United States General Accounting Office

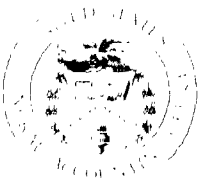
GAO

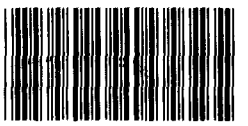
Report to Congressional Requesters

October 1990

AIRCRAFT MAINTENANCE

Potential Shortage in National Aircraft Repair Capacity





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GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-241110

October 31, 1990

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, we are reviewing various aspects of the United States' aircraft repair station industry. We are currently obtaining a broad range of detailed information. As requested, we are providing you with an interim report that contains information based on discussions with selected airline-owned and independent repair stations. After completing our review, we will issue a report containing a more complete analysis of the aircraft repair station issues.

This report discusses

- reasons for recent increases in demand for maintenance,
- the extent to which the industry's capacity is being used, and
- the factors affecting future demand for and supply of airline and independent repair station services.

Because the Federal Aviation Administration (FAA) recently mandated repairs and modifications to aging aircraft (approximately one-third of the U.S. fleet could need major repairs within 4 years), we raised concerns during hearings in late 1989 that the demand for aircraft maintenance could exceed the aircraft repair industry's short-term capacity.[1] This demand could mean that some carriers would be taking aircraft in need of maintenance out of service until maintenance can be scheduled, which, in turn, could have undesirable effects on air fares and schedules. Alternatively, under some conditions, FAA can allow carriers to defer certain structural modifications if they agree to inspect more frequently for evidence of fatigue so that damage can be identified before it exceeds allowable limits. If FAA permits this alternative to be exercised on a widespread basis, however, it could mean that the intent of FAA's orders to repair aging aircraft is not being met.

[1]See Meeting the Aging Aircraft Challenge: Status and Opportunities (GAO/T-RCED-89-67, Sept. 27, 1989).

We base the information in this report on our analysis of the Department of Transportation's (DOT) aircraft maintenance data and our discussions with five airlines[2] and four independent repair stations. These repair stations are nonairline facilities that perform maintenance on business, commercial, and other aircraft on a contractual basis.[3]

Results in Brief

FAA's recent regulatory changes to ensure the safety of aging aircraft will require substantial structural modifications and significantly increase short-term demand for repair services, affecting over the next 4 years about 1,400 of the 4,100 planes in the U.S. fleet. The increase in aircraft maintenance costs—primarily for airframes—is expected to total $2 billion or more over the next 4 years, or an average of $500 million per year. This increase in cost is an amount equal to all of the industry's 1988 expenses to repair airframes and represents an almost 9-percent increase in the existing $5.7 billion annual cost of aircraft repair and maintenance.[4]

According to the airlines and repair stations we contacted, this increased demand for repair services may not be matched by corresponding increases in capacity in the immediate future. This situation is particularly true for maintenance facilities of four of the five airlines we contacted which expected to be operating in 1990 at or near 100 percent of their hangar space capacity.[5] On the other hand, because of recent expansion, some additional capacity will exist in the independent side of the industry. For example, three of the four repair stations expect to have between 5- and 19- percent (average was 10 percent) excess capacity during 1990. Thus, if these organizations' experiences fairly represent the total industry, the independent portion of the industry could have about 10-percent excess capacity in 1990 and the airline-owned portion may well have no excess. However, because the

[2]The five airlines are Alaska (a 54-plane national carrier) and American, Continental, Trans World, and United—all major carriers. In total, these carriers account for about 39 percent of the U.S. fleet.

[3]The independent repair stations we surveyed are Tramco (Everett, Wash.), Tracor Aviation Inc. (Santa Barbara, Calif.), the Dee Howard Company (San Antonio, Tex.)—all of which are relatively large facilities with more than 100,000 square feet of hangar space (a 747 requires 75,000 square feet to be fully enclosed)—and Aerotest (Mojave, Calif.), with 24,000 square feet of space.

[4]Although these dollar figures are in current year terms—usually 1988 because this is the most recent summarized data in DOT's database—additional historical data on maintenance costs that have been deflated to a common 1982 base are contained in appendix I.

[5]Hangar space is used in the industry as the measure of capacity because compared with other supply-constraining variables, such as labor and parts, space is most difficult to vary in the short-term.

independents constitute only about 20 percent of the industry, excess capacity in the repair industry as a whole may be only about 2 percent in 1990.

If these examples reflect the situation in the industry as a whole, the industry's 2-percent excess capacity in 1990 may fall short of meeting the increase in demand. Moreover, without improvement, airlines may need more than the FAA-allowed 4 years to meet FAA's new requirements to fix aging aircraft. If airlines cannot comply with the FAA requirements, they will need to request FAA's approval to defer maintenance, seek repair service overseas, or take noncompliant aircraft out of service.

According to the nine repair stations we contacted for this interim report, the immediate obstacles to expanding the supply of repair capacity are the shortage of skilled aircraft mechanics in some markets and the long time required to bring new facilities on line. In addition, FAA officials said that some special spare parts are not currently available and that this is critical to proper modification of aging aircraft. Our subsequent report covering the whole industry will provide a more thorough analysis of the situation.[6]

Operating at Near Full Capacity, the Repair Station Industry Is Expanding

New demand for repair services is stimulating broad growth in the aircraft repair industry. Not only are existing firms expanding, but also new entrants are appearing in the industry. Moreover, out-pacing industrywide growth is growth in work that airlines contract out to other airlines or to independent repair stations. Even with expansion, however, the industry is operating at near full capacity.

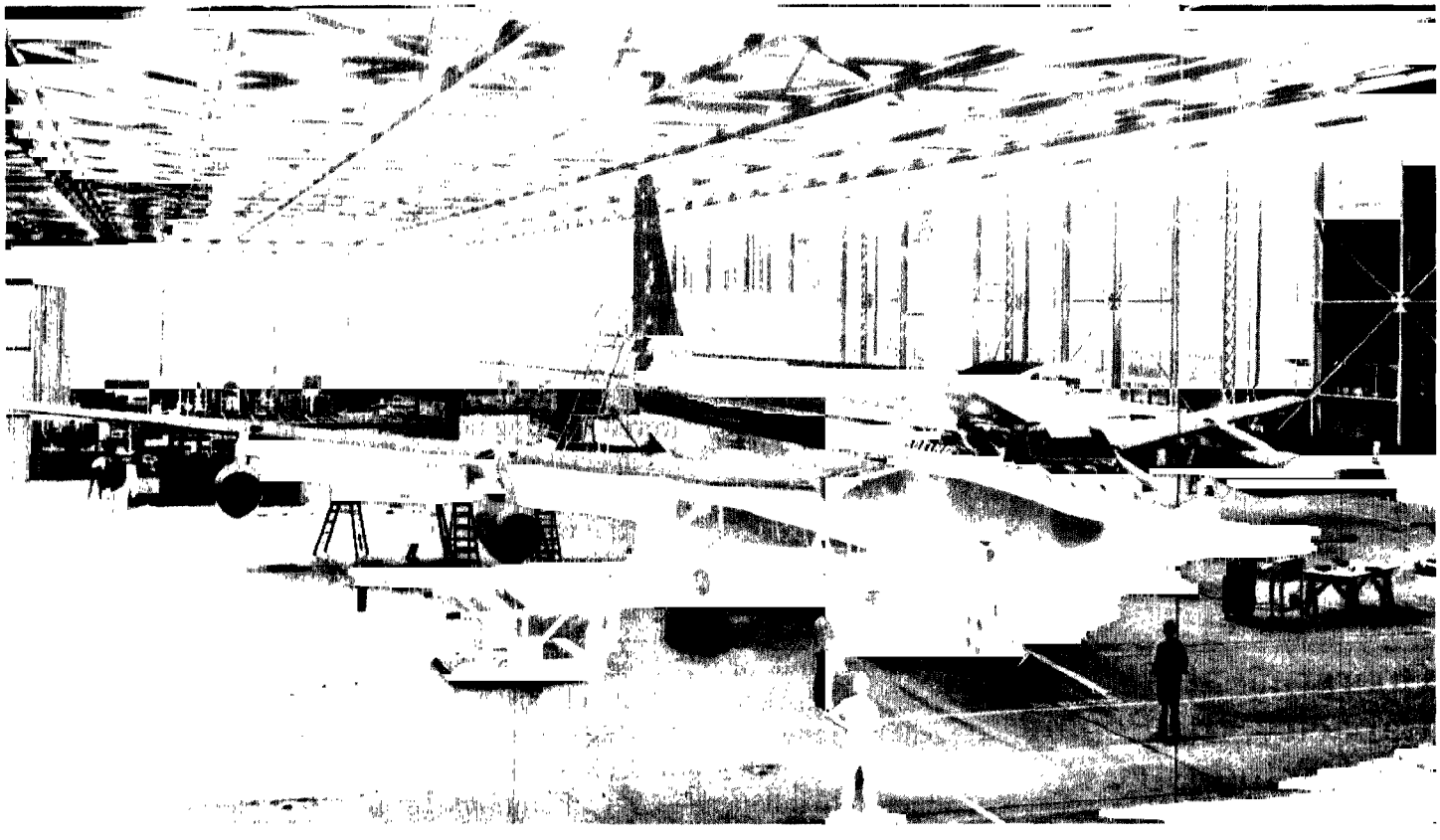
Aircraft Repair Industry Structure Is Changing; Airline Use of Industry Varies

