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LIST OF ACRONYMS

A&P	Airframe and Powerplant Certificate
AC	Advisory Circular
AMT	Aviation Maintenance Technician
ASI	Aviation Safety Inspector
ATOS	Air Transportation Oversight System
CASE	Coordinating Agency for Supplier Evaluations
CFR	Code of Federal Regulations
DoD	Department of Defense
DOT	Department of Transportation
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FBO	Fixed Base Operator
FSDO	Flight Standards District Office
GA	General Aviation
GAMCO	Gulf Aircraft Manufacturing Company
GAO	General Accounting Office
GMM	General Maintenance Manual
ICAO	International Civil Aviation Organization
JAA	Joint Aviation Authorities
MRO	Maintenance, Repair, and Overhaul
NPRM	Notice of Proposed Rule Making
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
P&W	Pratt & Whitney
PMA	Part Manufacturer Approval
PMI	Principal Maintenance Inspector
RFP	Request for proposal
SUPs	Suspect unapproved parts

EXECUTIVE SUMMARY

The objective of the study was to identify the most common criteria that airlines use to select, monitor, and assess the performance of third-party maintenance facilities. These criteria formed the basis to develop performance measures and risk indicators for the operation of aviation maintenance repair stations. In particular, this study focused on outsourcing of major maintenance to larger repair stations.

A limited data collection effort was conducted by interviewing representatives from both airlines and repair stations, primarily in their respective quality assurance departments. In interviews with airlines, information was sought about the criteria the airline use for selecting repair stations and how the airlines monitor and assess vendor performance. Repair station interviews focused on information about labor, management, and certification issues; quality control and assurance functions; and use of subcontractors. Responses from these interviews formed the basis for developing risk indicators and performance measures for repair station operation.

Ten airline interviews were conducted, which included respondents from United States major, regional, and cargo airlines. In addition, select questions were asked of a major international carrier. The most frequently outsourced tasks included engine maintenance and component overhaul. Cost savings was the motivating factor in the decision to outsource, a decision which takes into consideration the personnel, training, and tools and test equipment necessary to complete the maintenance task. However, a cost savings is only realized if the repair station performance is satisfactory. Larger contracts require airline personnel on-site at the repair station to act as a resource and ensure timely and satisfactory completion of the work.

Six representatives from repair stations were interviewed. These included three component overhaul facilities and three nose-to-tail facilities. Three of these facilities are original equipment manufacturers—two of the facilities are independent and one of the facilities is a subsidiary of a regional airline. Certification of maintenance personnel at the repair stations interviewed varied from 20%-90% of the total maintenance workforce. Temporary or contract maintenance personnel were used at half of the repair stations in the sample to even out surges in the workload or as a trial period before permanent hire. Most respondents said that contracted labor should comprise no more than 20% of the workforce, though some respondents did exceed that guideline on occasion. It was not standard practice to inform a client that a subcontractor was used; however, such an arrangement would be reflected in the client's paperwork. The respondents reported that they were audited by a number of agencies and their clients with varying frequency.

Using the analysis as a basis, risk indicators and performance measures were developed as variables within certain areas of repair station operations that the respondents stated they monitored. In addition, a subset of the respondents rated each of these measures in terms of relative criticality. The measures are grouped into three categories.

1. Repair station capability refers to the capability of a repair station to offer certain services. The most important measures of capability include training of employees, experience level of employees, and tools and test equipment of the repair station.

2. Repair station performance refers to the quality of work that is actually performed. The most important measures of performance include audit procedures, ability to meet turntimes, the number of work discrepancies, suspect unapproved parts infractions, and certification infractions.
3. Repair station administration refers to the overall organization and operation of the facility. The most important measures of administration include the financial status of the repair station and the number of changes in management.

1. INTRODUCTION.

1.1 BACKGROUND.

Airlines and lessors often rely on third-party aircraft maintenance providers to perform a variety of maintenance tasks. The work that is outsourced varies widely in scale and in scope. Such tasks may be servicing a particular component, overhauling an engine, or performing a D-check for an entire fleet of aircraft.

Outsourcing is an attractive option for operators for a number of reasons. For example, an operator may not have a sufficient number of aircraft in a particular fleet type to justify the expense of trained personnel, facilities, tooling and test equipment required to perform the maintenance function internally. In this situation, substantial savings are realized when maintenance is performed externally. An outside vendor will usually have multiple contracts and the larger density of work allows the vendor to complete such tasks at a lower cost to the operator. In other instances, an outside vendor may be able to complete a particular task more quickly than if it was performed by the operator due to staffing constraints at the airline.

