to be taken out of service.

Shortly after the Aloha incident—in June 1988—FAA sponsored a conference on aging airplanes. Conference participants included regulatory and aviation industry officials. FAA concluded from the conference that because of the huge increase in air travel, the limited ability to produce new aircraft quickly enough to both satisfy demand and replace substantial numbers of aging planes, and the apparent economic feasibility of operating older airplanes, older airplanes would continue to be operated rather than retired. Because of the problems that the Aloha incident revealed, conference participants agreed that increased attention should be focused on maintaining the continued operational safety of the aging fleet.

The conference produced a consensus to abandon the previous heavy reliance on inspections. FAA and the air carrier industry concluded that periodic airframe inspections were insufficient to ensure identification and repair of structural damage. Instead of this approach, FAA and the air carrier industry agreed that requirements should be established to modify specified structural components that had a history of sustaining damage. They agreed that this should be done before damage occurred as a result of the normal aging process, regardless of the actual condition of the structure.

Industry and FAA Developed Structural Modification Requirements for Aging Aircraft

The June 1988 conference also initiated a process for determining which parts on aging aircraft should be modified according to what schedule. Established in August 1988, formation of an Aging Aircraft Task Force (later changed to Airworthiness Assurance Task Force) was one of the conference's key recommendations. The Task Force has representatives from the aircraft operators, manufacturers, regulatory authorities, and other aviation interests. One of its goals was to study aircraft manufacturers' service bulletins related to aircraft structures to determine if

[4]Aircraft corrosion is the deterioration of metals resulting from reactions between these metals and their environment. It typically occurs in areas where moisture can collect, such as beneath doorways and around lavatories, galleys, and interior cabin walls.

their recommended procedures (voluntary means for the air carriers to eliminate inspections called for in the service bulletins) should be made mandatory for aging aircraft.[5] The working groups completed their work, selected the structural service bulletins whose work they believed should become mandatory, and made their recommendations to FAA. In making recommendations on needed structural repairs, the working groups also recommended deadlines for making the repairs, according to the Task Force Chairman. He also told us that the compliance dates chosen for the structural repairs were based on aircraft manufacturers' and air carriers' estimates that the airlines could fit the work into their existing maintenance schedules and complete the required work by the compliance dates.

On the basis of the Task Force's recommendations, FAA issued ADs requiring that air carriers modify their aging aircraft according to the service bulletins. FAA issued structural ADs affecting 115 Boeing and 1,153 Douglas aircraft in March and August 1990, respectively. Each AD specified that the repair work should be completed on all affected aircraft within 4 years of the AD's effective date. Structural ADs for Lockheed aircraft became effective in March 1991; however, FAA is not certain when the ADs for Airbus aircraft will be finalized. According to FAA's Associate Administrator for Regulation and Certification and Manager, Transport Airplane Certification Directorate, in terms of their total cost impact on the airlines, these ADs are the single largest requirement ever placed on air carriers. On a per plane basis, estimates for airframe-related work alone range from about $100,000 for a DC-9 to over $1,000,000 for a 727 for fatigue-related work alone. Industry officials say that costs to repair corrosion are difficult to estimate, but they will exceed the costs of the structural repairs.

Objectives, Scope, and Methodology

In a September 19, 1989, letter and subsequent agreements, the Chairman and the Ranking Minority Member of the Subcommittee on Aviation, House Committee on Public Works and Transportation, asked us to provide information on the U.S. aircraft repair industry, and in particular, that portion of the industry that repairs and performs heavy airframe maintenance on large transport aircraft. On the basis of a survey of five air carriers and four independent repair stations, we

[5]According to the Boeing Company, a service bulletin is prepared by the manufacturer to inform operators of a maintenance or inspection change applicable to their aircraft. The bulletin describes how to gain access to the part or area, perform the necessary action (inspect, repair, or modify), and reassemble the airplane. It also explains why the bulletin was issued and the consequences of not incorporating it.

issued a report in October 1990, concluding that the increasing demand for repair services might not be matched by corresponding increases in supply in the immediate future. To answer more precisely the question of whether the industry can cope with the increased demand, we expanded the scope of our work to include the industry as a whole. For this report, we analyzed the extent to which airlines' compliance with the structural ADs during the 4-year compliance period is being impeded by

- increases in demand for heavy airframe maintenance (see ch. 2) and
- constraints on supply, including availability of parts, skilled mechanics, and hangar space (see ch. 3).

We reviewed air carriers' efforts to comply with the new requirements for aging aircraft and assessed FAA's oversight of air carriers as they attempt to comply with the new rules (see ch. 4).

To evaluate the airline industry's ability to repair their aircraft, we relied on the results of a mail survey to 54 Part 121 air carriers and 38 independent repair stations. (See Volume B of this report for the summary results of that survey). We identified the independent repair stations by contacting 100 certified repair stations provided in a list by FAA. The 38 receiving our survey had earlier told us that they could maintain and modify large airframes. We received completed surveys from 48 air carriers (see app. I), representing 99 percent of the large transport aircraft in the U.S. fleet, and 35 independent repair stations (see app. II). To augment the survey's results, we visited 17 air carriers and 10 independent repair stations (see app. III). For industrywide information on the demand and supply of aircraft repair services, we interviewed representatives from the Department of Labor, Air Transport Association of America, Aeronautical Repair Station Association, Air Freight Association, National Air Carriers Association, and National Air Transport Association, all located in the Washington, D.C., area.

To determine the obstacles facing airlines as they comply with the aging aircraft airworthiness directives, we analyzed the results of our survey in light of information obtained from pertinent documents and from discussions with aircraft manufacturers, air carriers, and FAA. For example, air carriers discussed with us the impact of parts shortages on their operations. To evaluate the availability of mechanics, we first examined survey results to determine if a shortage existed and if plans were in place to increase the number of mechanics. We then discussed with air carriers and independent repair stations the impact of mechanics

shortages and the steps carriers and independents are taking to deal with the problem. To evaluate the adequacy of hangar space, we examined the results from the survey for utilization rates and expansion plans to increase total available capacity.

To obtain the perspective of aircraft manufacturers and their impact on the repair industry, we interviewed officials of the Boeing Commercial Airplane Company, Seattle, Washington; Douglas Aircraft Company, Long Beach, California; and Lockheed Aeronautical Systems Company, Burbank, California. We established FAA's role in monitoring the repair industry and discussed the actions FAA may take in the event that air carriers cannot comply with the aging aircraft structural airworthiness directives during meetings with officials in FAA's Washington, D.C., headquarters, FAA's Northwest Mountain Region in Seattle, Washington, and the National Transportation Safety Board in Washington, D.C.

We performed our review between January 1990 and February 1991 in accordance with generally accepted government auditing standards.

Repair Work on Aging Aircraft Is Placing Heavy Demand on Industry's Resources

The aviation industry is finding that it takes longer to repair its aging aircraft than the time that the Federal Aviation Administration (FAA) and the industry estimated would be needed when FAA issued airworthiness directives to repair and modify the structures of older aircraft. Three reasons account for this increase.

- The time that repair facilities need to complete specific steps called for in the structural airworthiness directives (AD) is expected to be generally greater than FAA and the industry estimated.
- Air carriers that have begun the structural AD repairs have found substantial amounts of collateral damage—secondary and usually unforeseen damage in addition to what was expected. In the original estimates, FAA included no time for repairing collateral damage.
- FAA is in the process of issuing another set of ADs that will apply to the U.S. transport fleet and require inspection for, and if necessary repair of, airframe corrosion over the lifetime of the aircraft. Maintenance to address these ADs is expected to involve some 3,000 commercial aircraft—more than twice the number that need to undergo structural modifications within the next 4 years.

While over the whole compliance period airlines will have more work ahead of them to repair their aircraft than FAA estimated, other events—the recession and the recent war with Iraq—reduced airlines' 1991 demand for repair services.

Carriers Accomplish as Much Structural Work as Possible During Each Heavy Maintenance Visit

Industry practice is to complete as much airframe work as possible during heavy airframe maintenance and airframe modifications[1] because several days are needed to strip the airframe of exterior paint, entirely remove the cabin interior, and remove flight control surfaces (for example, elevator and wing flaps) and landing gear. Additional time is needed to replace these items during the final days of visits. Therefore, to reduce both the amount of revenue lost while the aircraft is out of service and the number and frequency of repeated heavy maintenance visits, carriers typically attempt to accomplish as many FAA requirements and discretionary tasks during a heavy maintenance visit as possible.

[1]Heavy airframe maintenance, repair, and modification includes (1) routine airframe maintenance ("D" checks or equivalent) including nonroutine discrepancies, repairs, and service bulletins affecting airframes; (2) mandated FAA airframe inspections and modifications ADs and other FAA rules affecting airframes); and (3) non-mandated airframe modifications affecting the airframe (for example, fleet standardization, cabin refurbishment, and reconfiguration affecting the airframe).

Figure 2.1: Interior of an Aging Aircraft Undergoing a Heavy Maintenance Visit

Figure 2.2: Exterior of Aircraft Undergoing Heavy Maintenance

According to air carriers we visited, the principal heavy maintenance visit is the "D" check, typically taking from 10 to 60 days and performed once every 3 to 9 years, depending on the carrier. The more frequent visit when heavy airframe work may occur is the "C" check, typically performed about once a year and taking from 3 to 30 days. C or D checks typically include completing work to address

- all FAA-mandated AD and rule requirements before their compliance dates;
- all periodically scheduled maintenance required by the airline's FAA-approved maintenance plan, which lists the inspections, lubrications, and systems checks required by FAA and the frequency with which each task is to be performed;
- manufacturer's service bulletins that the carrier has chosen to implement at its discretion;
- marketing modifications to improve the aircraft's appearance, comfort, or passenger convenience, including new seats, seat covers, floors and/or carpets, exterior paint, galleys and lavatories, overhead storage bins, air telephones, and audio/video equipment; and
- standardization and/or improvement of major aircraft components such as cockpit instrumentation and controls to improve pilot familiarity and/or safety.

According to a major carrier, before FAA issued its aging aircraft ADs, a heavy maintenance visit for a Boeing 747 typically took 1 month and cost $2.3 million. The work accomplished included a D check, all aging aircraft structural and corrosion AD requirements, other FAA mandatory work, collateral damage repair, some manufacturer's service bulletins, extensive marketing modifications, engine overhauls, and improvements to avionics and cockpit instrumentation. During its next heavy maintenance visit, each of this carrier's aging Boeing 747 aircraft is scheduled to receive this kind of extensive renovation as well as the new structural modifications and corrosion work.

Many Factors Affect the Industry's Ability to Make Required Repairs to Aging Aircraft

After the Aloha tragedy, one of FAA's and the aviation industry's first concrete responses to the aging aircraft phenomenon was to work together in developing and issuing mandatory requirements to ensure that other aging members of the fleet would not suffer Aloha's fate. Although most carriers believe that FAA's ADs had the greatest impact on their demand for heavy airframe maintenance in 1990, several other important determinants of demand exist. These include repairing collateral damage, inspecting for and repairing damage caused by corrosion, and modifying aircraft for safety and competitive reasons. The

industry's ability to complete the aging aircraft ADs within the FAA-mandated time frames will be greatly affected by these other demands on the repair infrastructure.

FAA's ADs Have Strongest Influence on Maintenance Demand

In the past few years, demand for heavy airframe maintenance and other kinds of maintenance that use similar labor and facility resources has risen considerably. According to responses to our mail survey, time spent by mechanics during 1988 and 1989 on heavy airframe maintenance increased by 30 percent at air carriers and by about 24 percent at independent repair stations. Moreover, independent repair stations expect this increased demand to continue because of the following conditions.