Under the Code of Federal Regulations, title 14, part 145, FAA has certified about 4,000 repair stations to work on aircraft and aircraft components. However, relatively few stations have the necessary facilities, equipment, and personnel to perform significant structural repairs on large transport aircraft. Out of the 4,000 stations, we identified 38 repair stations that claimed to be capable of performing heavy airframe maintenance—the type of activity necessary to accomplish recent FAA-

[6]In the longer term, the excess demand might lead to higher prices for aircraft repair services, which could stimulate investment in additional repair capacity and raise the wages of aircraft mechanics, thus attracting more workers to this industry.

ordered repairs to the 1,400 oldest aircraft in the U.S. fleet. (See app. II.) Figure I shows a Boeing 707 receiving maintenance inside the hangar.

Figure I: A Boeing 707 Receiving Maintenance

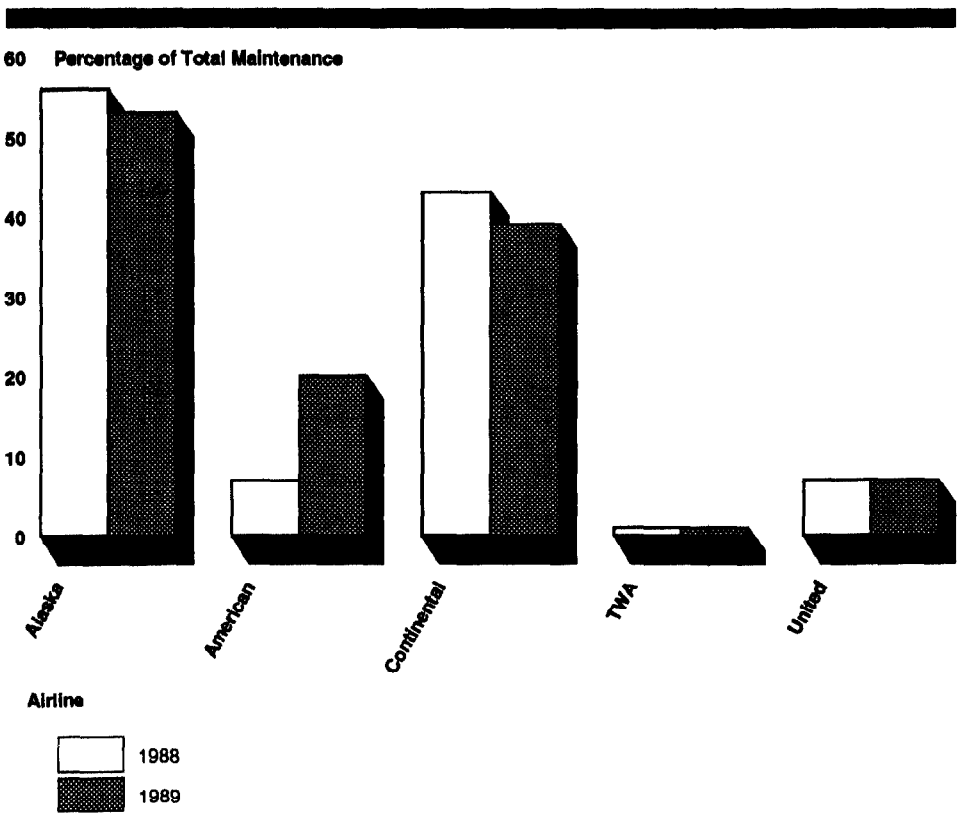


Uncertainty about the current structure and continued evolution of the industry has led to doubts about repair stations' capacity to handle repair work. Some airlines, for example, believe that the number of independent repair stations capable of performing heavy airframe maintenance is probably much smaller than 38. Four of the five airlines we visited said that although some FAA-certified repair stations may have the hangar space for such work, the stations either (1) lack the expertise, training, or equipment needed to perform the kinds of repairs and modifications FAA requires or (2) may not be able to complete the work in a reasonable time. In addition, industry composition is changing to include portions of the defense sector that are beginning to develop a commercial repair capability. For example, Defense contractors such as

Rockwell International, Grumman St. Augustine, and Lockheed Aerospace have begun to develop commercial aircraft maintenance capabilities. Further, an association of military repair facilities, concerned about maintaining the facilities' productivity in the face of the shrinking defense dollar, is trying to keep its resources fully employed by accepting airline repair work.

All airlines use independent repair stations to at least some degree, according to the Vice President for Maintenance of the Air Transport Association (ATA), an organization representing 22 air carriers. However, the extent to which airlines use independent repair stations varies considerably. As shown in figure 2, at the five airlines we visited, reliance on independent repair stations ranged from near zero percent to 53 percent of total maintenance costs in 1989.

Figure 2: Five Airlines' Use of Independent Repair Stations



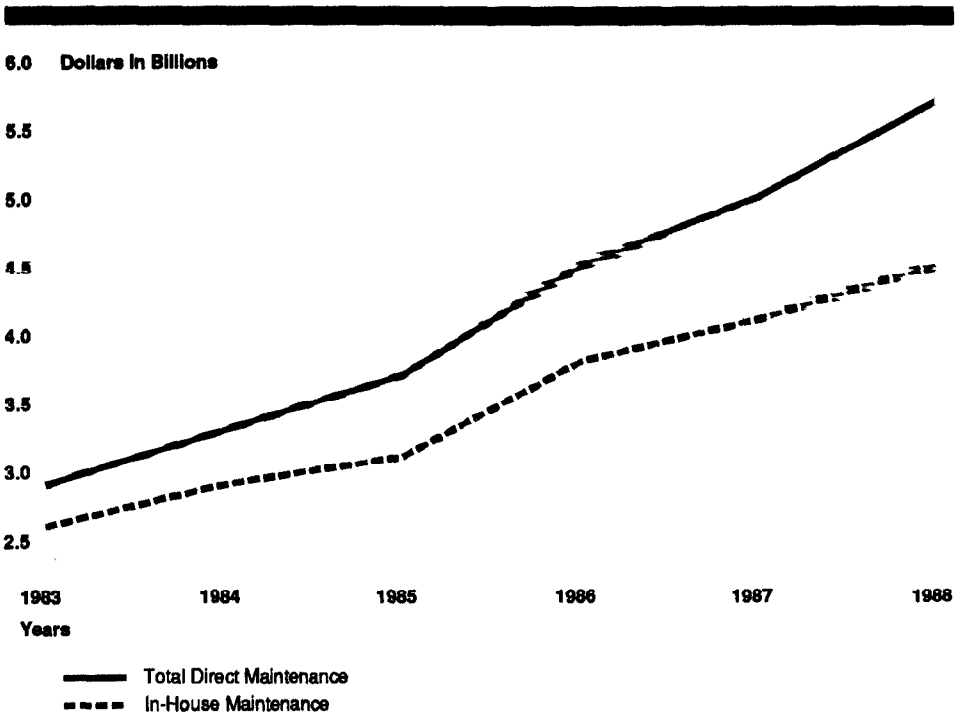
The extent of an airline's reliance on independent repair stations generally corresponded to its amount of in-house maintenance capacity. Trans World Airlines (TWA), for example, barely uses the independent repair station industry because its own maintenance facilities can accommodate the airline's needs. Collectively, the five airlines relied on repair stations to provide maintenance repair service for all major aircraft components, including airframes, power plants, communication equipment, instruments, and accessories.