Due to a perceived increase in demand for third-party maintenance services, the number of vendors continues to grow. A 1997 General Accounting Office (GAO) report estimated that one-half of the maintenance performed by United States airlines is actually outsourced to repair stations, creating an extremely competitive environment within the third party aviation maintenance industry. While cost savings may be the initial motivation to outsource, many other factors are evaluated. For example, the quality of the work performed is a significant consideration in the selection of a vendor. Poor quality of maintenance and repair could result in decreased reliability of the aircraft, which in turn quickly erodes any cost savings gained by outsourcing.

When a task is performed by a third-party maintenance facility, the operator of the aircraft is still responsible for compliance of the vendor with respect to the operator's approved policies, procedures, and requirements. As a result, Federal Aviation Administration (FAA) oversight of the operator will include the repair station that completes work for the operator. Oversight of the outsourcing process has become an increasing concern in light of the ValuJet accident of May 1996. In response to this incident, the FAA has created several initiatives to improve the oversight of repair stations. One specific action was to improve the information and data collected from both operators and repair stations in relation to outsourcing.

1.2 OBJECTIVES.

To better understand the process of outsourcing maintenance and its implications for the FAA and the air transport community, the Transportation Center at Northwestern University examined the criteria for the selection and qualification of third-party maintenance facilities by the major airlines. This objective was accomplished by interviewing representatives from maintenance departments at major, niche, and regional airlines. To provide a balanced perspective, representatives from a sample of larger repair stations were also interviewed. Based on the results of the interviews, prototype performance measures and risk indicators for repair stations were identified.

The objective of this study was two-fold. The interviews sought to uncover the data and information that is currently collected by operators of aircraft and to identify areas in which the data is insufficient. Second, the performance measures and risk indicators defined provided a basis for describing the characteristics of a repair station. Collectively, these two outcomes will provide additional insight into the outsourcing process.

1.3 APPROACH.

An interview process provided the primary means of gathering information and data for this study. Representatives from both repair stations and airlines were interviewed to provide a balanced perspective on the outsourcing process. A separate set of questions was developed for the airline and repair station interviews respectively.

Four broad areas were investigated as part of the airline interviews:

- Background information. This section seeks to gain background information about the airline with which the respondent is associated.
- Criteria for third-party vendors. This section focuses on how airlines identify potential vendors, the requirements of both the airline and the vendor for each other, and how contracts are awarded.
- Monitoring and assessing vendor performance. This section focuses on what an airline monitors in terms of vendor performance and how that is completed.
- Oversight by other entities. The questions in this section seek information regarding the airline's relationship with Coordinating Agency for Supplier Evaluations (CASE), industry groups, and the FAA.

Six broad areas were investigated in the repair station interviews:

- Background Information. This section seeks information about the repair station for which the respondent is employed.
- Labor and Management Issues. This section focuses on the organization of the repair station and staffing and personnel issues related to the maintenance workforce.
- Certification/Regulatory Issues. The questions in this section focus on how the repair station ensures compliance with both FAA and client requirements and seek reaction to the proposed changes to Title 14 of the Code of Federal Regulations (14 CFR) Part 145.
- Relationship with Clients. This section seeks information regarding how contracts are managed with the clients and what information flows between the two entities.
- Use of Subcontractors. This section seeks information about the process and practices of repair stations using subcontractors to complete work.

- Quality Control Issue. The questions in this section focus on how quality control is maintained for clients in the repair station environment.

1.4 OVERVIEW OF REPORT.

This report details the research activities conducted as part of the Practices and Perspectives in Outsourcing Aircraft Maintenance study (FAA grant 99-G-007). Section 2, Literature Review, provides references to other studies and various literature, both academic and trade, related to topics in outsourcing aircraft maintenance. Section 3, Research Methodology, details the development of the interviews of both the airlines and the repair stations and the corresponding protocols in administering the interviews. Sections 4 and 5, Analysis of Airline Interview Results and Analysis of Repair Station Interview Results, report the data that has been collected as part of the interview process and the subsequent analysis. The analysis forms the basis for performance measures that are discussed in Section 6, Development of Performance Measures. Finally, Section 7, Summary and Conclusions, lists the major findings of the report.