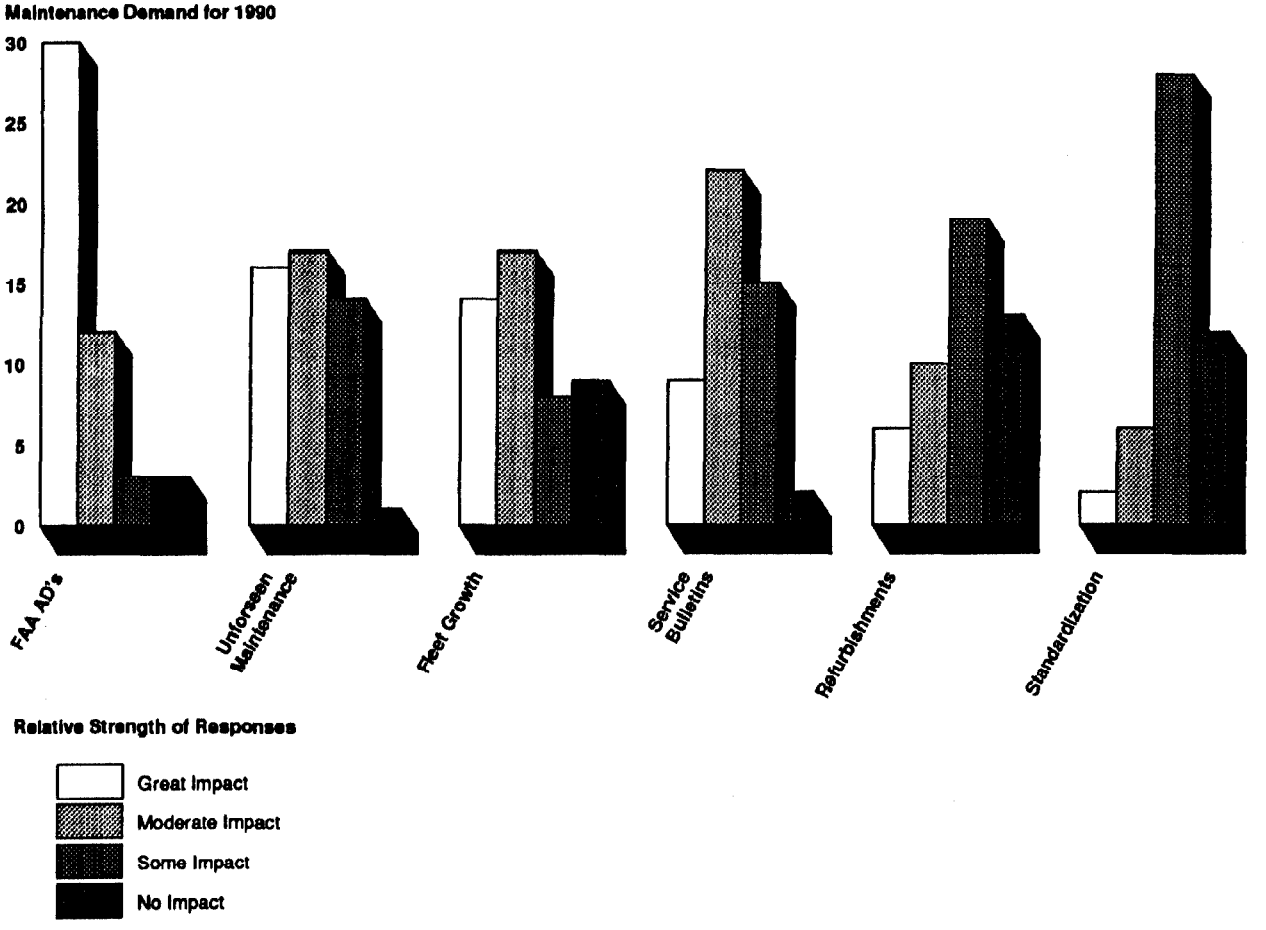
- The required amount of maintenance continues to increase because of FAA rules to install additional safety related equipment on aircraft for such purposes as collision avoidance and windshear detection, the structural ADs for aging aircraft and the new requirement for airlines to implement corrosion control programs.
- The need for more routine and unforeseen maintenance increases as aircraft age—about half the U.S. fleet is now over 15 years old.
- The demand for non-mandated modifications, such as interior refurbishment or seating reconfiguration, will increase. For example, modifications in galleys, lavatories, overhead storage bins, seating carpeting, lighting, and airphones will continue to increase as carriers compete with each other for air fare revenue.
- The total number of aircraft in service worldwide is increasing. The Boeing Company has projected that there will be 14,772 aircraft in the year 2005, a 78-percent increase over the 8,302 aircraft in the 1990 world fleet.

In addition, some air carriers attribute rising demand to other factors, including their doing more of the work suggested in aircraft manufacturer's service bulletins (partly because aging aircraft require more maintenance than new ones) and their standardizing of aircraft obtained from other carriers to create identical cockpit configurations and to improve safety and pilot familiarity.

Although all these factors are currently influencing maintenance demand increases, air carriers view FAA's ADs as the strongest influence. We asked carriers to tell us whether each factor had a great impact, moderate impact, some impact, or no impact on their heavy airframe maintenance demand in 1990 (see fig. 2.4). Thirty of the 48 carriers said

that the ADs had a great impact. The factor rated second highest in terms of great impact was "unforeseen maintenance," according to 16 carriers. "Fleet growth" also ranked high with carriers—31 said it had a moderate (17) or great (14) impact on their demand for maintenance.

Figure 2.4: Relative Impact of Several Factors on Heavy Airframe Maintenance in 1990



Amount of Work on Structural ADs May Exceed Initial Estimates

When developing the structural ADs, the industry and FAA used time and cost estimates taken from aircraft manufacturers' service bulletins, according to the Airworthiness Assurance Task Force chairman. Further, the chairman said that the Task Force was not as concerned about the time and cost to do the structural AD work as it was about correcting

the identified structural problems as soon as possible. These service bulletins, the basis for work required in the structural ADs, contain cost data and a staff-hour estimate. Air carriers believe that manufacturers base their service bulletin estimates on making repairs under nearly ideal conditions: they envision prototypical repairs to new production aircraft in a modern hangar at or near production facilities; mechanics who are experienced and receive immediate consultation from structural engineers at the scene of the repair; and availability of required parts and tools.

Actual repair conditions are usually much different from those on which manufacturers base service bulletin estimates, according to air carriers. The aircraft to be repaired typically is not new, but instead has been in service a decade or more. The aircraft interior is not removed beforehand to expose the airframe and the areas to be repaired. Access to the repair area often is difficult because of corroded fasteners and damage in adjacent areas. In addition, required parts and tools are not always present unexpected collateral damage is found, mechanics are not necessarily familiar with the repairs, and structural engineers are not necessarily readily available for consultation. As a result, large differences can result between service bulletin estimates and carriers' experience, as illustrated in the following examples.

- According to the manufacturer's service bulletin, repairing lap joints[2] on a Boeing 737 should take 1,984 man-hours. However, after performing this work on nine of its Boeing 737s, an airline found that it needed an average of 2,549 man-hours (exclusive of repairs to collateral damage), or about 28 percent more than Boeing had estimated.
- Another service bulletin, according to one airline, estimated that a rib chord[3] modification on a Boeing 727 should take 728 man-hours. However, the airline found that it needed an average of 1,200 man-hours to do the work, or about 65 percent more work than contained in the service bulletin estimate.

If the time to make repairs at repair stations under actual conditions, as discussed above, had been factored into the information the industry task force provided to FAA, estimates of the time needed to accomplish the structural ADs might have been higher. FAA told us that factoring actual repair experience into a final AD has never been done before and

[2]Lap joints are sections of an aircraft's outer aluminum skin, overlapped and joined by multiple rows of rivets and adhesive bonding agents.

[3]Rib chords are structural braces used to connect, configure, and stabilize an aircraft airframe.

could not be done in this case because the experience was only achieved after the ADs were issued. However, two of the largest U.S. carriers told us that they completed some of the AD requirements while the rule was still in the draft stage. Their experience with cost, time, and collateral damage far exceeded FAA's estimates and could have been used by FAA to develop more realistic AD time frames.

Repairing Collateral Damage Adds to Time and Cost

Air carrier maintenance officials told us that about 50 percent of heavy airframe maintenance is for unforeseen, unscheduled repairs—the "collateral damage" found when performing scheduled maintenance.[4] This proportion rises to about 65 percent on aircraft over 10 years old, and it continues to rise as the planes age. However, FAA's estimates of time and cost for complying with structural ADs included no allowance for collateral damage work and are therefore greatly understated.

Maintenance officials also told us that collateral damage is often found during structural AD work and that such damage adds significantly to the workload. For example, the carrier that completed the lap joint work on nine of its Boeing 737s found that collateral work added an average of 2,918 man-hours to the 2,549 already spent—in effect, more than doubling the work that had to be done before each aircraft's maintenance could be completed on the most economic manner. Other carriers told us that, because of collateral damage, the total time spent complying with an AD typically is two to three times more man-hours than included in the structural AD estimates. One carrier told us that to comply with the AD for the skin lap work on its Boeing 737-200s the carrier needed nearly 3 hours of work to repair unexpected damage for each hour of planned maintenance. The estimate called for 2,000 man-hours, but with the collateral damage the carrier needed an average of 5,500 additional hours.

Scheduling Work on Other ADs Places Additional Demand on Resources

FAA plans to issue additional requirements for mandatory work on aging aircraft. Foremost is a series of airframe corrosion ADs, one for each aging aircraft model. The corrosion ADs for the Boeing aircraft, issued in November 1990, require that each airline begin a corrosion inspection and repair program within 1 year of the effective date of the ADs. The air carriers then have to inspect all aircraft affected by the corrosion ADs at specified intervals. For example, all aircraft over 20 years old

[4]Collateral damage can vary from slight to significant and, therefore, may or may not affect airframe airworthiness in individual cases.

must be inspected within 6 years or less. Specific places—around galleys and restrooms—also must be inspected over the aircraft's lifetime. All damage discovered during these inspections must be repaired before further flight.[5] Industry experts believe that over an aircraft's life the corrosion work will take more time and cost more per aircraft than the structural work.

If possible, many air carriers plan to group all AD work—both structural and corrosion—into the next heavy airframe maintenance and modification visit for each aircraft—the "D" check, even when this visit is well before the AD deadlines. Their reason is not only to comply with the ADs, but also to eliminate the time and cost of repetitive heavy maintenance visits. These costs include lost income—estimated by one carrier at $25,000 to $100,000 a day, depending on aircraft type and usage—from extra days out of service during repetitive removal and replacement of the aircraft interiors before airframes are inspected and repaired.

Work on corrosion ADs, according to carriers, is thus adding substantially to the short-term demand for heavy airframe maintenance. Repairing both structural problems and corrosion means longer or more labor intensive maintenance visits. Moreover, the corrosion ADs add more aircraft to the maintenance schedule. FAA estimates that corrosion ADs, which apply to newer aircraft as well as those approaching the end of their design lives, will involve about 3,000 aircraft—1,700 more than could be affected by the structural ADs. Air carriers will be scheduling corrosion work on many of these additional aircraft during the next few years. In response to our survey, domestic air carriers identified over 2,600 of their aircraft that will require corrosion or structural AD work by January 1995.

Several Factors Create Uncertainty About Demand for Aircraft Repair

At least in the short-term, several significant current events will increase the demand for heavy airframe maintenance. These include

- a worsening of long-standing airline financial problems primarily as a result of some carriers' excessive debt,
- the current economic recession and the residual effects of the war with Iraq, and

[5]As of February 1991, FAA had not issued corrosion control ADs for other manufacturers' aircraft. FAA has, however, issued notices of proposed rule-making for other aircraft models that would require corrosion control programs similar to those for Boeing aircraft.

- recent legislation mandating that carriers upgrade their fleets to meet stage 3 noise rules by the end of the century.

Over the past decade, the airline industry has developed serious financial problems that have weakened some carriers' competitive positions. Among these problems are high levels of debt taken on under the assumption that a growing demand for air travel would generate enough revenue to service the debt. The increase in debt raises fixed charges for interest payments and makes these carriers much more vulnerable to a temporary decrease in demand due to a recession or to an increase in such expenses as fuel.

These high debt ratios, coupled with low profits, have taken their toll on U.S. carriers. Eastern has ceased operations; Pan Am, Midway, and Continental are in bankruptcy; and TWA has tried several tactics, including merger and selling off routes and slots, to remain financially solvent. Together, these five airlines had an almost 30-percent share of the U.S. market. For the stronger carriers in the industry including American, United, and Delta with a combined share of 45 percent, the recent decline in profitability will probably cause temporary financial distress but should not lead to long-term problems. Although we cannot assess the prospects of survival of any particular carrier, several carriers clearly are threatened. Whenever an airline ceases operations as a result of this threat, the maintenance for its aircraft probably will be deferred until operations can resume or until another carrier takes ownership of the aircraft.

In addition, airline industry profitability has declined recently primarily because of the softening in the demand for airline service. Reduced demand is directly related to the health of the economy—now in recession. Complicating this internal constriction on demand is the impact that the war with Iraq had on travel demand because of threatened security. The war also had a significant impact on jet fuel prices. The spot price of jet fuel rose 97 percent during the Persian Gulf crisis and pushed up airline operating costs by more than 10 percent. Fuel prices have begun to fall, and if this continues, at least this component of airline operating costs will not further erode airlines' profitability.

Noise legislation passed during the last Congress poses another dilemma for operators of older aircraft. Their aircraft are required to meet stage 3 noise standards by December 31, 1999. Because over half the fleet currently does not meet stage 3 standards, and it can cost $2 million to $8 million to convert from stage 2 to stage 3, keeping these aircraft will be

costly for airlines, especially because they are noisier and generally older, more maintenance intensive, and less fuel efficient aircraft will be costly for airlines. Whether it would be more costly than replacing them with newer models can only be answered on an airline by airline basis. Complicating this picture, airlines' financial problems are causing them to place many airliners on the market for sale or lease, which drives down the value of used aircraft.