Airlines Are Contracting Out a Larger Proportion of Repairs and Maintenance

In 1988, U.S. carriers spent over $5.7 billion to maintain and repair their aircraft. This amount is almost double of what they spent in 1984. Although DOT does not track changes in the price of aircraft maintenance labor or materials, a DOT maintenance data analyst estimated that little of this increase in airline spending for maintenance could be attributed to the increasing costs of labor or materials needed for performing maintenance. Instead, he said that it was due primarily to industry expansion, including fleet growth (from 2,400 planes in 1980 to over 4,100 in 1990), to accommodate increases in air travel since deregulation in 1978.

Although large carriers most often accomplish this maintenance in facilities they own themselves, the airline industry as a whole contracted out a significant portion—$1.2 billion or 21 percent—in 1988. As shown in figure 3, maintenance that is contracted out is growing faster than maintenance done in-house. (See app. I.)

Figure 3: Comparison of In-House Aircraft Maintenance Versus Direct Maintenance Costs



Capacity Utilization Is High

Both the airline and independent repair stations we contacted are operating near full capacity. Four of the five airlines said they will be operating at 100 percent of their in-house maintenance capacity in 1990 and that they expect their use of independent repair stations to increase or remain at 1989 levels. Also, three of the four independent repair stations we visited said they expect demand for their services to increase over 1988 and 1989 levels. The repair stations, too, have been operating at near 100 percent of capacity. For example, one of the four stations performed maintenance on 132 large transport aircraft in 1989, while during the same period it turned away 153 more aircraft. To meet perceived increases in demand, all four repair stations recently have finished expanding, are in the midst of expanding, or are planning to expand in the near future. As a result of this expansion, the repair stations estimate that they will have from 5- to 19-percent excess capacity in 1990. (See app. II.)

Factors Affecting Demand for and Supply of Repair Station Services

Demand and supply in most free market industries with competitors depend on consumer preferences, cost of labor and materials, prices of substitute goods, and many other factors. On the basis of our discussions with airline and repair station officials, we have identified the short- and long-term factors that seem to be most relevant to the repair station industry. (See app. III.)

In the Short Term, Regulatory Changes Have Most Impact on Demand

Recent regulatory changes affecting airlines' need for maintenance have been the greatest stimulant of increased short-term demand for repair station services. Chief among these changes have been the FAA-issued "aging aircraft ADs," or airworthiness directives, requiring structural and other modifications instead of more frequent inspections. These ADs must be accomplished within the next 4 years on all aircraft that have exceeded the initial economic design life set for them by the manufacturers. After that, the ADs apply as the aircraft exceed their design life.

FAA's initial estimated cost to the airline industry to implement the aging aircraft ADs on approximately 1,400 aircraft was about $1.4 billion. However, on the basis of remarks by FAA's Deputy Associate Administrator for Regulations and Certifications and our discussions with industry officials, we believe that FAA's estimate probably is too low and the true cost could be $2 billion or more. In discussing the cost impact figure, the Deputy Administrator cautioned that it was only an estimate and that actual data from aircraft operators would be more accurate. In turn, airline officials of Eastern and USAir told us that their initial experiences with completing the aging aircraft ADs on specific aircraft resulted in much more time than expected and at least twice the cost that FAA had estimated for generic models (Boeing 727, DC-9, etc.) of aircraft. Therefore, for analytic purposes in this report, we are using a figure of $2 billion, and even this could be conservative.

On the supply side, officials from the independent repair stations pointed to a series of factors that most affect their ability to provide maintenance or to expand to meet increasing short-term demands for services. These factors are (1) affordable capital for operation or expansion; (2) availability of qualified workers; and (3) ready access to equipment, supplies, and spare parts. Of these, officials said that skilled labor, tooling, and facilities are currently in shortest supply, and spare parts or "kits" of parts that aircraft manufacturers make for specific applications often are difficult to obtain on a timely basis.

Whether any one of these factors is a problem for a specific repair station often depends on the specific market. For example, repair stations in the Miami airport area said hiring mechanics to work on aircraft is not a problem; however, the opposite was true for repair stations in the West. On the basis of our limited data gathering, we cannot now quantify the severity of labor or other microeconomic problems. However, we will have more definitive data based on our industrywide questionnaire and will report those results in a subsequent report.

More Factors Involved in the Long-Term Equation

In the longer term, both the demand for repair station services and the industry's supply of those services could be affected by a host of economic, regulatory, and other factors including the following:

- Changes in macroeconomic conditions, either globally or nationally, could affect airline operations and demand for air travel in a single market or in many markets. As indicated earlier, since 1978 the growth in air travel—itself dependent on air fares, disposable income, and other variables—has driven up demand for aircraft maintenance. On the other hand, ATA observed that a recession could affect airlines' plans for deploying their fleets, and this, in turn, could reduce demand for maintenance.
- Decisions by air carriers to expand their own maintenance facilities could decrease the reliance on independent repair stations. For example, one of the largest U.S. carriers, American Airlines, is building a new maintenance facility at the Alliance Airport in Texas.
- Changes in legislation and/or federal regulations often take several years to implement but can have a significant impact. For example, FAA plans to require airlines to incorporate a corrosion control program into their FAA-approved maintenance programs. Airline and repair station officials believe that incorporating this program will add to the overall volume of maintenance workload required on all aircraft, thus increasing the need for independent repair stations. Also, a congressional decision is expected soon on H.R. 3774, "the Aging Aircraft Act of 1990," which would require FAA to perform a comprehensive inspection of all aircraft after they reach a predetermined point in either age or number of flights flown.[6]
- Changes in the factors affecting air carriers' decisions to maintain their aging aircraft or to buy new ones instead also play a role. For example,

[6]For a full discussion of our comments on this proposed legislation, see our testimony submitted for the record to the Subcommittee on Aviation, House Committee on Public Works and Transportation, entitled Observations on H.R. 3774: The Aging Aircraft Safety Act of 1989 (GAO/T-RCED-90-82, May 23, 1990).

the federal government could require carriers to modify or phase out of U.S. operation the noisiest—and often the oldest—aircraft. This phaseout would require operators to trade-off the costs and benefits of installing engine-quieting technology against removing the aircraft from their fleets. Because such a requirement was not included in recent statements of National Transportation policy, noisier aircraft received a temporary reprieve and will remain in carriers' fleets. In addition, higher fuel costs have a greater effect on the operating costs of older, less fuel-efficient planes than on newer, more efficient ones. Steep increases in the cost of fuel, as we have seen in recent weeks as a result of events in the Mideast, could cause air carriers to purchase new aircraft rather than keep old ones, depending on how purchase or lease costs are traded-off against fuel and maintenance costs. In the past, stable fuel prices combined with manufacturers' backlogs—Boeing's is currently 2 years before a new order can be satisfied—have encouraged operators to retain their older aircraft. It remains to be seen how Mideast instability will further affect fuel prices and operators' decisions to retire less fuel efficient aircraft.