2. LITERATURE REVIEW.

Aircraft maintenance encompasses a broad set of activities that must be performed so that an aircraft remains in a condition of airworthiness. These activities are commonly referred to as maintenance, repair, and overhaul (MRO) to include a complex blend of preventive scheduled and unscheduled work, as well as major refurbishments that return aircrafts and aircraft subsystems as closely as possible to their original condition. Planning and coordinating of aircraft MRO tasks is complicated because each aircraft has more than a million serviceable parts. Subject to the type of operations, these parts of a same type aircraft, i.e., B-737, may have different service intervals as measured by flight hours, flight cycles, or calendar periods. MRO of airframes, engines, and other systems and components requires a wide range of tools and equipment, training and skills, and spare parts. As a result, a growing trend within the airline industry is to outsource maintenance tasks to vendors who, through economies of scale and gains achieved through specialization in fleet types and maintenance procedures, can benefit in cost and expertise.

The following sections describe the current trends in the airline maintenance outsourcing industry, exploring airline perspectives, and the regulations that govern the industry. Source documents for this review consist primarily of industry periodicals appearing from 1997 to the present, as well as two GAO reports "FAA's New Inspection System Offers Promise, but Problems Need to Be Addressed" [1] and "FAA Oversight of Repair Stations Needs Improvement" [2].

2.1 TRENDS IN OUTSOURCING.

Prior to airline deregulation in 1978, airlines performed most of their own maintenance; however, since that time the practice of outsourcing maintenance has become widespread. Today, it is common for airlines to perform line and light maintenance in-house to preserve flexibility in responding to simple maintenance needs and to outsource heavy maintenance and overhauls that require more specialized and costly equipment and training. While some airlines continue to perform major maintenance tasks in-house, the third-party (contracting) maintenance industry is growing. Contracting maintenance is especially attractive to smaller startup airlines, for whom keeping a fully-equipped, fully-staffed maintenance department is often inefficient or even infeasible.

The global MRO market is estimated to be worth between \$25 billion [3] and \$30 billion a year [4]. Inventory in the airline industry's supply chain is valued in excess of \$50 billion [5]. Maintenance and spares together are often viewed as potential areas for cost-savings for airlines, as repair stations offering to efficiently manage maintenance and spares needs.

Department of Transportation (DOT) Form 41 Financial Data indicates that the ten major U.S. air carriers spent over \$9 billion dollars on aircraft MRO in the year 2000, where more than \$2.5 billion of that consisted of outsourced services. Table 2-1 shows the annual amount spent on outsourced maintenance by the ten major U.S. air carriers between 1996 and 2000. The table also shows that the total outsourced maintenance expenditures for these ten air carriers increased between 1996 and 1999, and decreased slightly between 1999 and 2000. Table 2-2 shows the proportion of outsourced maintenance relative to total maintenance expenditures for the ten

major U.S. carriers for the same time period. Table 2-2 also shows that the proportion of maintenance expenditures allocated to outsourced services increased steadily from 24.2% in 1996 to 29.2% in 1999, but dropped slightly in 2000 to 27.7%.

TABLE 2-1. CHANGES IN OUTSOURCED MAINTENANCE EXPENDITURES OF THE TEN MAJOR U.S. AIR CARRIERS*

	Outsourced Maintenance Expenditures (millions of dollars)	Change
1996	1,657	
1997	1,901	+ 14.8%
1998	2,272	+ 19.5%
1999	2,569	+ 13.1%
2000	2,524	- 1.8%

*The ten major U.S. air carriers include American Airlines, Alaska Airlines, America West Airlines, Continental Airlines, Delta Airlines, Northwest Airlines, Southwest Airlines, Trans World Airlines, United Airlines, and USAirways.

TABLE 2-2. MAINTENANCE EXPENDITURES OF THE TEN MAJOR U.S. AIR CARRIERS*

	Outsourced Maintenance Expenditures (millions of dollars)	Total Maintenance Expenditures (millions of dollars)	Proportion of Maintenance Expenditures Spent on Outsourced Services
1996	1,657	6,855	24.2%
1997	1,901	7,806	24.4%
1998	2,272	8,415	27.0%
1999	2,569	8,814	29.2%
2000	2,524	9,110	27.7%

*The ten major U.S. air carriers include American Airlines, Alaska Airlines, America West Airlines, Continental Airlines, Delta Airlines, Northwest Airlines, Southwest Airlines, Trans World Airlines, United Airlines, and USAirways.