Operators of older and noisier aircraft that are not in a financial crunch will begin to question the wisdom of spending more money on these aircraft to comply with stage 3 noise standards and, by the same reasoning, with FAA's aging aircraft ADs. Instead, they may exercise their options to buy new aircraft to replace those needing work. On the other hand, airlines feeling a cash crunch may not be able to afford the new aircraft price ($40-50 million) and may opt to retain their existing fleet mix. If they do, they will need to repair their aging aircraft and quiet their stage 2 aircraft.

The factors discussed above—financial problems leading to reductions in service and possibly insolvency, overall decline in demand, higher fuel prices, and potential costly modifications to comply with new noise rules—all tend to diminish the near-term demand for maintenance. However, these factors will affect airlines differently, depending on their financial conditions and the actions they are taking, if any, to improve the conditions. Midway Airlines, for example, is reported to have grounded seven older model DC-9s and a 737—over 10 percent of its fleet—as a result of cutbacks in planned expansion because of high fuel costs. On the one hand, while the opportunity now exists to schedule these eight aircraft for heavy airframe maintenance, the pressure to repair them is gone as well might be the funding.

In addition to raising the cost of fuel, the war with Iraq also provided a second factor in airlines' decisions regarding maintenance. Although current numbers are difficult to obtain, some carriers participate in the Civil Reserve Air Fleet program by providing aircraft to the military for carrying troops and equipment to and from the Middle East. As of February 1990, some 75-85 civil aircraft were in service under this program. In the absence of a softening in the demand for air travel, providing aircraft to the military would curtail airlines' ability to serve their established routes. It also might encourage them to defer maintenance on their remaining fleet until their loaned planes returned from war.

In some ways, therefore, the demand for maintenance is being deferred. Planes that either have been grounded because of slackened demand for air travel, grounded by financially weak carriers, or taken out of service to be loaned to the military may have their maintenance deferred. They will probably not be first in line to receive costly repair and modification for purposes of keeping them airworthy according to FAA's aging aircraft ADs. On the other hand, as the economy regains its momentum and fuel prices drop back to pre-war levels, many currently underused aircraft will return to service. These aircraft will need to undergo the maintenance that was pending when they left service. However, by that time, FAA's 1994 deadline for repairing aging aircraft will be that much closer.

Conclusions

The outlook for maintenance demand during the 4-year compliance period for structural ADs differs greatly from the outlook when FAA first issued the structural ADs and set the compliance deadlines. Air carriers' experience to date suggests that structural AD work will take more time than estimated and that repairing collateral damage, a task not included in the estimates, will add significantly to the total. Air carriers' plans to conduct corrosion and structural AD work concurrently will add still further to the workload needed to be done by the 1994 deadline. In effect, as the carrier responses to our survey suggest, the industry-FAA initiative to address the aging aircraft phenomenon is having the following impact on the airlines' maintenance activity.

- Twice the number of aircraft are involved than the number FAA and the industry initially foresaw being affected by the structural ADs, from about 1,300 to 2,600—over half of the 4,100-plane fleet. This is because carriers are performing both corrosion and structural work as long as they have the aircraft out of service and torn apart.
- Carriers reported that two to three times as much work is needed, exclusive of the corrosion work, than FAA estimated for the structural ADs because of their need to repair collateral damage.
- The cost increase for the industry is difficult to quantify because airlines do not systematically record this data. However, if this increase over initial estimates is proportional to the increases in work as experienced to date, the final tab to the industry will be in the $2 to $3 billion range.
- The simultaneous impact of the recession and the war with Iraq have dampened air travel demand, raised airline operating costs, further weakened some carriers' financial positions, and resulted in some aircraft being taken out of service. Although reduced service has reduced near-term demand for heavy airframe maintenance, that demand could

rebound and even become stronger than it was before FAA's 1994 deadline for completing the structural repairs to older aircraft.

Although current events in 1991 have put pressure on airline profitability, they have relieved somewhat the pressure to repair aircraft. As the economy improves and the consequences of war diminish, however, requirements for maintenance of aircraft now out of service will return. In chapter 3 we address the problems that airlines will face in completing the AD work within the FAA deadline, and in chapter 4 we discuss FAA's oversight role in these matters.

Scarce Parts, Labor, and Space Are Hindering Airlines' Compliance With Structural AD Deadlines

The ability to maintain heavy, commercial airframes is limited to 24 domestic air carriers and about 38 independent repair stations that have the hangar capacity and technical capability to repair these airframes. Although the carriers and independents are rapidly increasing their maintenance capacity and capability in response to increasing demand, they will need several years to plan for and acquire new facilities, skilled mechanics, and replacement parts. Of these three resources, parts are the most critical problem. An immediate shortage of parts is forcing some postponement of structural AD work on aging aircraft. A skilled labor shortage as well as inadequate hangar space also could hinder compliance if industry expansion does not occur as planned. An imminent threat to these plans for expansion is the current economic recession. Its length and severity will have much to do with the repair station industry's preparedness for the coming airline demand for service.

Limited Number of Repair Facilities Shoulder Significant Burden of Major Structural Repairs

As part of its responsibilities, FAA has certified about 4,000 repair stations to perform varying types of maintenance services for the air carrier industry. The kind of FAA repair station certification depends on the kind of work the station can perform and the types of aircraft it is qualified to repair. FAA divides maintenance into six main categories—airframes, powerplants, radios, propellers, instruments, and accessories. Some repair facilities specialize in one of these specific maintenance and repair categories, while others may specialize in several.

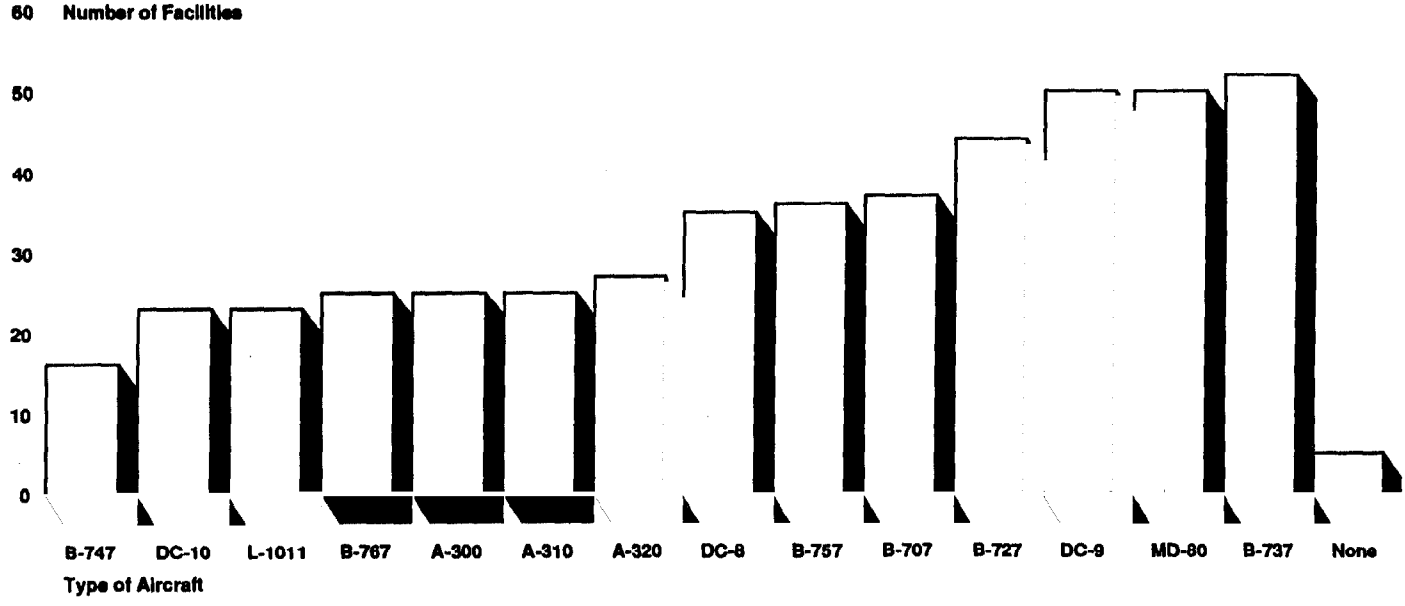
Few stations, however, have sufficient facilities, equipment, and personnel to perform heavy airframe maintenance, and airframe modifications—the type of activity necessary to renovate major structural members on aging aircraft. Those that do are either owned and operated by air carriers or are independent repair stations that maintain carriers' aircraft on a contract basis. Of these, we identified 38 independent repair stations that said they could do heavy airframe maintenance. In addition, we identified 24 part 121 air carriers that perform heavy airframe maintenance.

Starting a new airframe maintenance facility or expanding existing facilities requires sufficient capital to purchase the land, then design, construct, and furnish the facility, or alternatively, to lease the land and facilities. Facility operators also must hire skilled employees to carry out maintenance requirements and capable managers to oversee the operations. Finally, to ensure that people are effectively employed, the facility must obtain the equipment, tools, and replacement parts needed

for its airframe inspections, repairs, modifications, and compliance with FAA airworthiness directives. Each of these factors of production—hangar space, skilled labor, and sufficient parts—is a key ingredient for an aircraft repair facility to be successful.

The 24 carriers and 35 of 38 independents responding to our survey reported that at their principal maintenance facilities they employed a total of 44,000 mechanics in 1990, planned to spend 53 million man-hours on heavy airframe maintenance, and occupied a total of 15 million square feet of hangar space. These repair facilities range in size from small independent repair stations that cannot fully enclose 1 Boeing 737 and employ less than 100 mechanics, to a large national carrier capable of enclosing 20 aircraft at one time, including 747s, and employing several thousand mechanics. The range in ability to enclose airframes is illustrated in figure 3.1 below.

Figure 3.1: Combined Number of Air Carrier and Independent Repair Stations That Can Fully Enclose Aircraft



While typically the smaller independents' hangar space and component shops are limited, the large national carriers can completely overhaul

and renovate not only airframes, but also engines, landing gear, and avionics. In addition, on the basis of approved specifications, they can manufacture some, but not all, of the structural parts that they are typically asked to replace.

Scarcity of Parts Hampers Airlines' Early Compliance

The aviation industry has an insufficient inventory of replacement parts for aging aircraft. Almost half of the airlines and cargo carriers responding to our survey said that insufficient spare parts would contribute to limiting their plans to increase maintenance capacity. Aircraft manufacturers are rationing some parts to make them available to aircraft in the poorest condition. In some cases, this rationing is forcing domestic air carriers to postpone mandatory modifications on some aircraft and to return others to service with mandated work only partially completed. On the basis of information obtained during our visits to 17 carriers, by April 1991 requirements for FAA's structural ADs issued in April 1990 had been met for only 28 aircraft. The requirements had been partially met for 705[1] of the 1,300 that FAA says will need the work before the 1994 dates set for completing the ADs. Of the 13 carriers we visited that had begun to repair their aircraft, 8 said that parts shortages kept them from completing repairs. Manufacturers expect parts shortages to continue for some aircraft into 1992 or later, which we believe could place great strain on the final years of the compliance period.

Structural Modifications Require Substantial Numbers of Replacement Parts

ADs mandating structural modifications to aging aircraft call for replacing many parts. Airframe manufacturers generally package these parts into "terminating action" kits—so called because modifying the aircraft terminates preceding requirements for frequent inspections. The airframe manufacturers intend that these kits, which could contain from 2 to 300 parts, provide the air carrier with all the materials necessary to accomplish a mandated permanent modification. Air carriers obtain kits primarily from the airframe manufacturers, although the company owning the proprietary design can provide carriers they deem capable with the data and authority to make their own parts and assemble kits themselves. Carriers also can purchase kits from each other.

[1]Before these aircraft will be in compliance with the AD, they all will have to return to the maintenance bay to complete the work.

The types and number of kits necessary to comply with a specific AD depend on the aircraft model, its age, and the extent to which an aircraft operator has already completed previously optional terminating actions described in manufacturer's service bulletins. According to FAA, air carriers that began repairing their aging fleet by implementing service bulletins before FAA mandated the work will have less service bulletin work to do under the AD than carriers that did not. The number of kits required also varies with the individual service bulletins referenced in the Ads. Some service bulletins do not require a parts kit; others require as many as 50 kits. For example, one of the 74 individual service bulletins included in the structural AD for the Boeing 727 calls for modifying certain skin panels on the fuselage before the aircraft reaches 20 years old; this service bulletin requires 21 parts kits. Table 3.1 shows the total number of service bulletins and related kits applicable to certain aircraft under FAA's structural ADs.