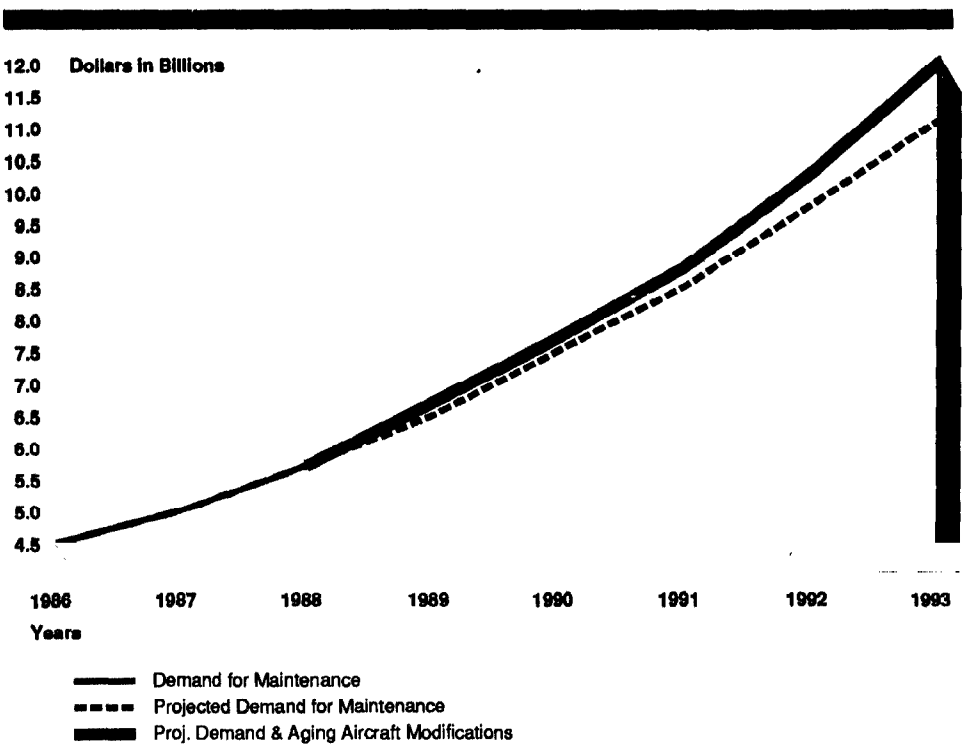
While the future impact of many of these factors is unknown, airline and repair station officials cited several reasons why they are expecting a general increase in demand. These reasons included the fleet's increasing average age (older aircraft require more maintenance than newer aircraft), a continued industrywide practice of making modifications unrelated to safety such as refurbishing interiors, and the increase in the number of aircraft in service worldwide. (See app. III.)

Airframe Repair Capacity May Fall Short of Demand

As stated earlier, FAA's new requirements to repair aging aircraft have increased the projected demand for airframe repair and maintenance over the next 4 years by about $2 billion. This averages about $500 million per year or about 9 percent of the industry's 1988 total cost of engine and airframe maintenance; however, airlines as a group probably will not schedule their aircraft for repair evenly across the 4 years. In fact, as of May 1990, airlines have been slow to begin scheduling their aircraft for this work. This slow scheduling means that most of the demand for aging aircraft repairs could occur during 1992 and 1993, the latter 2 years of the 4-year period. Therefore, we estimate that an increase in actual demand may range from about $200 million in the first year to about $700 million in the last year; the size of the increase depends on how fast airlines recognize that their fleets need this work and can schedule them for it.

Adding this increase in demand to what would be expected of aircraft maintenance on the basis of the past, we have created the curve shown in figure 4. This figure shows historical demand for total direct maintenance from 1985 to 1988, projected demand at the average growth rate (14.4 percent) over the last 5 years, and the added demand for airframe maintenance caused by the aging aircraft ADs. The impact of new regulations and ADs anticipated within the next couple of years—for example, a mandatory corrosion control program—is not factored here because of the difficulty in preparing an accurate estimate of their economic impact on the industry.

Figure 4: Relation of Aging Aircraft Airframe Modifications to Total Direct Aircraft Maintenance



With enough time and if excess demand causes higher prices for aircraft repair services, the industry could likely adjust its capacity to absorb the new work. However, we do not know whether this added demand for airframe maintenance will be absorbed in the short term by the average 10-percent excess in capacity that repair stations say they will have in 1990, especially in light of the small size of that portion of the industry. More specifically, an approximate dollar equivalent of the industry's excess capacity would be, at most, 10 percent (repair stations'

estimate) of the $1.2 billion mentioned earlier as the value of maintenance contracted out in 1988. This amount is $120 million (2 percent of total 1988 maintenance), and it is far short of the $500 million (9 percent of 1988 total maintenance) annual average cost over 4 years to modify aging aircraft. Still in question is whether the repair industry has the ability to expand rapidly enough in the short term to meet the expected increase in maintenance demand.

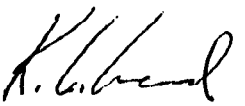
Scope and Methodology

To obtain information on recent increases in demand for maintenance, the capacity utilization of the repair industry, and the factors affecting future demand for and supply of airline and independent repair station services, we interviewed airline association representatives, aircraft manufacturers, and FAA officials for industrywide information. The five airlines we visited account for about 37 percent of all aircraft flown by United States carriers, including cargo and charter companies. Of the four independent repair stations we visited, three have been heavily involved in conducting maintenance on large transport aircraft for at least 9 years; the fourth is planning to expand its aircraft hangar facility to become one of the largest facilities in the country. To obtain information on historical demand for aircraft maintenance and compare it with industry capacity, we analyzed a DOT data base containing such data. We conducted our review between November 1989 and August 1990 and performed our work in accordance with generally accepted government auditing standards. See appendix IV for more details on our scope and methodology.

We discussed the information in this report with responsible FAA, DOT, and ATA officials. They generally agreed with the information presented, and we have incorporated their comments where appropriate. As requested, however, we did not obtain official comments from FAA or the airlines and repair stations we visited.

As arranged with your office, 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 Administrator, FAA; the Director, Office of Management and Budget; and other interested parties. We also will make copies available to others upon request.

Major contributors to this report are listed in appendix V. If you have any questions or wish to discuss these matters in more detail, please contact me at (202) 275-1000.



Kenneth M. Mead
Director, Transportation Issues

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Abbreviations

AD	airworthiness directive
ATA	Air Transport Association
DOT	Department of Transportation
FAA	Federal Aviation Administration
GAO	General Accounting Office
TCAS	Traffic Alert and Collision Avoidance System
TWA	Trans World Airlines

Analysis of Selected Maintenance Costs of U.S. Transport Aircraft

Maintenance costs (in current dollars) for transport aircraft have risen over the last 8 years from $2.9 billion in 1980 to $5.7 billion in 1988.[1] This increase reflects primarily a growing U.S. transport fleet. During the 1980s maintenance on airframes rose faster than total maintenance. In 1988, for example, airlines spent over $2 billion on this component of total maintenance. Although most large U.S. airlines do virtually all of their major repair work at their own extensive maintenance bases, many smaller airlines must rely on a third party—an entity that neither owns nor operates the aircraft—to perform major maintenance. These airlines usually contract work out to one of the larger airlines that has excess capacity available or, more frequently, to an independent repair station.

As an industry, airlines are relying more on third parties to maintain the airframes and engines of their planes. In 1988, airlines contracted out $1.2 billion worth of this work. As a proportion of the industry, contracted maintenance grew from 13 percent in 1980 to 21 percent in 1988. This growth is even more dramatic in terms of airframes, for which contracted repair work grew from 14 percent of all airframe work in 1980 to 26 percent in 1988.

Tables I.1 through I.6 and the following discussion provide more detailed analysis of aircraft maintenance costs:

Table I.1: Total Direct Maintenance Costs for Large Commercial Jet Aircraft

Dollars in millions

	Direct Maintenance Costs	
Year	**Current dollars**	**Constant 1982 dollars**
1980	$2,860	$3,338
1981	2,924	3,110
1982	2,809	2,809
1983	2,918	2,808
1984	3,316	3,079
1985	3,677	3,315
1986	4,500	3,955
1987	4,975	4,238
1988	5,704	4,703
Total	**$33,683**	**$31,335**

[1]The maintenance cost data in this appendix are based on a data base created and maintained by DOT. This data base draws from information submitted quarterly by airline operators on Form 41, "Aircraft Maintenance Costs."