In measuring the true cost of maintenance, airlines consider not only the equipment, personnel, and parts costs of its own maintenance department, plus the cost of purchased services, but also the operational consequences of maintenance, such as the impact of maintenance on aircraft availability and of passenger inconvenience due to technical irregularities. Reflecting this reality, a global survey of airlines' MRO requirements, commissioned by Lufthansa Technik in 1997, found that airlines are not simply looking for maintenance at the lowest price, but rather the highest value for money in terms of overall operations [6]. Appropriately, the same survey found that the majority of airlines considered quality of work and service the most important factor in choosing an MRO provider. Other important criteria included short turnaround time, range and capabilities, depth of experience, and the ability to assure the highest aircraft utilization. Cost was rated only sixth in importance.

2.2 TYPES OF REPAIR STATIONS.

For the purposes of this discussion, three basic types of repair stations are defined: independent repair stations, maintenance divisions of major carriers, and original equipment manufacturers (OEMs). The basic types of maintenance services range from servicing, maintaining, or overhauling components to complete nose-to-tail maintenance services on the entire aircraft. This section discusses the types of maintenance providers offering heavy maintenance.

Large airlines can leverage their inventory, technical expertise, and scale to sell maintenance services to smaller airlines. This makes use of the large airline's spare capacity and gives smaller airlines more maintenance options; however, this arrangement raises the concern that the customer will be treated less favorably than the parent airline. Further, since the two airlines may share a market and, thus, be in competition with each other, the initiation of a maintenance relationship may represent a conflict of interest.

Airline attempts to offer third-party maintenance services were made in the U.S. in the 1980s, and then in Europe in the 1990s. United Airlines performs a small amount of third-party work, but is restricted by union agreements. Recently, Delta Airlines had won a number of contracts to perform third-party maintenance.

Another complication associated with airlines offering third-party maintenance services is that in-house and third-party maintenance are two different businesses that must be managed separately. An airline's ability to react to short-term problems is diminished, where the operator is only one of many customers rather than the sole user of an in-house facility. As a result, when maintenance divisions break off into stand-alone companies offering maintenance services to other airlines without special consideration for their parent company, they become independent repair stations.

OEMs are also competing for a share of the MRO market. With a slowing demand for new transport and bleak future sales outlook, MRO, which was once an afterthought for OEMs, has become a source of revenue. OEMs have the advantage of a skilled workforce, in-depth product knowledge, and direct access to spare parts. Further, OEMs have the advantage of being able to bundle aftermarket service with new product sales.

A popular trend now is for OEMs to offer multiyear service agreements. This provides airlines with long-term contracts that enable them to know what their costs will be several years into the future. For example, Lucas Aerospace has a 10-year agreement to service all its products with Trans States Airlines so that the airline will not need to establish its own heavy-maintenance facility or negotiate repair contracts with others.

OEMs have also entered joint ventures with other MRO providers to become more competitive. For example, Rolls Royce and American Airlines forged a 50/50 partnership in 1997, giving Rolls Royce more North American capacity and making use of American's excess capacity. Prior to the agreement, American's facility could handle up to 350 engines per year but only worked on 100 per year, where 7% of those were third-party jobs. In 1998, less than a year later, third-party work had increased to 16% of the facility's load and was expected to rise further to 33% in 1999. This joint venture's third-party customers include America West Airlines,

Midway Airlines, and Mexicana Airlines. Another successful joint venture was created when Pratt & Whitney (P&W) Engine Services teamed with Gulf Aircraft Manufacturing Company (GAMCO). In this arrangement, GAMCO provided the partnership with storage facilities and received P&W parts at reduced rates.

While OEMs have the benefit of being inherently equipped in terms of tools, personnel, and spares to service their products, they tend to be limited in the range of maintenance services they can offer. More specifically, airlines are increasingly interested in one-stop service, preferring to arrange for a single source for all their maintenance requirements. As such, many major carriers have reduced their supplier base from 50 to a core of 5 to 10. Airlines are often seeking long-term contracts and prices that enable them to control their costs; one-stop maintenance allows them to determine this for all of their maintenance needs at once.

To remain competitive, repair stations are accommodating the airlines' desire for convenient one-stop service by offering a wide range of services and capabilities. For example, Lufthansa Technik (LHT) has entered a number of liaisons and joint ventures as part of its plans to be an even bigger player in the MRO industry. By absorbing the services and capabilities of their joint venture partners, LHT can offer customers many different services under a single agreement.