Table 3.1: Summary of Service Bulletins and Terminating Action Kits Needed for Structural ADs

Model aircraft	Number of service bulletins per aircraft	Number of terminating action kits per aircraft
Boeing 707	141[c]	a
Boeing 727	74	292
Boeing 737	58	267
Boeing 747	29	129
DC-8	52	a
DC-9/MD-80	56[b]	a
DC-10	33[b]	a

[a]Boeing and Douglas did not know the number of terminating action kits that were required for these models.

[b]FAA has allowed the manufacturer to revise some of these service bulletins before mandating compliance. Not all inspections contained in these bulletins were clearly defined before FAA issued the ADs.

[c]This AD was still in the proposal stage at the time of our work.

Terminating action kits are not the only kinds of parts necessary to accomplish the structural ADs. Parts such as those to repair collateral damage may be necessary. For example, fasteners such as rivets and bolts often must be removed to expose the airframe. If corrosion or wear is evident around these fasteners, the fastener hole is often made larger in the process of removing the damage, and larger sized fasteners must be used to rejoin the airframe when the aircraft is reassembled. These other parts are essential to ensuring the continued airworthiness of an aircraft. Even if an air carrier has modified all parts of an aircraft required by the AD, it cannot return an aircraft to service unless it also

has repaired collateral damage and has replaced fasteners that no longer fit in their original holes.

Because Parts Are Scarce, Manufacturers Are Rationing Stocks to Air Carriers

Air carriers typically order replacement parts for scheduled repairs and modifications before each aircraft arrives. However, aircraft manufacturers may require up to 2 years advance notice on parts that are not in stock and rarely ordered. According to repair industry officials, obtaining seldom-needed replacement parts is a long-standing aggravation to air carriers and repair stations because of the long lead times and the unpredictability of finding unanticipated structural damage to the airframe once it has been stripped and inspected.

In October 1989, when the structural ADs were still proposed rules, Boeing had sufficient parts kits for only 41 percent of the work envisioned in the ADs. Boeing has since improved its inventory and reports that it now has an adequate supply of 85 percent of the parts kits that would be needed for the AD work. Boeing expects to establish an adequate supply of the remaining 15 percent by December 1992. Douglas, on the other hand, was unable to provide us with similar information. A Douglas official responsible for parts management told us that as of January 1991 he could not be certain of having a sufficient parts inventory to support all Douglas-made aging aircraft. He noted, however, that Douglas also does not know what the demand will be for these parts.

Until air carriers plan for and order all the parts they will need to repair their aircraft, the manufacturers will not know whether their current inventories are sufficient. However, as we discuss later in this chapter, for various reasons air carriers have been reluctant to commit themselves to complying with the ADs.

Faced with a parts demand that in some ways cannot be quantified and in other ways exceeds supply, both major manufacturers are rationing some kits, making them available to air carriers for only selected aircraft. For example, Boeing was rationing about 500 of the 688 kits for the 727s, 737s, and 747s in September 1990. By January 1991, Boeing was still rationing about 100 parts kits. The highest priority of both Boeing and Douglas for kit distribution is an "airplane on the ground," an aircraft that the air carrier has taken out of service pending critical maintenance or repairs. Boeing's second priority is aircraft nearing their economic design life in terms of calendar age or cycle threshold. As of February 1991, according to Douglas, only a few parts were restricted to aircraft on the ground. However, except for supplying parts for

grounded aircraft, Douglas requires carriers to submit purchase orders for all aging aircraft kits and other parts according to its manufacturing lead times. These lead times, which include time to plan and manufacture, range from a few weeks to 2 years. To the extent that aircraft must wait for parts, greater pressure will be put on the repair stations to accommodate demand within the last 2 years of the AD compliance period.

At a September 1990 industry task force meeting on parts availability, air carriers suggested that Boeing allow additional companies to manufacture proprietary parts to improve parts supply. One carrier suggested that Boeing release engineering drawings to capable companies provided that the scarce parts they manufacture be used exclusively by a carrier contracting for the work and that Boeing be paid for the drawings. A parts management official at this carrier believes that this provision would protect Boeing's financial interests by limiting parts production to the contracting carrier while also responding to the air carriers' immediate parts needs. However, Boeing declined, citing its right to protect intellectual property. To ensure that future parts kit inventories can meet the industry's needs, Boeing and Douglas officials urged carriers to submit purchase orders at least 2 years in advance. In contrast, a Douglas participant at the meeting said that he thought his company would agree to release proprietary drawings to qualified suppliers. Officials of one independent repair station told us that they already have a licensing agreement with Douglas to manufacture parts for DC-8s and DC-9s.

An FAA official noted that the agency lacks authority to force an airframe manufacturer to permit other manufacturers to produce proprietary parts to alleviate the shortages. The agency is limited to approving new sources proposed by the airframe manufacturer and approving the design of a suitable substitute replacement part by a parts manufacturing company.

Complicating the scarcity of parts is the unpredictable need for collateral parts and related materials such as rivets and bolts. Air carriers view fasteners as particularly problematic because carriers cannot determine the type and size of fasteners needed until after they begin structural modifications. Manufacturers said that keeping inventories of these seldom-used parts is not economical. While terminating action kits include standard size fasteners, they may not fit properly after the modifications are made.

Parts Shortage Causes Carriers to Postpone Repairs and Lose Valuable Compliance Time

Unable to obtain the necessary parts kits, some air carriers have postponed modifying their aging aircraft until later into the compliance period. The 17 carriers we visited, which operate more than 83 percent of the U.S. transport fleet, had completed the work on 19 aircraft as of November 1990. In addition, air carriers returned 350 aircraft to service with mandated work only partially completed, citing unavailable parts as one of the reasons. One cargo carrier, for example, had to cancel most of its 1990 AD modification program. With 85 of its aircraft affected by the ADs, this carrier had scheduled 28 aircraft to receive all structural AD work in 1990. However, the scarcity of kits enabled AD work on only two aircraft in 1990. As a result, this carrier must now attempt to finish the considerable AD work in 3 years instead of 4.

Air carriers generally prefer to complete ADs on aging aircraft during regularly scheduled heavy maintenance checks, which occur at 1- to 9-year intervals, depending on aircraft use and model. During this check, they routinely strip airframes to look for metal fatigue and corrosion because completing the mandated structural modifications while doing other routine maintenance is the most cost-efficient approach. Nevertheless, it can create delays. For example, one air carrier official said that his company tried to accomplish the structural ADs on three aircraft in 1990 during a heavy check. But because the aircraft did not qualify for parts under the airframe manufacturer's rationing policy, the carrier could not obtain all the required kits. While they returned to service with some AD work left undone, they are scheduled for another heavy check before the 1994 compliance deadline set by FAA.

Seven of the 17 carriers we visited reported that they have at least 4-year intervals between their heaviest checks. These carriers said that they are scheduling aging aircraft for the AD work at either a regular heavy maintenance check or during a special AD terminating action visit, depending on whether their regular heavy checks are scheduled before or after the 1994 compliance dates. Most of these seven carriers—which included the three largest domestic cargo carriers and two major domestic carriers—said that parts shortages could create problems in scheduling structural modification work. They said that the timing of such shortages is critical because sufficient hangar space may not be available when the parts are more plentiful. We believe that even if carriers could add visits to their maintenance schedules, carriers with large numbers of aging aircraft and no planned retirements may have to take so many aircraft out of service at once that it could threaten their economic livelihood.

This may be especially true in the highly competitive overnight package delivery business. According to the Air Freight Association representing all-cargo air carriers, a significant reduction in the number of planes carrying packages between key cities would threaten a cargo company's financial viability. A maintenance official of one cargo company said that his firm must complete the AD work on most of its aging aircraft during special visits because they are not scheduled for a heavy check until after the 1994 deadline. He said that this could threaten the success of his operations because too many aircraft would be out of service at once.

Air carriers reported to us that they are now having some difficulty obtaining all the parts they need do the AD work within FAA's 4-year compliance period. However, the extent to which this parts shortage will ultimately be responsible for grounding aircraft is not clear at this time. Boeing and Douglas both recognize the problem and are taking steps to mitigate its effects on carriers repair plans. Nevertheless, this could have a significant impact on air service because FAA's Manager of Aircraft Certification has said that aircraft not in compliance at the end of the period will be grounded unless carriers have demonstrated good faith efforts to comply.

On the other hand, alternatives to grounding aircraft are available to FAA, and agency officials have said that they do not rule out resorting to these alternatives as long they provide an equivalent level of safety. However, we question whether they will adequately deal with noncomplying carriers. We are concerned because these alternatives usually involve either more frequent inspections to the area of the airframe affected by the AD or manufacturer- and FAA-approved changes to the recommended repair. Either way, if toward the end of the compliance period carriers seek alternative means of compliance for many aircraft, these alternatives would pose a significant workload burden over a relatively short time period for FAA's limited inspection staff. Moreover, permitting carriers to continue to inspect aging aircraft contradicts the basic change in philosophy that moved the industry away from relying on inspection and produced the structural ADs requiring permanent modifications.

Age of Aircraft Age and Suddenness of Demand Make Parts Supply Inadequate

Several factors are converging to tighten the supply of parts with which to repair aging aircraft. First, the age of the aircraft themselves—most models are no longer in production—is responsible for some parts being out of production.[2] According to Boeing and Douglas, subcontractors that had ceased producing parts for aging aircraft must locate raw materials and fit parts production into their manufacturing schedules. Even for some models still in production, some parts do not have a history of demand; therefore, production must be newly initiated. In both cases, parts delivery can take as long as 2 years.

Second, by mandating compliance for structural repairs, FAA created a sudden demand that existing inventories could not accommodate. This is because airframe manufacturers had established more modest parts kit inventories for aging aircraft service bulletins when compliance was voluntary and demand was lower.

A third factor is the airframe manufacturers' preference to keep their costs as low as possible. Neither manufacturers nor air carriers have wanted to establish a costly inventory of aging aircraft parts for which no demand history exists and no future demand can be ensured. Manufacturers believe that advance orders for parts are the best indication of probable demand and the best means of ensuring sufficient inventories without leaving manufacturers with millions of dollars of unused parts.

Despite the acknowledged demand for parts, airlines are not ordering them as expected. According to the manufacturers, air carriers have been reluctant to submit orders because they do not know the maintenance history of some aircraft in their fleet. Officials at one air carrier, whose parent company recently acquired aircraft from other carriers through mergers and purchases, said they do not have complete maintenance histories for newly acquired aircraft and do not know what repairs and modifications prior owners may have accomplished. They said that parts kits will be ordered after they have determined each aircraft's needs. In addition, carriers have not decided whether to sell aging aircraft—many of which are affected by the legislative requirement for a national noise policy—return them to lessors, or retire them before 1994 and replace them with newer aircraft. For example, because of

[2]According to a Boeing official, of the transport aircraft still being operated, the following models are no longer being manufactured: Boeing 707, 720, 727-100 and -200, 737-100 and -200, 747-100, -200, and -300; Douglas DC-8, DC-9, and DC-10; and the Lockheed L1011. These aircraft account for nearly three-quarters of all aircraft commercial transports manufactured by Boeing, Douglas, and Lockheed by the end of 1989, or 5,911 of the 7,818 aircraft these companies manufactured that are still in service worldwide.

financial questions, officials at one air carrier said that the company will begin work in 1991 if they decide to keep older aircraft or comply with the costly ADs. This carrier has not yet ordered parts or scheduled AD work.

Steps Taken by Manufacturers Should Ease Parts Shortage

The parts shortage now facing the industry may ease somewhat but still could hinder repair efforts well into 1992. Because some parts are scarce, the manufacturers are taking the following actions to improve the supply.

- Boeing, according to company officials, has requisitioned sufficient parts to cover the needs of its aging fleet for the next 4-5 years. They said that 85 percent of all parts kits were in sufficient supply to meet demand by January 1991. They expect the remainder to be more plentiful by the end of 1992.
- Douglas officials said that Douglas has had difficulty analyzing worldwide demand for aging aircraft kits in part because air carriers have not told them how much of the mandated parts replacement already has been done and how much additional work they plan to do in the future. Furthermore, they have not been ordering parts as expected. Nevertheless, Douglas has speculated on possible demand and has ordered $46 million of aging aircraft parts from its suppliers.
- At the request of its membership, the Air Transport Association formed a task force in spring 1990 to determine whether the aviation industry could cooperatively improve parts availability. The task force includes representatives of the U.S. and European air carriers, airframe manufacturers, and parts manufacturers. The task force is examining means to improve parts availability, particularly the supply of oversized fasteners for aging aircraft. One promising action involves a proposed data base to ease locating and obtaining these and other parts.