As table I.1 shows, direct maintenance costs for commercial jet aircraft have increased steadily from 1980 to 1988, except for a slight decline in 1982. Direct maintenance costs in current dollars have grown from $2.9 billion in 1980 to a high of $5.7 billion in 1988. This large increase is primarily due to the growth in the number of aircraft in the U.S. fleet: according to FAA, the fleet has grown from about 2,400 aircraft in 1980 to about 3,500 in 1988, an increase of about 1,100 aircraft.

Table I.2: Comparison of Operating Expenses and Maintenance Costs

Dollars in millions

Year	Total aircraft operating expenses	Total direct maintenance cost	Direct maintenance percentage
1980	$18,103	$2,860	15.8
1981	19,762	2,924	14.8
1982	19,122	2,809	14.7
1983	18,800	2,918	15.5
1984	20,360	3,316	16.3
1985	20,934	3,677	17.6
1986	20,065	4,500	22.4
1987	22,037	4,975	22.6
1988	23,815	5,704	24.0
Total	**$182,998**	**$33,683**	**18.4**

As table I.2 shows, aircraft operating expenses have generally risen on a yearly basis—except for brief declines in 1982, 1983, and 1986—from $18 billion in 1980 to almost $24 billion in 1988. After a slight decline in 1982, direct maintenance costs for aircraft have steadily formed a larger share of total operating expenses. In fact, direct maintenance costs, which accelerated in the late 1980s, reached a high of 24 percent of total operating expenses in 1988. The share of total operating expenses devoted to direct maintenance has grown from about 16 percent in 1980 to about 24 percent in 1988.

Table I.3. Comparison of Airframe and Total Direct Maintenance Costs

Dollars in millions

Year	Total direct maintenance costs	Airframe	Airframe percentage
1980	$2,860	$721	25.2
1981	2,924	737	25.1
1982	2,809	676	24.1
1983	2,918	754	25.8
1984	3,316	863	26.0
1985	3,677	1,218	33.1
1986	4,500	1,549	34.4
1987	4,975	1,739	35.0
1988	5,704	2,072	36.3
Total	**$33,683**	**$10,329**	**30.7**

From 1985 to 1988, maintenance on airframes for large commercial jets has consumed over 30 percent of all direct maintenance costs. The airframe share of direct maintenance costs has increased from 25 percent in 1980 to over 36 percent in 1988. Except for small declines in 1981 and 1982, airframe repair has accounted for an increasingly larger portion of direct maintenance costs. The dramatic increase in costs for airframe repair can be attributed, in part, to a change in DOT reporting requirements that allowed carriers to combine avionic and airframe costs into airframe accounts. However, our preliminary analysis suggests that avionics alone may not account for all of the increase.

Table I.4: Comparisons of Outside Maintenance Work to Total Direct Maintenance

Dollars in millions

Year	Maintenance	Outside repair	Outside percentage
1980	$2,860	$374	13.1
1981	2,924	330	11.2
1982	2,809	339	12.1
1983	2,918	315	10.8
1984	3,316	423	12.8
1985	3,677	578	15.7
1986	4,500	720	16.0
1987	4,975	861	17.3
1988	5,704	1,208	21.2
Total	**$33,683**	**$5,148**	**15.3**

As table I.4 shows, airlines are spending more, on an annual basis, for outside repair services for aircraft engines and airframes. From 1980 to

1988, airlines spent over $5 billion for third party maintenance of airframes and engines. In 1980, airlines spent about 13 percent of direct maintenance costs on outside repairs of engines and airframes and 21 percent in 1988. After spending an average of $356 million per year for outside repair services from 1980 to 1984, airline costs for outside repair work dramatically increased from $578 million in 1985 to $1.2 billion in 1988.

Table I.5: Comparison of In-House and Outside Costs for Airframe Maintenance

Dollars in millions

Year	Total airframe	In-house	Percentage in-house	Outside	Outside percentage
1980	$721	$623	86.4	$98	13.6
1981	737	631	85.6	106	14.4
1982	676	582	86.1	94	13.9
1983	754	654	86.7	100	13.3
1984	863	720	83.4	143	16.6
1985	1,218	976	80.1	242	19.9
1986	1,549	1,226	79.1	323	20.9
1987	1,739	1,357	78.0	382	22.0
1988	2,072	1,543	74.5	529	25.5
Total	**$10,329**	**$8,312**	**80.5**	**$2,017**	**19.5**

As table I.5 shows, except for a slight decline in 1983, airlines are spending more on outside airframe repairs on an annual basis. In 1980, airlines contracted out almost 14 percent of all airframe repair work, while in 1988 this percentage had grown to 26 percent. In 1988 alone, airlines spent over $500 million for outside repair work on airframes. Because of FAA-mandated aging aircraft modifications, airlines are expected to significantly increase their use of third party maintenance facilities or expand in-house facilities for airframe repairs.

Table I.6: Comparison of Total Aircraft Operating Expenses and Fuel Costs

Dollars in millions

Year	Total aircraft operating expenses	Fuel	Fuel percentage
1980	$18,103	$9,771	54.0
1981	19,762	10,791	54.6
1982	19,122	9,970	52.1
1983	18,800	9,265	49.3
1984	20,360	9,647	47.4
1985	20,934	9,636	46.0
1986	20,065	7,295	36.4
1987	22,037	7,896	35.8
1988	23,815	7,912	33.2
Total	**$182,998**	**$82,183**	**45.0**

Airlines have benefited significantly from stable fuel prices in the 1980s. As table I.6 shows, while total operating expenses have increased from 1980 to 1988, the percentage of total operating expenses allocated to fuel has significantly decreased. In fact, fuel's share of total operating expenses has fallen from 54 percent in 1980 to a low of 33 percent in 1988. Stable fuel prices have off-set increased maintenance costs for older aircraft and allowed the less fuel efficient aircraft to remain in service. If fuel prices should rise sharply, many air carriers may rethink their decision to operate older and less fuel efficient aircraft like the Boeing 727.

Background on the Repair Station Industry

FAA has certified several thousand aircraft repair stations to serve the air carrier industry by performing varying types of maintenance. These stations, either owned and operated by air carriers or independent of them, perform maintenance for carriers on a contract basis. However, this report is concerned only with a handful of these independent repair stations that perform heavy airframe maintenance on large transport aircraft. The five airlines in our survey varied substantially in the extent to which they used independent repair stations. The four independent repair stations, not all homogeneous either, varied in the types of aircraft maintenance they were capable of performing.

Four Thousand Repair Stations Nationwide

A repair station is a facility that performs maintenance on aircraft used for business, commercial, and other purposes. In all, the United States has about 4,000 repair stations certified by FAA under the Code of Federal Regulations, title 14, part 145. A repair station's certificate specifies the types of maintenance it can perform and the types of aircraft it can repair. FAA licensing divides maintenance and repair activities into six main categories:

- airframes,
- power plants,
- radios,
- propellers,
- instruments, and
- accessories.

Some repair stations specialize in one of these specific maintenance and repair categories, while others may specialize in several.

In addition to limiting the types of maintenance a repair station can perform, FAA may limit the scope of a repair station's activities. For example, whenever appropriate, FAA may, by issuing a rating, limit a repair station's work to maintaining or altering only certain types of airframes, power plants, propellers, radios, instruments, or accessories. Such a rating may be limited to a specific model of aircraft, engine, or constituent part or to any number of parts made by a particular manufacturer.

Few Repair Stations Extensively Maintain Large Transport Aircraft

One form of maintenance and the focus of our work for this report is that of heavy airframes on large transport aircraft. 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, 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. Heavy aircraft maintenance includes the following activities:

- routinely scheduled airframe maintenance;
- nonroutine repairs of problems found during scheduled maintenance, such as fatigue cracks found on the skin of the aircraft that would require replacing or patching the skin;
- FAA-mandated airframe inspection and modifications, such as those required by airworthiness directives (ADs).[1] For example, according to a United Airlines official, an AD applicable to certain Boeing 737s requiring that "protruding head, solid fasteners" (a kind of rivet) be installed in the upper row of all lap splices in the fuselage;
- nonmandated airframe modifications affecting the airframe, such as turning a passenger Boeing 727 aircraft into a package freighter (which involves cutting a 10-foot-wide by 6-foot-high hole in the fuselage to install a cargo door, strengthening the floor, and installing tracks on the floor for a roller system).

Relatively few domestic stations have the facilities, equipment, and personnel to perform heavy airframe maintenance on the approximately 8,000 transport aircraft worldwide. These few stations consist of airline-owned repair stations and independent companies that perform maintenance on a contract basis. About 14 air carriers certified by FAA to fly aircraft holding more than 30 passengers or payloads of more than 7,500 pounds (called Part 121 carriers after the section of FAA regulations that apply to them) have their own repair stations, and we identified an additional 38 independent repair stations that said they were capable of performing heavy airframe maintenance.

Use of Independent Repair Stations Varies

All airlines and cargo carriers rely on independent repair stations to at least some degree, according to the Vice President for Engineering and Maintenance, Air Transport Association, an organization representing

[1] Airworthiness directives are FAA instructions that require airlines to correct conditions in their aircraft, such as cracking and corrosion, that can jeopardize safety.

22 airlines.[2] This statement is true in terms of the five airlines in our survey. As a group, the five airlines relied on independent repair stations for maintenance and repair activities in all of the six main categories. (The maintenance category of propellers is excluded because it is not applicable to jet aircraft.) As table II.1 shows, the airlines varied in the work they asked independent repair stations to conduct.

Table II.1: Categories of Maintenance Activities Requested by Airlines GAO Surveyed

	Maintenance category				
Airline	Airframe	Power plants	Avionics	Instrument	Accessories
Alaska	Yes	Yes	Yes	Yes	Yes
American	Yes	Yes	Yes	Yes	Yes
Continental	Yes	Yes	Yes	Yes	Yes
Trans World	No	Yes	Yes	Yes	Yes
United	Yes	Yes	No	No	No

The following are more specific descriptions of the work done for each airline by independent repair stations:

- Alaska Airlines uses repair stations to cover peaks in workload demand and to provide services that the airline cannot economically accomplish because of its insufficient volume of repair work (Alaska Airlines' fleet consists of 59 aircraft, mostly relatively newer versions of Boeing 727s and Douglas MD-80s[3]). For example, Alaska Airlines used Tramco to routinely maintain and modify several of Alaska Airlines' Boeing 727s and 737s. Also, the airline uses the facilities of another airline, Air Canada, to routinely maintain the airframes of its fleet of Boeing 727s because Alaska does not operate enough of these aircraft to warrant in-house repair capabilities for this type of maintenance.
- American Airlines uses independent repair stations for aging aircraft modifications, fleet interior reconfiguration, and routinely scheduled maintenance. According to American Airlines officials, ADs applying to all aging aircraft have added maintenance requirements for its fleet (American's fleet consists of 509 aircraft, 150 of which are more than 15 years old on the average). In many cases, the new requirements supplement the revised procedures currently in American's maintenance program. The added maintenance requirements have forced American to

[2]In our subsequent report, we will be able to verify and quantify this statement on the basis of the results of our questionnaire to all Part 121 airlines.

[3]Numbers in this discussion on fleet size and age are from Aviation Data Services, Inc., of Wichita, Kansas, and were current as of April 4, 1990.

take some modification work to an independent repair station because its in-house maintenance capacity is lacking.

- Continental Airlines uses independent repair stations for its airframe work when FAA airworthiness directives or manufacturers' service bulletins are released with short notice or when the directives call for extensive modifications. The airline also uses independent repair stations for special refurbishment or fleet standardization projects, overflow work, or when the airline has no in-house capabilities to perform repair work. (Continental's fleet of 322 aircraft contains 126 that are more than 15 years old on the average.)
- Trans World Airlines (TWA) uses repair stations to work on its aircraft parts and components when the airline does not have the necessary tooling, equipment, or facilities. For example, turbine exhaust cases for certain jet engines are rebuilt for the airline by TK International Inc., an independent repair station. (TWA's fleet of 215 aircraft includes 140 that average more than 15 years old.)
- United Airlines is using independent repair stations to maintain the heavy airframes of its aging aircraft. Such maintenance is, either mandated by FAA or internally specified. (Of United's 436 aircraft, 204 average more than 15 years old.) Also, to augment its own capacity, United uses repair stations to maintain engines and engine modules.

Although each of the five airlines reported using independent repair stations, the airlines varied considerably in the extent to which they relied on such facilities for their maintenance needs. As shown in table II.2, maintenance performed by independent repair stations ranged from less than 1 percent to 53 percent of total maintenance costs.

Table II.2: Percentage of Maintenance Performed by Independent Repair Stations

Airline	Percentage	
	1988	1989
Alaska	56	53
American	7[a]	20[a]
Continental	43	39
TWA	Less than 1	Less than 1
United	7	7

[a]Percentages refer to airframe maintenance only.

Independent Repair Stations Conduct Wide Variety of Maintenance

Collectively, the four repair stations we surveyed performed all five categories of maintenance, as shown in table II.3.

Table II.3: Categories of Maintenance Conducted by Repair Stations GAO Surveyed

Repair station	Airframe	Power plants	Avionics	Instrument	Accessories
Tramco	Yes	Yes[a]	No[b]	Yes[a]	Yes
Tracor	Yes	Yes[a]	Yes	Yes[a]	No[b]
Aerotest	Yes	Yes[a]	No[b]	No[b]	No[b]
Dee Howard	Yes	Yes[a]	Yes	Yes	Yes

[a]Limited to particular types of airframes, power plants, radios, instruments, or accessories.

[b]Replacement only; repair station is not certified to perform this type of maintenance.

Independent companies provided the following information describing their maintenance in more detail:

- Tramco's facility is 250,200 square feet which includes a 143,000-square-foot hangar, a 6,400-square-foot nose dock, and 100,800 square feet of support shops at Paine Field in Everett, Washington. The hangar can accommodate one wide body aircraft, such as a Boeing 747, and five narrow body aircraft, such as the Boeing 737, or nine narrow body aircraft. Tramco primarily conducts regularly scheduled maintenance and modifications of airlines and air cargo carriers. It also modifies new aircraft when specifications are changed after manufacturing is completed. Tramco is experienced in routine maintenance as well as in maintanence required by service bulletins[4] and airworthiness directives. It also conducts cockpit and avionic modification; interior installation, refurbishment, and reconfiguration; exterior refurbishment (paint, strip, and polish); and structural inspection and modifications. Tramco's staffing levels have increased annually from 109 employees in 1982 to currently over 1,000. Also, Tramco has worked on over 1,000 Boeing and McDonnell Douglas aircraft for over 75 airlines and package delivery operators from all over the world.

[4]According to the Boeing Company, a service bulletin prepared by the manufacturer informs operators of a change or inspection that can be done on their in-service airplanes. 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 describes the reason the bulletin was issued and what can happen if the bulletin is not incorporated.

- Tracor Aviation's operations in Santa Barbara, California, are housed in three facilities whose total area is 327,450 square feet in Santa Barbara and Santa Maria California. The plant is three hangars, located at the Santa Barbara Airport, whose total area is 118,800 square feet, and are used for aircraft modification, maintenance, and painting. Tracor typically performs regular maintenance and modifications for airlines and air cargo carriers. For example, Tracor performs routine maintenance, interior refurbishment, aging aircraft inspections and terminations, lap joint repairs, and exterior painting. Aircraft models include Boeing 727, 737, and 707, and McDonnell Douglas DC-9, DC-10, and MD-80. Tracor's diverse capabilities are illustrated by the maintenance checks; exterior aircraft painting; modification to aircraft interiors; reconfiguration of cockpit avionics; and incorporation of service bulletins it performed on 19 American Airlines DC-10 aircraft between 1983 and 1985; and by routine, service bulletin, and AD compliance maintenance, as well as miscellaneous airframe modifications and exterior airframe painting it performed for 76 Northwest Airlines DC-9s and MD-80s between 1987 and 1990.
- Aerotest specializes in commercial aircraft engineering, maintenance and repair, modifications, flight testing and FAA certification. Located in Mojave, California, it began operations in January 1987. The company's 24,000-square-foot facility was modified in early 1989 to accommodate McDonnell Douglas's DC-9 and Boeing's 727 and 737 aircraft. In June 1990, Aerotest expanded its maintenance operation into a new 125,000-square-foot facility tailored specifically to large air transports, such as the Boeing 747. Aerotest performs regularly scheduled maintenance inspections and associated repairs. Structural and aging aircraft repairs are Aerotest's current focus.
- The Dee Howard Company is situated on 42 acres at the San Antonio, Texas, International Airport. The company has more than 265,000 square feet of hangar space capable of accommodating three Boeing 747s and several other narrow body aircraft at the same time. The Dee Howard Company performs routine maintenance, cockpit modernization, and avionic upgrades on such aircraft as the Boeing 747. In addition, the company is currently modifying Boeing 727 passenger aircraft so that they can be used as cargo aircraft.