Shortage of Skilled Mechanics Could Hinder Compliance

The aviation industry currently faces a shortage of airframe mechanics, particularly sheet metal mechanics essential to structural work on aging aircraft. One-third of the carriers responding to our survey said that not being able to hire skilled employees would greatly limit their plans to increase capacity to maintain and modify the airframes of their aircraft through 1995. Independent repair stations also reported being short of skilled labor. To correct this shortage, air carriers and repair stations plan to increase the number of airframe mechanics they employ by over 30 percent by 1992 and to continue this trend in subsequent years. However, air carriers cite the low productivity of inexperienced, newly hired

mechanics as a factor that could hinder carriers' compliance with the structural ADs' 1994 deadline. Major air carriers told us their mechanics need 2 years of airframe mechanics school, plus 2 to 3 years of on-the-job training under close supervision, before they can be fully productive. Therefore, while plans call for raising the industry's number of mechanics, questions remain as to whether the experience and skill level will be sufficient to hasten completion of the structural AD requirements by 1994.

Air Carriers and Repair Stations Are Understaffed

According to the Department of Labor, air carriers employed over three-fifths of the nation's 124,000 aircraft mechanics in 1988. Aircraft assembly firms, the federal government, independent repair stations, and private companies that operate their own aircraft employed the remainder. Labor recently reported that the demand for aircraft mechanics probably will exceed the supply during the next few years.[3]

Complementing Labor's forecast is our survey of air carriers and independent repair stations showing a shortage of mechanics as of December 31, 1989. As table 3.2 shows, air carriers reported they were about 6 percent short of being fully-staffed—having a sufficient number of employees with the appropriate skills to make productive use of existing facilities—and repair stations reported a 7.4-percent shortfall, resulting in a 1989 shortage of almost 3,000 mechanics, or 6.6 percent.

Table 3.2: U.S. Employed Airframe Mechanics as of December 31, 1989 (35 Independent Repair Stations and 24 Air Carriers)

	Mechanics employed 12-31-89	Additional number needed to fully staff	Percent short
Air carriers	32,533	2,046	6.3
Repair stations	11,655	863	7.4
Total	**44,188**	**2,909**	**6.6**

Concerned about airframe maintenance, industry officials said that the lack of mechanics who specialize in sheet metal work is especially critical because of their specialized skill to inspect for corrosion and metal fatigue and repair the damage they find. Although specific figures on the shortage of sheet metal mechanics were not available, industry officials regard this problem as critical and believe that it could hinder repairs to aging aircraft. We found this to be true during a visit we made

[3]Occupational Outlook Handbook 1990-1991, U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2350-16.

to a major carrier's maintenance facility where we saw a repair bay standing empty because mechanics could not be hired to staff it. A carrier official said his company had lost 379 days of potential aircraft service partially because of a lack of mechanics. While this problem is critical with respect to repairing structural damage, it will become even worse after FAA issues all of its ADs on inspecting and repairing the damage caused by corrosion.

Shortage of Skilled Mechanics Due in Part to Suddenness of Demand and Need for Training

Industry representatives gave several reasons for the current shortage of mechanics, including the increasing number and diversity of aircraft in the U.S fleet and the time needed to train a newly-hired mechanic. According to an official responsible for one carrier's training, a survey he conducted of domestic air carriers' recruiting efforts attributed the shortage to fleet growth and diversity of aircraft. He said that each jet aircraft requires about 20 skilled mechanics. At this rate, the industry would need about 7,060 additional mechanics to service the 353 aircraft[4] added to the domestic fleet in 1988 and 1989. The Department of Labor also reported that fleet growth is generating a growing demand for aircraft mechanics and that a wave of retirements in the near future is likely to continue the current demand for skilled mechanics. As for fleet diversity, one industry official said that manufacturers now produce many more variations of the same aircraft model. Such diversity requires additional training for existing mechanics, on top of the extensive training already required for new-hires. A growing loss of experienced mechanics to training activities creates staff shortages and a reduction of overall skill on the maintenance line, this official said.

Some air carrier officials also said that they have faced mechanic shortages at maintenance bases located in the West. One air carrier official said that his firm cannot pay entry-level mechanics wages high enough to cover the cost of living near the firm's California maintenance base.

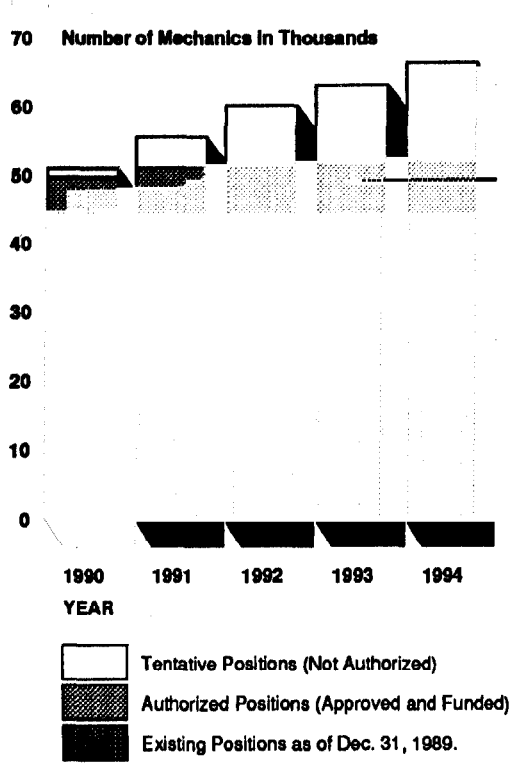
Industry Plans Substantial Increase in Number of Mechanics

Air carriers and independent repair stations we surveyed said that they plan to increase substantially the number of heavy airframe mechanics. We asked carriers and repair stations to report both authorized and tentative plans for each year from 1990 to 1994. Counting both types of plans, the industry expects to increase the number of positions by 15,860 by the end of 1992 and by an additional 6,349 mechanics by the

[4]Source: "World Jet Airplane Inventory," Boeing Commercial Airplane Group.

end of 1994, as shown in figure 3.2. The planned total of 59,860 positions for 1992 represents an increase of 35.4 percent over 1989 staffing levels, while the planned total of 66,209 positions for 1994 represents an increase of 49.8 percent.

Figure 3.2: Aviation Industry Authorized and Tentative Plans to Hire Heavy Airframe Mechanics



Source: GAO compiled data from questionnaire responses.

Air carriers and independent repair stations are taking several actions to increase the supply of mechanics for these new heavy airframe maintenance positions. For example, one carrier has established a tuition reimbursement program for its mechanics, and in 1990 it opened its own airframe and powerplant training school in association with a community college. This carrier has nine regional training schools, eight based at major airports, and it also works with public secondary schools near its main maintenance base to encourage aerospace-related curricula. Similarly, a large independent repair station that has tripled its staffing over the past 3 years has initiated a cooperative training program at a local junior college. It also has stepped up its own in-house training with

paid apprenticeships and continuing education courses, and it has established its own sheet metal training school. Actions taken by other carriers and repair stations we contacted include donating aircraft tooling and equipment to airframe and powerplant certification programs at neighboring junior colleges and working with administrators to update courses.

However, several factors could frustrate the industry's plans to obtain the maintenance skills it needs to meet the demand. First, repair stations have not authorized more than half the planned increase in the number of mechanics through 1992, and they may not fully realize their goal. Second, a Department of Labor economist concluded that airframe and powerplant school enrollment probably would not be enough to support these new positions. And, according to Labor, these schools are the primary source of most new mechanics. Finally, air carriers told us that newly-hired mechanics will require extensive training to become fully productive and skilled in airframe work. One carrier training official said that inexperienced mechanics will be particularly problematic as carriers try to accomplish the structural ADs because these mechanics require significant supervision and tend to slow the completion of maintenance work. After increasing its staff by 3,000 in 1989 to meet growing maintenance demand, one carrier reported doubling its training activities that year because its overall skill level declined so much that it measurably reduced productivity.

Greater demand for airframe mechanics, especially sheet metal mechanics, should tend to raise the wage rate for this profession and attract more of the labor force to it. This could take time, however. The most promising solutions seem to be those in which the repair stations, both carrier-owned and independent, adopt a formal training program and integrate that program into their operations.

Sufficiency of Hangar Space Depends on Expansion and Shifts in Air Carriers' Practices

Most of the 24 air carriers handling more than half of their own heavy maintenance anticipated operating their hangars at full capacity in 1990, while most of the 35 repair stations did not. However, air carriers and independent repair stations have plans to increase hangar capacity at their principal maintenance facilities by about 40 percent through 1992, with most of that expansion authorized for 1990. The sufficiency of hangar space for accomplishing the structural ADs rests on whether these plans materialize and whether air carriers rely more heavily upon the independent sector than they have in the past.

Heavy Airframe Maintenance Requires a Hangar

Regulations require air carriers and independent repair stations to fully enclose a large transport aircraft in a permanent structure when it needs to be shored (jacked up) and when maintenance is being performed on the airframe structure or fuselage skin. The reasons for this enclosure requirement are to prevent moisture (a major cause of airframe corrosion) from entering the exposed interiors of airframes and to avoid the possibility of extensive airframe damage or twisting caused by wind on the tail section when the aircraft is shored. Within the last year, FAA has begun to enforce this requirement more rigorously than in the past, especially for newly certificated repair stations. Therefore, an organization trying to obtain FAA certification to repair large airframes must have—in addition to technical expertise, management, and tooling—a permanent structure large enough to house large transport aircraft.

Building such structures is expensive and time-consuming. For example, according to an independent repair station official, a 75,000-square-foot hangar, large enough to enclose the biggest jumbo jet (a Boeing 747), recently cost $6 million. The typical elapsed time from the corporate decision to build until the hangar is completed and operating as a repair facility is 18 months. Therefore, establishing heavy airframe repair capacity cannot be taken lightly, and it cannot be done overnight. In the next couple of years, airlines and their increasing need for maintenance services will have to make do with the capacity that exists now in the repair industry.

Only Independent Repair Stations Had Excess Space in 1990

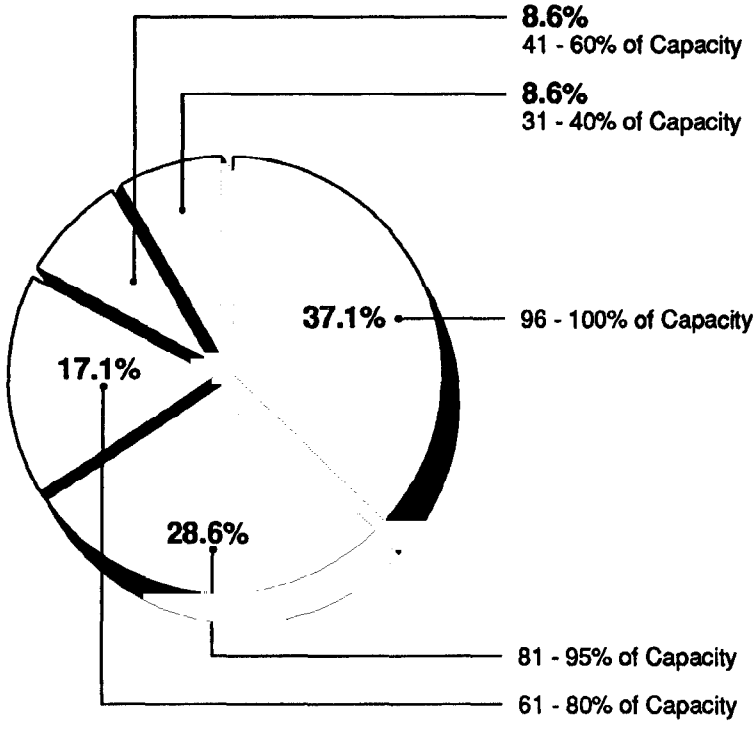
According to the respondents to our survey, independent stations have about 9.3 million square feet of hangar space, while air carriers have about 4.8 million square feet of space. In nearly every instance, air carriers' maintenance hangars are virtually full. Almost two-thirds of the 24 air carriers that do more than half of their own maintenance said that they would be operating at full capacity in 1990. An additional six carriers said that they would be operating at more than 80 percent capacity. In addition, lack of hangar space was a major reason that 10 carriers reported planning no contract work for other carriers.[5] Several of these carriers also said that, while they preferred not to, they probably would use independent repair stations more than they have in the past.

[5]None of the three air carriers reporting excess capacity reported that they had the capability to do much additional work. Each carrier has only one hangar and is unable to fully enclose some aircraft, thus limiting its ability to provide the widest range of repair services. Two of these carriers attributed excess capacity to their inability to coordinate hangar availability to potential customers' needs.