Factors Affecting Demand and Supply of Independent Repair Station Services

Four of the five airlines we reviewed are operating at or near 100 percent of their maintenance capacity, and they expect their use of independent repair stations to remain the same or to increase. However, future use of independent repair stations could be altered or affected by many factors, such as economic conditions, availability of facilities, and changes in regulatory requirements. In addition, a number of other factors, such as availability of capital, labor, and equipment, can affect the industry's ability to expand. Even so, the four independent repair stations we surveyed expect demand from air carriers to increase and have recently finished expanding, are in the midst of expanding, or are planning to expand in the near future.

Most Airlines We Surveyed at 100-Percent Capacity Expect Their Use of Independent Repair Stations to Increase

Four of the five airlines we surveyed said that they will be operating at 100 percent of their maintenance capacity in 1990. Also, four of the five airlines said that they expected their use of independent repair stations to remain the same or to increase.

- United Airlines expects its use of independent repair stations to increase in 1990 in order to comply with FAA-mandated ADs and to complete heavy airframe maintenance associated with ADs. In the case of the airline's Boeing 727s and 737s, the aging aircraft workload has more than doubled the time required to maintain heavy airframes: maintenance visit times increased from 16 days in 1988 to 35 planned days in 1990. Man-hour requirements for these visits also have more than doubled from about 17,000 to 37,000 planned hours. This increase has consumed all of United's available facilities and has required the airline to lease three hangar bays for its own work and to contract out over flow maintenance to three independent repair stations.
- Continental Airlines expects its use of independent repair stations for heavy airframe maintenance to increase in 1990 over 1989 because of new additions to its fleet and FAA-mandated modifications, such as the Traffic Alert and Collision Avoidance System (TCAS) II program. (TCAS II is an FAA requirement to install a radar-activated collision avoidance system in all commercial transports operating in the United States by December 31, 1993.) According to a Continental official, Continental is currently unable to obtain maintenance capacity from any independent repair stations to perform FAA-mandated nose (Section 41) modifications on its Boeing 747s. (The Section 41 modification is an FAA requirement to inspect for cracking, and repair as necessary, of airframe structures and skin in the nose area of certain Boeing 747s.)
- Alaska Airlines and TWA expect their use of independent repair stations to remain at 1989 levels.

The fifth airline, American Airlines, expects to use independent repair stations for airframe maintenance less after the completion of lap seam maintenance on the airline's Boeing 727s. Nonetheless, the company's decreased use of independent repair stations for heavy airframe maintenance is still beyond the company's traditional level of work performed by outside companies. Normally, American has maintained its heavy airframes in-house. After the issuing of aging aircraft airworthiness directives by FAA, American's demand for maintenance exceeded its capacity, and the company had to use independent repair stations to complete the work.

Factors Affecting Air Carriers' Need for Repair and Maintenance

Many factors could affect the way in which airlines and air cargo carriers use independent repair stations in the future. These factors include economic conditions; the availability and price of facilities, skilled labor, and spare parts; changes in regulatory requirements; and costs of operating older aircraft which, in turn, affect a carrier's incentive to continue maintaining the aircraft.

Economic Conditions

Favorable economic conditions could foster more need and justification for business travel, higher disposable incomes relative to the price of air travel, and more entrants into the airline business. These factors could, in turn, by increasing the number of airline passengers and, therefore, the number of planes flying, increase the need for aircraft maintenance and modification. At present, airline plans point in this direction. Four of the five airlines we surveyed are expanding the size of their fleets. For example, American Airlines plans to expand from 509 aircraft to 727 by the year 1995, and United Airlines plans to expand from 429 aircraft to 593 by 1995.

On the other hand, unfavorable economic conditions that constrain business and personal travel budgets could decrease the number of airline passengers and, therefore, of planes flying. In such a case the amount of maintenance and modification work for repair stations would decrease. The effects of such unfavorable economic conditions could be offset to some extent by other events. For example, according to one repair station official, in a worsened economy air carriers potentially would retain older repair-intensive aircraft and cancel options on new orders, perhaps increasing rather than decreasing the demand for maintenance.

Economic conditions also can affect another type of maintenance—the renovation or refurbishing of aircraft interiors. According to airline officials, they continually refurbish their aircraft interiors so the airline can maintain a competitive edge. For example, one of the four repair stations we surveyed (Tramco) installed and refurbished storage bins, lavatories, and galleys on 74 aircraft for 16 airlines between 1983 and 1988. According to airline officials, when an airline acquires either new or used aircraft, it must bring them into conformity with the rest of the fleet in terms of features such as seating, galley, and cockpit configurations. At Tramco, for example, modifications of such features were made on 145 aircraft for 26 airlines between 1983 and 1988. Favorable economic conditions could encourage such work; unfavorable conditions could discourage it.

Availability of Resources

A shortage among air carriers of maintenance facilities or mechanics willing to work for an affordable wage rate would force carriers to look to independent repair stations for their maintenance needs. A shortage of facilities had indeed occurred at the five airlines we surveyed. An increase in maintenance workload had eroded any surplus capacity these companies had enjoyed in the past. At United Airlines, for example, until 1989 the in-house maintenance capacity had been sufficient for the company to accept contracts for repairs on aircraft from other airlines. United officials say that, currently, their own needs for maintenance prevent them from taking in other airlines' work.

Some of the larger carriers are reversing this trend, however, by increasing their maintenance capability. For example, American Airlines is building a new facility at Alliance Airport near Ft. Worth, Texas, and expanding its current facility in Tulsa, Oklahoma. In doing so, American is reducing its reliance on independent repair stations. Moreover, if other air carriers were to expand their capabilities enough to once again do contract maintenance work for other carriers, they would be competing against independent repair stations. Also, according to officials from two independent repair stations, since work on existing military aircraft is declining, companies that build or maintain military aircraft are looking to commercial aircraft maintenance work to fill their excess capacity. For example, Grumman St. Augustine began modification work on large commercial transport aircraft in 1989, while North American Rockwell International Corporation began performing maintenance on such aircraft in 1990.

Changes in Regulatory Requirements

Changes in maintenance requirements and regulations to ensure safety could also foster demand for independent repair station services. Sources of these changes include FAA's ADs, manufacturers' service bulletins and other guidance to aircraft operators, and proposed legislation such as H.R. 3774, the Aging Aircraft Safety Act of 1990, which, if enacted, would require inspections and records reviews of all aging aircraft during their next major maintenance period. Recent trends show that these requirements are increasing. For example, FAA's annual issuance of ADs has increased from 105 in 1981 to 437 in 1989. Also, air carriers told us that service bulletins issued by aircraft manufacturers are increasing the amount of maintenance that must be done. United Airlines pointed to modifications in a wing beam and a landing gear support beam as two examples of recent Boeing service bulletins that are labor intensive.

In addition to safety questions, environmental issues also could stimulate demand for repair station services. In commenting on a draft of this report, ATA's Director for Environment and Operational Engineering told us that EPA has recently issued a proposed new air quality management plan for Southern California that contains an aircraft emissions allocation scheme. Under the proposal, existing aircraft operators would be allocated emissions rights based on their 1989 operating levels. According to ATA, this would mean that growth beyond 1989 levels may depend on a carrier's ability to modify its engines to achieve lower emissions and that this could be a widespread problem because of the more than 100 U.S. urban areas needing to reduce emissions to meet ozone standards.