For example, a major carrier with more than 400 aircraft in its fleet reported that it was operating at full capacity in 1988 and 1989 and expected this level to continue throughout 1990. This carrier reported that it had not performed any heavy airframe maintenance on aircraft for other carriers since at least 1988. Although this carrier preferred to do its heavy airframe maintenance in-house, it planned to use five repair stations in 1990. Another large carrier said that because of insufficient hangar space for its own aircraft, it eliminated contract maintenance services it had performed for other carriers and began contracting for maintenance with independent repair stations.

In contrast, most of the 35 repair stations we surveyed said that they would not be operating at full capacity in 1990. As Figure 3.3 shows, only about one-third (13) of the 35 repair stations reported they would be operating at 96 to 100 percent of capacity in 1990. The remaining facilities reported 31 to 95 percent of full capacity.

Figure 3.3: Utilization of Independent Repair Stations



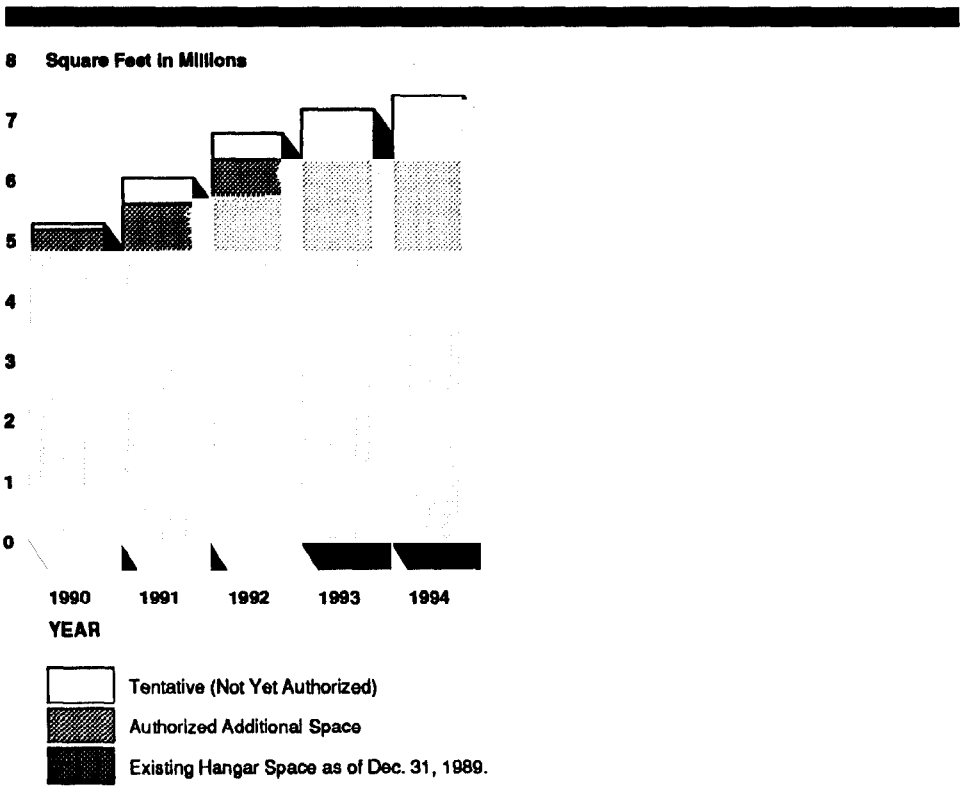
Repair stations generally attributed unused hangar space to scheduling gaps that occur when repair stations cannot match their hangar availability with the maintenance schedules of customer air carriers. For example, an independent repair station in Florida reported that gaps in hangar use exist because the station could not schedule its hangar space when customers needed services. This repair station was operating at 41 to 60 percent of hangar capacity in 1989 and expected to operate at 61 to 80 percent of capacity in 1990.

Substantial Increases Planned in Hangar Space

Air carriers and independent repair stations reported their plans for substantial increases in hangar space during 1990-1994, citing FAA aging aircraft mandates as a major reason for this expansion. Including both authorized and tentative expansions, hangar space will increase, according to industry plans, by 5.7 million square feet by the end of 1992 and by an additional 1.3 million square feet by the end of 1994. This represents an increase in hangar capacity of 40 percent by the end of 1992 and 50 percent by 1994. Of this increase, the repair station increase was substantially more than that reported by air carriers.

Air carriers' plans are summarized in figure 3.3. Thirteen of the 24 air carriers that do more than half of their own maintenance said that they were planning to increase their hangar space in the near future. The 24 carriers reported having 4.8 million square feet of hangar space in 1989. Carriers planning to expand reported authorized plans totaling 1.5 million square feet, one-half of it scheduled for 1992. Plans for 425,000 additional square feet through 1992 are tentative and have not yet been funded. Thus, air carriers already have funded plans to expand their current hangar capacity 32 percent by the end of 1992. And if tentative plans are carried out, they will have added almost 2 million square feet of hangar space by the end of 1992, an increase of almost 41 percent over 1989.

Figure 3.4: Air Carriers' Authorized and Tentative Plans to Construct Hangars, 1990 to 1994

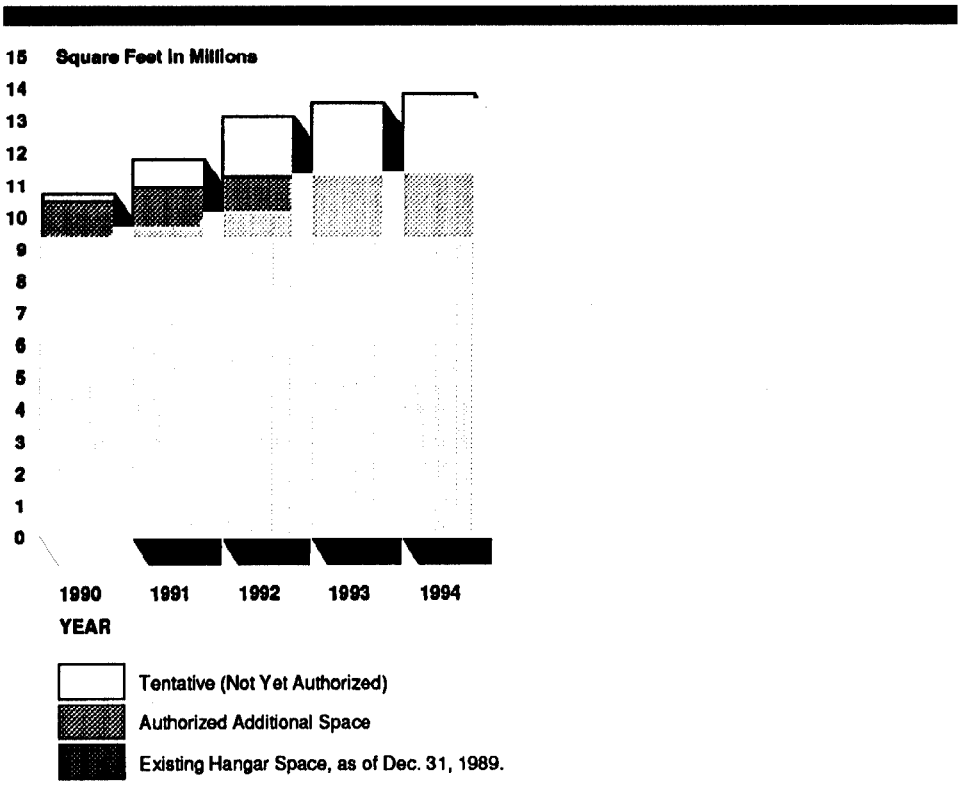


Source: GAO compiled data from questionnaire responses.

Independent repair stations' plans are summarized in figure 3.5. Even though most repair stations did not expect to operate at full capacity in 1990, 20 of the 35 repair stations we surveyed reported that they have plans to expand hangar space over the next several years. Moreover, 15 of these 20 plan to construct facilities that would enclose wide-body (Boeing 747) aircraft. This additional space is planned because the space that independent repair stations have had until now did not adequately accommodate the carriers' demand for repair of wide-body aircraft, which might also explain why repair stations had more unused space than did the air carriers. Together, the 35 repair stations in our survey had 9.3 million square feet of hangar space in 1989. Authorized plans will add 1.9 million square feet of hangar space from 1990 to 1992, most of it in 1990. Additional tentative plans would add another 1.9 million square feet by the end of 1992. If they realize all their plans, repair stations will have added 3.8 million square feet of hangar space by the end of 1992, an increase in current capacity of over 40 percent. Even if tentative plans ultimately fall through, repair stations already have

funded plans to expand hangar capacity by 21 percent by the end of 1992.

Figure 3.5: Independent Repair Stations' Authorized and Tentative Plans to Construct Hangars, 1990 to 1994



Source: GAO compiled data from questionnaire responses.

To Meet Deadlines, More Hangars and Carrier Use of Independents Could Be Needed

If air carriers and repair stations move as quickly as planned, a substantial amount of new space will be available for accomplishing the structural ADs ahead of the 1994 compliance deadlines. However, because two-thirds of the new and the total space will be at independent repair stations, air carriers will need to rely on these stations more than in the past. Some air carriers told us that in the past they have been reluctant to contract with independent repair stations because of concerns about whether independents could meet quality and time requirements. Traditionally, air carriers that did their own heavy airframe maintenance would contract for repair services only when their need for maintenance exceeded their own supply of maintenance resources. They told us that they are highly selective of the repair stations they use. All carriers we surveyed that do at least half of their own maintenance reported that

they prefer to maintain their fleet themselves because they can better control the quality, cost, or schedule of the work.

Despite the concerns associated with independent repair stations, some air carriers already are relying more heavily upon outside facilities. For example, independent repair stations we surveyed reported that they have done airframe maintenance on a growing number of commercial U.S. aircraft since 1988. Repair stations reported working on 835 aircraft in 1988 and 988 aircraft in 1989; they planned to work on 1,252 aircraft in 1990. In addition, most air carriers we surveyed reported that they were planning to use independent repair stations to conduct some of their heavy airframe maintenance over the next 4 years. Of the 48 carriers who responded to our survey, 31 said such repair stations would do some of their aging aircraft AD work. Of the remaining 17, two said other carriers would do AD work for them, 14 said they would not use outside facilities at all, and 1 said that its aircraft would not be affected by the ADs.

We discussed this issue with officials at one large carrier that already is relying more heavily than it prefers to do upon independent repair stations. This carrier recently acquired additional aircraft by merging with other carriers and faces considerable fleet standardization costs besides the aging aircraft work. Officials said that plans to expand maintenance facilities were unfunded and construction was at least 5 years in the future. Representatives from this carrier said that they will continue to use independent repair stations in the future because its maintenance needs will continue to exceed its maintenance capacity.

Current Economic Recession Poses Uncertainties for the Supply of Repair Services

In response to our mid-1990 survey, airline and independent repair stations reported to us their plans to hire additional mechanics and expand their hangar capacity. Since then, however, the country has entered an economic recession that could dampen such plans because of the decline in business activity and demand for air travel. The airline industry is especially hard-hit by the recession because of several firms' already weakened financial condition and the simultaneous impact on airline costs that higher fuel prices are having. In turn, the aircraft repair industry also will feel the effects of the recession, although the lasting effect, if any, on the overall supply of repair services is difficult to foresee.

Nevertheless, some short-term effects of the recession are likely. For example, to adjust for declining air travel, carriers take planes out of

service, thus causing overall demand for repair and maintenance to also decline. In addition, plans to construct new hangars, hire and train new mechanics, or even enter the market as a new firm may be deferred. However, deferring expansion now could mean that after the recession the repair industry will not be able to meet airlines' demand for services because of the long lead times needed to add hangar space and train mechanics. Ultimately, whether supply of repair services can meet demand may depend on the length and severity of the recession.

Conclusions

The mandated AD work is testing the capacity and growth potential of the airline industry's heavy airframe maintenance resources. The industry faces shortages in parts, skilled labor, and hangar space. Air carriers and repair stations are taking positive steps to relieve these shortages, but timing is critical. It takes time to produce enough parts, train aircraft mechanics, and build new hangars. Nevertheless, by the end of 1992, the industry should make good progress in all three of these areas. If air carriers delay AD work in the meantime because of resource shortages, the industry may not be able to fully accomplish the AD work before the end of the compliance period. Some carriers have already experienced delays in completing this work. A few major carriers also expressed concern that they could experience substantial economic problems if they take aggressive steps to comply with the 1994 deadlines.

The current recession is not making it easier on the industry. Weakened demand for air travel and higher fuel costs are causing aircraft to be taken out of service. This is further evidence that current demand for maintenance could be postponed until the latter part of the compliance period. In chapter 4 we discuss the implications this might have for FAA oversight policy.

FAA's Oversight of Aging Aircraft Repairs Is Ineffective

The Federal Aviation Administration (FAA) could be doing more to monitor, follow up, and help the air carrier industry to comply with airworthiness directives (ADs) aimed at correcting structural problems with older aircraft. Until recently, however, FAA officials did not know of the magnitude of the obstacles facing carriers trying to comply with the ADs. This lack of knowledge may be why some necessary analysis and planning with regard to the implementation and monitoring of the aging aircraft ADs has not been done.

First, FAA may not have allowed enough time for the industry to comply with the ADs, given such constraints on timely compliance as parts shortages, collateral structural damage, and the recently-issued corrosion ADs (see ch. 3). In determining the AD's effective dates as part of its formal rule-making process, FAA policy requires the agency to consider air carriers' ability to schedule required AD work and to obtain needed spare parts. In this case, however, FAA discounted carriers' written statements saying the period might be too short. Instead, FAA placed more credence on advice from an industry task force. Second, FAA did not adequately identify at the outset the parts shortage that many carriers would face in complying with the ADs. Finally, FAA's initial plan to enforce the ADs involved the one-dimensional action of grounding all aircraft not meeting the requirements. The agency wrongly believed that this threat would encourage maximum efforts by air carriers. However, if parts and labor shortages continue to slow the repair pace, the agency could be forced to ground hundreds of noncomplying aircraft, which would result in severe disruption of the nation's air commerce, financial hardship for affected air carriers, and the potential for increased safety risk.

We believe that more active monitoring of air carriers' progress between now and 1994 would provide better information to alert FAA of carriers' parts, labor, or space problems and enable the agency to both facilitate solutions to these problems and act appropriately if an unreasonable level of noncompliance occurs.

FAA Did Not Adequately Evaluate the Impact of Structural ADs

Before it established the effective dates for the structural ADs, FAA could have obtained better information, as well as acted more appropriately on the information it had, to assess air carriers' ability to comply in a timely manner with the ADs. First, FAA did not evaluate the AD's economic impact on the economy, in accordance with Executive Order 12291. Officials said that this would have been too onerous a task and

that no precedent exists for it. Second, instead of heeding formal comments from carriers, it relied upon the collective opinion of the Airworthiness Assurance Task Force that airlines could do the work within 4 years from the 1990 effective dates and on manufacturers' advice that they could supply the required parts. With the benefit of a more rigorous evaluation of national repair capacity, FAA could have addressed, and dealt with if necessary, concerns already beginning to surface about parts, labor, and space availability.

Regulatory Impact Analysis Could Have Provided Needed Economic Insight

FAA's actions to determine the ADs' consequences were not fully in keeping with Executive Order 12291. This order requires a federal agency to prepare a regulatory impact analysis for any proposed regulation with an annual effect on the economy of $100 million or more. However, FAA believed that it did not have to comply with this requirement because, standing alone, none of the structural AD cost estimates exceeded the $100 million threshold in any given year. This is because each aircraft model, such as a Boeing 727, has a separate structural AD—seven in all for Douglas and Boeing aircraft—and the work and its cost could be spread over 4 years. Taken together, however, the Air Transport Association initially estimated the cost worldwide of the structural ADs to be $1.4 billion over the 4-year compliance period. On the basis of remarks by FAA and airline officials, we believe that the initial estimate probably is too low. The true cost of the these ADs could be over $2 billion by 1994. Thus, because the U.S. fleet accounts for about half that figure (U.S. carriers operate half of the world's jet transport fleet), the annual cost impact would far surpass the $100 million criterion set in the Executive Order.

FAA did not perform an impact analysis of the aggregate effects of the ADs because officials believe that the Executive Order did not require such analysis and that the burden it would place on the agency's regulatory resources would be overly cumbersome. Nevertheless, we believe that an economic analysis of some dimension would have provided better information on which to base the duration of the compliance period, given the likely economic and competitive effects the ADs might have on the financially strained air carrier industry.

In Setting Compliance Dates, FAA Could Have Been More Sensitive to Carrier Concerns Over Parts and Space

According to FAA Order 8040.1B, entitled Airworthiness Directives, FAA should answer the following questions, among others, when proposing effective dates for new ADs:

- Does the effective date allow time for obtaining needed parts?
- Does the effective date allow sufficient lead time to permit operators to schedule their aircraft for maintenance without disrupting flight schedules?

To answer questions such as these for proposed rules, FAA generally relies on the comments provided during the rule-making comment period by the aviation industry and other interested parties. FAA issued "notices of proposed rule-making" for structural ADs on Boeing aircraft in the spring of 1989 and requested comments by July 1989. The comments received by FAA showed that problems with parts, scheduling, and other issues needed to be addressed. For example, the Air Transport Association and most major carriers said parts unavailability from Boeing could hinder their ability to meet the compliance deadlines. One carrier commented that FAA understated its labor and cost estimates and that FAA also should include in its estimates the cost of labor and materials for collateral damage. Other carriers expressed concern that because of the unprecedented magnitude and scope of the required work, the proposed 4-year compliance period may be insufficient and that FAA should be receptive to requests for other means of compliance and for extensions of the compliance dates. Several carriers recommended that FAA not issue final AD rules until it had assurances from Boeing that the parts would be available when needed by the carriers.

A major carrier told us that although it had been represented on the task force by its structural engineering staff, this staff was responsible for determining and designing structural modifications, not for determining parts availability, evaluating maintenance capacity, planning complicated maintenance schedules, or estimating the time and cost to complete mandated work. Despite attempts by this carrier's maintenance planning staff to communicate with FAA, a carrier official told us that FAA had not discussed parts availability, the actual time and cost to do the work, or maintenance capacity and scheduling with this staff. According to this official, his first opportunity to express his views came in July 1989, in his airline's comments to FAA's proposals.

As early as summer 1989, carriers were sending other signals of concern. In response to the need for additional resources to meet the pending ADs, two major carriers told us of their new policy of no longer

providing maintenance for other carriers' planes, ending service provided for decades to these smaller carriers. In addition, major carriers rapidly expanded their use of independent repair stations to serve their growing maintenance demand.

FAA did not, however, heed carriers' comments about their ability to schedule their aircraft for maintenance and obtain needed spare parts. According to FAA, it relied entirely upon task force assurances that the work could be done within the 4-year period and manufacturers' assurances that parts would be available when air carriers needed them. FAA officials said they felt justified in this reliance because the task force included representatives of all major domestic air carriers, and the chief maintenance officials of several leading air carriers were on the task force's steering committee. Moreover, aircraft manufacturer officials served on the task force and on the steering committee. However, their expertise may not have been in the everyday functions of planning maintenance schedules, ordering spare parts, and completing maintenance work. This may explain, in part, why these factors are currently so prominent in jeopardizing carriers' ability to comply with the deadlines.

The task force working groups that advised FAA and were responsible for recommending model-specific repairs probably would not have known about these limitations. The teams addressed particular models of aircraft and were thus limited to examining only a small part of the total picture. Providing the perspective—and thus spotting the problems—would have to be done by an oversight body such as FAA. However, FAA arrived at its estimate of the total cost and time involved essentially by totaling the work of the study teams. By taking no further action, FAA added no longer-term perspective to the process. Instead of this passive approach, another method would have been to obtain actual cost data from airlines that had completed the structural repairs when they were still optional under manufacturer service bulletins. If the AD had no service bulletin basis, selected air carriers could have first done the work to provide FAA with actual man-hours and cost experience. The actual data should have come from a cross section of the repair station industry, in our opinion, because of the inevitable variances among repair stations. These improvements would have helped to eliminate future compliance problems created by setting compliance deadlines that are not based on accurate estimates.

Thus, on the basis of assurances received during task force meetings and from the manufacturers directly, FAA chose to dismiss the warnings it

received during the comment period. In March 1990 it established a 4-year compliance period for Boeing aircraft and declared its intention to ground all aircraft not meeting the deadline.

FAA Has Taken Limited Action to Monitor Carriers' Mixed Progress

Until recently, FAA was not systematically collecting information on air carriers' progress in completing structural AD modifications. And information the agency is obtaining now is not sufficient to evaluate carriers' progress. The results of our industrywide survey and discussions with 17 carriers showed that progress throughout the industry toward timely compliance with the ADs has been mixed at best. FAA was not aware of this situation, according to FAA officials, until we shared the results of our survey with them.

Developing an Approach to Compliance Varies Widely Among Carriers

We are concerned about the industry's efforts to date to comply fully with FAA's structural ADs by the 1994 deadlines because some of the 17 carriers (representing 83 percent of the U.S. fleet) we visited have not developed plans for compliance. Thirteen of the 17 carriers had prepared plans, but many had not ordered parts, secured mechanics, or scheduled hangar space. Their best efforts included these five basic types of actions:

- a plan that includes a compliance schedule and dates each aging aircraft will receive the AD work;
- parts ordered before scheduled work;
- mechanics secured to do the work;
- hangar space secured for scheduled work; and
- aging fleet size reduced by selling, retiring, or returning aircraft to owners and replacing them with newer ones.

As table 4.1 shows, as of November 1990, some carriers had taken steps on all five types of actions, while others had not taken substantive actions at all.

parts. We believe that this carrier will find it difficult to obtain the needed maintenance toward the end of the compliance period because of the build-up of demand at this time.

A cargo carrier with a small fleet has adopted a much different compliance approach. This carrier has decided to replace its entire aging fleet because of the high cost of complying with aging aircraft ADs. It plans to replace its fleet with newer aircraft that are exempt from the mandates.

FAA Could Take a More Active Oversight Role

According to FAA officials, the agency traditionally does not evaluate the air carrier industry's progress in complying with ADs. This is because FAA's responsibility is to minimize safety risks to the traveling public by identifying air safety hazards and issuing ADs to correct them; responsibility for complying with the ADs rests with the industry. As a result, they said, FAA has never measured the progress of the U.S. fleet toward compliance before the compliance dates. Instead, FAA has focused its attention on the compliance of specific aircraft with individual ADs after the compliance dates. According to FAA, any industry concerns about an inability to comply should be expressed during the public comment period before AD issuance. Valid comments can then be incorporated into amendments to the AD, such as adjustments in the compliance period.

Although it is certainly the airline industry's responsibility to comply with the ADs, we believe that a more active FAA role is appropriate, given the exceptional burdens placed upon the industry's maintenance capacity by the aging aircraft ADs. In fact, some evidence suggests that FAA is moving in this direction. Near the completion of our review, we briefed the task force steering committee on some key facts we learned from our mail survey of the aircraft repair and maintenance industry. Present at the meeting were management officials from FAA's Transport Airplane Directorate and Aircraft Certification Division. Shortly afterward, on October 30, 1990, FAA issued a "draft" notice to its principal maintenance inspectors[3] asking them to monitor AD implementation schedules of their assigned carriers. The notice, which was finalized on January 30, 1991, appears, in part, below.

"It appears that while some airlines are actively pursuing an aggressive aging airplane repair and modification program, others are not. Based upon FAA's previous

[3]FAA's principal maintenance inspectors, or PMIs, are responsible for monitoring air carriers' compliance with FAA-approved basic maintenance plans and all FAA ADs and rules to better ensure aircraft airworthiness and safety.

experience involving AD's and changes to operational rules with extended compliance times, some operators are expected to wait until the last few months or weeks to comply with the AD's. These operators may then have to apply for an extension of the compliance time provided for in the AD. This last minute approach will cause an undue burden on FAA, impact the traveling public, and create significant problems for the airline industry."

By issuing this notice, FAA showed that it recognized the industry's need for assistance. However, we believe this guidance could be stronger in several ways. For example, the notice is only valid for 1 year and is automatically cancelled on January 30, 1992. This would leave over 2 years in the AD compliance period that field inspectors are not required to monitor carrier progress toward compliance. In addition, while the notice provides for determining whether carriers have plans to comply, it does not ask inspectors to determine underlying causes for carriers' lack of plans.

We believe that FAA could take a more active position in monitoring AD compliance. For example, we recommended in a 1989 report that FAA develop a plan that would facilitate its oversight of many aging aircraft-related actions—such as modifications to Boeing and Douglas aircraft.[4] We suggested in that report that FAA establish a regular means of reporting—especially to the Congress—its and the industry's progress toward addressing the problems posed by aging aircraft. FAA agreed with our recommendation but has taken 2 years to develop its plan and does not expect to issue it until June 1991. Moreover, actions we said needed to be taken then still need to be taken now. For example, FAA could request compliance progress information from all air carriers affected by the aging aircraft ADs. During our review, we obtained information from the 17 air carriers on the number of aging aircraft in each fleet, the number each carrier planned to retain beyond the 1994 compliance dates, the number of aircraft with the structural AD work totally completed and partially completed, the reasons for partial completion, and descriptions of barriers to carriers' compliance with the ADs. For each carrier, we also obtained information on compliance plans, maintenance schedule for completing the work, and availability of hangar space and spare parts. Armed with this kind of information, and periodic updates of it, FAA could better determine how best to help the industry comply with the ADs.