Finally, FAA has begun to enforce more rigorously one of its regulations that could reduce the space repair stations currently have available—space used to maintain heavy airframes. FAA officials said that in September 1989, they began informing independent repair stations and Part 121 operators in the Miami International Airport area that, according to the Code of Federal Regulations, title 14, part 145.37, they need to fully enclose a large transport aircraft in a permanent structure when it needs to be shored (jacked up) and when specific types of heavy airframe maintenance are being performed. In practice, many stations routinely perform many types of maintenance on the ramp outside of a hangar and at best enclose only the wings and fuselage, thus leaving the tail section outside the hangar. A large number of the independent repair stations providing heavy airframe maintenance are located in the Miami area because of its favorable weather, and many of these firms have operated for years without having the capability to fully enclose

large transport aircraft. According to several independent repair station officials, FAA's crackdown in this area is discouraging operators from using their facilities. This crackdown will demand even more from the facilities that can adhere to the rule.

On the other hand, some regulatory or policy changes could reduce the demand for independent repair station services. For example, a federal requirement to phase out Stage 2 aircraft—the noisiest aircraft—from the U.S. fleet or a congressional mandate to comprehensively inspect aircraft that have surpassed the lives of their economic design could be the incentive needed by some carriers to either retire, sell, or stop leasing their noisiest aircraft or their aircraft in most need of repair. Conversely, ATA advised us that if carriers were to comply with a Stage 2 ban by modifying existing engines instead of replacing the noisiest aircraft with new ones, a large increase in demand for maintenance dock space, labor, and materials would result.

Changes in Costs and Prices

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 the impetus behind a movement to replace older, more maintenance-intensive aircraft.

The precise effect of such decisions on maintenance needs may, however, be difficult to determine. According to a repair station official, the older aircraft will be sold to other air carriers—many Boeing 727s have been sold to package delivery companies—rather than being retired from service. If the aircraft were retained in service by another carrier, there would be no decrease in the overall level of demand for maintenance.

Factors Potentially Affecting Future Supply of Independent Repair Stations

As shown in table III.1, the four independent repair stations we surveyed were operating at near capacity in 1988-89. Three of the four stations expect the demand for their service to increase in 1990. Declines in hangar use shown for Tramco and Aerotest are the result of additional space coming on line, not decreasing work loads. One of the four stations (Tramco) reported turning away 153 large transport aircraft in 1989. According to a Tramco official, most of these aircraft went to four other independent repair stations.

Table III.1: Percentage of Hangar Space in Use at Independent Repair Stations

	Year		
Repair station	1988	1989	1990 (projected)
Tramco	100	100	95
Tracor	100	90	90
Aerotest	0	97	81
Dee Howard	100	100	100

According to repair station officials, air carriers create a sufficient demand for their services. However, a number of factors can affect the independent repair stations' ability to maintain the aircraft of air carriers or to expand to meet increased air carrier maintenance demands. These factors include capital, labor, and equipment. Starting up a new repair station or expanding existing facilities requires the capital to construct and furnish a new maintenance facility or to lease the land and facilities to be used as a maintenance facility. Once the facility is in place, repair stations need to hire skilled employees to carry out the maintenance requirements and capable managers to oversee the maintenance operation. Finally, to ensure that human resources are most effectively used, a repair station must obtain the necessary equipment and tooling and have sufficient spare parts needed for inspections, repairs, modifications, and compliance with FAA airworthiness directives or manufacturer service bulletins.

Repair Stations Are Expanding Their Capacity

Although one cannot accurately predict the way in which these factors will influence supply and demand in the future, independent repair stations in our survey believe the outlook points to increased demand from air carriers. They expressed the following assumptions as their reasons for expecting the demand to increase:

- The need for more routine and nonroutine maintenance increases as aircraft age—about half of the fleet is over 15 years old.

- The required amount of maintenance continues to increase because of new FAA mandates 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 proposed requirement for airlines to implement corrosion control programs.
- The demand for nonmandated modifications, such as interior refurbishment or seating reconfiguration, will increase. For example, modifications in galleys, lavatories, storage bins, seating, carpeting, lighting, and airphones will continue 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 in 15 years over the 8,302 aircraft in the current world fleet.

Anticipating this increased demand for their maintenance services, all four repair stations have recently finished expanding, are in the midst of expanding, or are planning to expand in the near future, as discussed below:

- In September 1989, Tramco more than tripled the size of its facilities. Its new hangar, 550 by 260 feet, or 143,000 square feet, can fully enclose a Boeing 747-400 or a McDonnell Douglas MD-11 and can accommodate combinations of up to nine narrow-body aircraft at the same time. Even with this added capacity, Tramco expects to operate at near 100-percent capacity in 1990.
- Tracor is planning to expand its capacity with additional hangar facilities in a new location and with potential joint ventures in Europe and Asia.
- In June 1990 Aerotest opened its new 105,000-square-foot facility which is capable of accommodating multiple jet aircraft at the same time. The facility was designed for performing inspections, maintenance, repairs, and modifications on any transport aircraft. The company ultimately expects to have a six-hangar complex comprising more than 500,000 square feet of hangar, shop, office, and warehouse space.
- The Dee Howard Company is planning to construct a 53,000-square-foot strip and paint hangar for wide-body transports in 1990. Also, the company is expanding its manufacturing shops with a 43,000-square-foot facility.

Two of the four independent repair stations we surveyed said that, with their increased capacity, they expect to perform more maintenance in 1990. For example, Tramco and Aerotest project that they will repair

237 and 36 aircraft in 1990 compared with the 132 and 6 aircraft in 1989, respectively.

Continuing Analysis of the Industry

Although the complex mix of economic factors makes it difficult to predict accurately the likely extent of future long-term demand for maintenance at independent repair stations, recent events and the opinions of repair station officials indicate an increase in the need for independent repair stations' services in the immediate future. However, because of questions raised about the ability of independent repair stations to expand rapidly enough to meet the increased demand, we are obtaining additional information from a wider range of air carriers and repair stations. We have sent a survey to all 38 independent repair stations that, according to their officials, were capable of maintaining heavy airframes and also to 54 Part 121 air carriers. We plan to present the results of our work in a subsequent report.

Scope and Methodology

For specific information on the use of independent repair stations by air lines, we included five airlines in our survey. These five air carriers account for over one-third (about 37 percent or 1,534 out of a total fleet of 4,125) of all aircraft flown by U.S. carriers, including cargo and charter companies, as shown in table IV.1.

Table IV.1: Airlines Surveyed for Use of Independent Repair Stations

Carrier	Number of aircraft as of Jan. 1990	Number of passengers carried in 1989
Alaska	54	5,017,000
American	509	72,083,000
Continental	329	34,958,000
TWA	213	25,150,000
United	429	54,859,000
Total	**1,534**	

For specific information on activities of independent repair stations, we selected four independent repair stations that are certified by FAA to perform heavy airframe maintenance on large transport aircraft. As shown in table IV.2, all four had repaired large transport aircraft for various U.S. and foreign air carriers. Three have been heavily involved in maintenance from 8 to 22 years; the fourth is planning to turn its aircraft hangar facility into one of the largest and most modern facilities in the United States, according to a company official.

Table IV.2: Independent Repair Stations Surveyed

Repair station	Location	Number of airline clients during 1988-89
Tramco	Everett, Wash.	20
Tracor Aviation, Inc.	Santa Barbara, Calif.	48
Aerotest	Mojave, Calif.	6
The Dee Howard Company	San Antonio, Tex.	11

For industrywide information, we interviewed airline association representatives from the Air Transport Association of America, Washington, D.C., aircraft manufacturers, the Boeing Commercial Airplane Company, Seattle, Washington; Douglas Aircraft Company, Long Beach, California; and Lockheed Aeronautical Systems Company, Burbank, California, and FAA headquarters, Washington, D.C., as well as FAA's Northwest Mountain Region, Seattle, Washington officials.

Our work did not include foreign repair stations, which are also used by U.S. air carriers for maintenance. Foreign repair stations were excluded

because of the limited scope of our survey and our inability to obtain reliable and timely data from non-U.S. facilities. We performed our review between September 1989 and June 1990 in accordance with generally accepted government auditing standards.

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