[4]AGING AIRCRAFT: FAA Needs Comprehensive Plan to Coordinate Government and Industry Actions (GAO/RCED-90-75, Dec. 22, 1989).

Being assured that the safety risk of aging aircraft has been reduced as far as possible is something that the Congress has demonstrated is important to the American public. To obtain this assurance, Chairman James Oberstar of the House Aviation Subcommittee introduced during the last Congress legislation that would require a special inspection and maintenance records review of every airliner as it approached the end of its economic design life. The bill, H.R. 3774, passed the House but not the Senate. Similar legislation has been reintroduced during this Congress as H.R. 172, The Aging Aircraft Safety Act of 1991. Until this bill and its required inspections and records reviews are enacted into law, FAA could substitute periodic summaries of the progress air carriers are making in implementing the structural modifications called for in FAA's ADS.

FAA May Need to Use Alternatives If Noncompliance Is Widespread

FAA's position is that aircraft not meeting the deadlines for structural ADs are to be grounded until the modifications are completed, unless an alternative means of compliance can be found that also ensures aircraft safety. FAA officials based this position on industry assurances that the work could be done within the dates recommended by the task force. They told us that the expert source of these recommendations gave FAA reasonable assurance that compliance was within the industry's resource capacity.

FAA officials note that the agency has other options for addressing noncompliance besides grounding planes. One, for example, is to allow air carriers to continue inspecting aging aircraft and fixing damage on an as-needed basis[5] so that airworthiness is assured until AD modifications can be made. Each structural AD contains options for other means of compliance or for extending compliance deadlines. FAA officials said, however, that other options were less preferable, not because they were less safe but because they might discourage air carriers from complying with the ADs.

We believe that a strong economic deterrent exists to FAA's grounding of large numbers of airliners and that many decisions involving alternative means of compliance could need to be made. In our opinion, the sudden unavailability of even 10 percent of the domestic fleet could affect air carriers' ability to maintain flight schedules. FAA may find itself unwilling to ground aircraft if the consequences are too severe in terms

[5]This is the "damage tolerance" approach discussed in chapter 1 and used by the FAA until the structural ADs were issued.

of economic hardship to weaker firms in the industry. Instead, FAA might want to focus on ensuring the safety of noncomplying aircraft without taking the aircraft out of service altogether. For example, because not all repairs required within a given AD affect airworthiness equally, aircraft having been substantially repaired with good faith efforts from carriers could be allowed to continue in service on the condition that final repairs be scheduled as soon as possible and that the aircraft meets FAA's criteria for airworthiness. The drawback to this strategy is that it is labor-intensive and would require FAA to obtain and analyze aircraft-specific data from carriers. It might also involve performing some direct inspections of aircraft not in full compliance with the structural ADs so that safety margins are not compromised.

As discussed in chapter 3, compliance progress has been slow. We visited 17 air carriers who operate 83 percent of the over 4,000-plane U.S. fleet. They told us that as of April 1991 they had completed the structural ADs on 28 aging aircraft and partially completed them on another 705 aircraft. The principal reasons carriers gave us for the slow progress were replacement parts shortages, insufficient maintenance scheduling time, and plans to finish the AD work at a later date. While discussing the industry's slow start and barriers to full compliance with us, the Chairman, Airworthiness Assurance Task Force, said he would be satisfied if the airline industry made substantial progress toward compliance by the 1994 compliance dates, thereby demonstrating to FAA and the Congress the industry's good faith effort. We might agree with this if every airline made substantial progress; however, we do not believe it is acceptable for some airlines to make limited or no progress.

We do not take issue with FAA's preference for grounding aircraft that are not in compliance. Our concern is that if FAA does nothing between now and 1994 to prepare for the possibility that other options may be needed, its inaction may lead to hasty and perhaps ill-considered decisions. For example, allowing a large number of carriers to continue inspecting for damage instead of fixing or grounding the planes could be a safety risk not worth taking because it could put us in the same position as we were in when the Aloha incident occurred.

Some precedent exists for considering other strategies. For example, FAA modified its position regarding the Traffic Alert and Collision Avoidance System (TCAS II), a system installed in aircraft to warn pilots of potential mid-air collisions independent of warnings from air traffic controllers. In January 1989 FAA required Part 121 carriers to install and operate TCAS II by December 30, 1991. Implementation would cost over $100,000

per aircraft. FAA officials said that TCAS II was then the most expensive, most industry-encompassing safety rule yet issued by FAA. On the basis of congressional and industry concerns about this schedule, before the final rule was issued FAA modified the schedule calling for a phased TCAS II installation over a period of several years, extending the compliance by 2 years.

In FAA's opinion, extending the implementation schedule enhanced air safety because it helped to minimize the prospect that air carriers would have to choose between installing TCAS II and performing other critical fleet maintenance. Further, the extension meant that a carrier could install TCAS II during its regular maintenance cycle, an economic benefit that reduces the number of maintenance visits and total aircraft downtime. An additional advantage cited was that the proposed time extension would give TCAS II equipment manufacturers time to produce and deliver the TCAS II equipment.

We are not advocating extending the structural AD deadline as FAA did with TCAS. However, to make any adjustments to its position, FAA will need information from carriers that it does not have now and is not collecting.

Conclusions

When issued by FAA, the structural ADs for aging aircraft represented the largest work requirement ever placed on air carriers. Since then, the corrosion ADs have added a workload that over time could be even greater than the structural AD work. Industry experts expect the combined impact on the airline industry of the structural and corrosion ADs to be several billion dollars, and recent experiences of repair stations seem to be bearing this out. However, FAA chose to base its estimates of the impact on the industry on advice it received from the Airworthiness Assurance Task Force rather than on an economic impact analysis as required by Executive Order 12291 or on information it received from carriers during its formal comment period before the ADs were made final. This decision removed an early opportunity to identify and address many of the barriers confronting air carriers' compliance with the structural AD deadlines.

Because service bulletin estimates made under the assumption of ideal conditions contributed to FAA's underestimating the actual time and cost of the aging aircraft AD work, we believe FAA should have availed itself of other sources of information, such as carrier comments on the draft AD, to help it develop estimates. However, because current uncertainty

about air carriers' ability to comply with the 1994 deadlines for structural ADs is significant, we believe that a more active approach by FAA to monitoring carriers' progress is warranted. We believe FAA's recent plan to monitor industry compliance progress is a positive step if it is made a permanent part of official policy. In addition, if FAA went further with more definitive monitoring and data collection, the agency could determine whether problems with parts, personnel, and space would be overcome in time to achieve compliance, and if not, whether its current plan to ground all noncomplying planes could be tempered with alternative strategies that do not compromise air safety.

Recommendations to the Secretary of Transportation

To improve FAA's oversight of aging aircraft AD compliance, we recommend that the Secretary of Transportation direct the Administrator, FAA, to require domestic Part 121 air carriers to submit periodic reports on their implementation of FAA's new rules for aging aircraft. Each report should include

- descriptions of critical compliance obstacles;
- an implementation schedule for each aging aircraft, including evidence of obtaining sufficient hangar space for the work;
- evidence that replacement parts have been ordered, plans for obtaining remaining parts, and facts relating to compliance being impaired by parts unavailability; and
- a status report on aircraft that have been (1) brought into compliance, (2) disposed of before doing the AD work, (3) newly acquired and will require the work, and (4) kept in operation and will still need the work.

We recommend that the Secretary of Transportation submit to the Chairmen of the aviation authorization subcommittees in the House and Senate a semiannual report on the industry's progress in implementing FAA's aging aircraft mandates. The report should discuss significant advances as well as shortfalls in the industry's progress and actions FAA is taking to mitigate any shortfalls.

To improve FAA's ability to respond in the event of widespread noncompliance with deadlines for completing structural AD work, we recommend that the Secretary of Transportation direct the Administrator, FAA, to explore options for extending compliance deadlines on a case-by-case basis or granting alternative means of compliance. Alternatives should be considered only when warranted by resource shortages and when the airworthiness of each aircraft granted such waiver can be ensured.

Agency Comments

We provided a draft of this report to FAA and Department of Transportation officials responsible for developing and enforcing the aging aircraft ADs. We incorporated their comments as appropriate to improve the technical accuracy and clarity of our report.

With regard to our recommendation that FAA require periodic progress reports from air carriers, FAA believes that these reports would impose a burden on the industry that is not warranted by the safety implications of the report. However, in view of the limited time for which these reports would be required, the ADs' cost impact on the industry, and the threat to air safety posed by fatigue and corrosion damage, we believe that the industry reporting is warranted.

List of Air Carriers That Completed GAO's Mail Survey of Maintenance Activities

Listed below are the 48 air carriers that completed our mail survey. These carriers represent 99 percent of the large transport aircraft in the U.S. fleet as of January 1, 1990.

Large Passenger Airlines (100 or More Aircraft)

American Airlines
Continental Airlines
Delta Air Lines
Eastern Airlines
Northwest Airlines
Pan American World Airways
Trans World Airlines
United Airlines
USAir

Small Passenger Airlines (Less Than 100 Aircraft)

Alaska Airlines
Aloha Airlines
America West Airlines
Hawaiian Airlines
Markair
Midway Airlines
Midwest Express Airlines
Southwest Airlines
The Trump Shuttle

Cargo Carriers

ABX Air, Inc.
Air Transport International
Amerijet International
Arrow Air
Buffalo Airways
Challenge Air Cargo
Connie Kalitta Services
DHL Airways
Emery Worldwide
Evergreen International Airlines
Express One International
Federal Express
Florida West Airlines
Independent Air
Ryan International Airlines
Southern Air Transport

TPI International Airways
Trans Continental Airlines
United Parcel Service

Charter Passenger Carriers

Airlift International
American Trans Air
Casino Express
Emerald Air Lines
Great American Airways
Key Airlines
MGM Grand Air
Private Jet Expeditions
Rich International Airways
Sun Country Airlines
Tower Air

List of Independent Repair Stations That Completed GAO's Mail Survey of Maintenance Activities

Thirty-five of the 38 repair stations to whom we mailed surveys completed them and returned them to us. The repair stations that responded are located in 12 different states.

Independent Repair Stations

Aero Corp.
Aerotest
Aircraft Maintenance Services, Inc.
Agro Air Associates
Associated Air Center, Inc.
Greenwich Air Services
Boeing Commercial Airplanes-Seattle
Boeing Wichita Company
Clinton-Sherman Aviation, Inc.
Commodore Aviation, Inc.
Cross Continent Aircraft Services, Inc.
Dalfort Aviation Services
Dee Howard Company
DynAir Tech of Arizona
DynAir Tech of Florida
E-Systems, Inc.
Chrysler Technologies Airborne Systems
Elsinore Airframe Services, Inc.
Georgetown Aircraft Services, Inc.
Grumman St. Augustine
Hamilton Aviation Company
Hughes Aviation Services
Intertec Aviation
Lockheed Aeromod Center
NARCAM Aircraft, Inc.
Page Avjet Corp.
Pan Aviation, Inc.
Pemco Aeroplex-Birmingham
Pemco Aeroplex-Clearwater
Pemco Aeroplex-Dothan
Professional Modification Services, Inc.
Rockwell, North American Aircraft
Tracor Aviation
Tramco
Volpar Aircraft Corp.

List of Air Carriers and Independent Repair Stations That GAO Visited

For specific information to augment the results of the mailed surveys, we visited 17 air carriers and 10 independent repair stations. The 17 air carriers account for about three-quarters of the more than 4,100 aircraft flown by U.S. carriers, including cargo and charter companies. The firms we visited are listed below.

Air carrier	Number of large transport aircraft as of Jan. 1990
ABX Air	37
Alaska Airlines	54
American Airlines	503
Amerijet International	8
Continental Airlines	326
Delta Air Lines	407
Federal Express	154
Florida West Airlines	5
Midway Airlines	66
Northwest Airlines	320
Pan American World Airways	176
Southern Air Transport	14
The Trump Shuttle	20
Trans World Airlines	213
United Airlines	429
United Parcel Service	99
USAir	364
Total	**3195**

FAA has certified the 10 independent repair stations we visited to perform heavy airframe maintenance on large transport aircraft. Nine of the 10 had repaired large transport aircraft for various U.S. and foreign air carriers. The remaining station is new in the heavy airframe business and only worked on U.S. carrier aircraft since 1989.

Repair Station	Location
Aerotest	Mojave, Calif.
Commodore Aviation	Miami, Fl.
Dee Howard Company	San Antonio, Tx.
DynAir Tech of Florida	Miami, Fl.
Greenwich Air Services	Miami, Fl.
Grumman St. Augustine	St.Augustine, Fl.
Page Avjet Corp.	Orlando, Fl.
Professional Modification Services	Miami, Fl.
Tracor Aviation, Inc.	Santa Barbara, Calif.
Tramco	Everett, Wash.

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