2.3 ISSUES FACING REPAIR STATIONS.

Repair stations are currently facing several issues and challenges that could affect the quality of the work they perform including

- shortage of qualified labor. In some cases, this has caused repair stations to rely on temporary and uncertificated mechanics.
- changes in spare parts regulations. The definition of approved parts has been relaxed, while quality-control requirements have increased the need for documentation and traceability of parts.
- revision of 14 CFR Part 145. The regulation governing repair stations is currently being revised and its changes are expected to place stricter requirements on many different aspects of operation.
- concern on foreign repair stations that perform maintenance for code-share partners of U.S.-based airlines.

These issues are described in more detail in the following sections.

2.3.1 Shortage of Labor.

The aircraft MRO industry is facing a critical shortage of qualified personnel to perform hands-on tasks, as well as managers to supervise the technical workforce [7]. George Ebbs, president of Embry Riddle Aeronautical University, has warned that the number of trained and experienced aircraft technicians is not keeping pace with industry expansion. He listed several factors contributing to the problem including the cost of obtaining an FAA Airframe and

Powerplant Certificate (A&P) license (about \$10,000 average), archaic training curricula and equipment that is out of synch with modern industry technologies, and the lure of more lucrative technical career fields such as computers and electronics.

To help fill the demand for MRO labor, repair stations and airline maintenance divisions are increasingly relying on contract workers, both licensed and unlicensed [8]. The use of contract workers allows flexibility to cover for seasonal or unplanned peaks in maintenance loads or for specialist maintenance and specific projects. An additional advantage of contract workers is that, while the hourly rates of pay for contract workers may be higher than those of permanent workers, they are more cost-effective to employ because there are no hidden costs for such things as overalls, meals, or transportation. Further, it has been suggested that temporary staff are more prepared to work extended hours than are permanent staff [8].

2.3.2 Spare Parts Regulations.

Spare parts inventory management comprises a significant portion of maintenance costs, as well as direct operating costs. For example, for moderate-sized fleets, the spare parts investment per aircraft is typically 15% of the purchase price. Since capital costs associated with aircraft are typically 30% of the direct operating cost, this makes spares capital about 5% of the fleet's direct operating cost. More importantly, the investment in spares inventory ties up cash flow since these investments are often required before any revenue is generated. As a result, carriers are less willing to stock and maintain large inventories of spare parts and are looking to independent spares providers, OEMs, or one-stop repair stations to manage their supply chain.

In terms of safety in the spare parts industry, the primary concerns include the prevalence of suspected unapproved parts (SUPs) and the problem of spares becoming more difficult to find as the pool of mechanics dwindles. To help deal with these problems, in February 1998, the FAA released AC 21-29B [9] outlining procedures for detecting and reporting suspected unapproved parts. Further, it defines what the FAA will accept as approved by describing 11 FAA-established criteria. By meeting any one of these criteria, parts that may not have received a formal FAA approval can be accepted as airworthy. In other words, some parts do not need to be explicitly approved by the FAA to be safe and legally eligible for installation.

Despite this broadened definition of approved parts, some airlines are unwilling to accept any part that does not come from an FAA regulatory-approved source such as the OEM, part manufacturer approval, repair station, or without the appropriate Form 8130-3 that certifies that the part has been repaired or overhauled and is airworthy. Form 8130-3, originally used for export airworthiness, was authorized by the FAA in the early 1990s for domestic return-to-service use. Air carriers' demands for Form 8130-3 are on the rise.

Further, in 1996, the FAA issued AC 00-56 [10] aimed at the voluntary accreditation of civil aircraft parts distributors, which in turn would "assist in alleviating lack of documentation and improve traceability." The AC established that a distributor could be FAA-accredited if its quality-control system was accredited by one of the following three organizations: the Society of Automotive Engineers, using AS 7103 and AS 7104, American National Standards Institute, using ISO 9000 series, and the Airline Suppliers Association, using its own ASA 100. The

essential parts of these quality-control programs are the establishment of documentation for parts, ensuring the end user that the part is legal and airworthy.

2.3.3 Revisions to Repair Station Regulations.

Under federal law, the safety of U.S. air passengers is a joint responsibility of the airlines and the FAA. The airlines are responsible for operating their aircraft safely and must ensure that any maintenance work contracted out is performed according to the carrier's policies, procedures, and requirements. The FAA is responsible for certifying airlines' or repair stations' operations and then performing periodic inspections to ensure continued compliance with safety regulations.

Repair station operations are regulated by 14 CFR Part 145. A Notice of Proposed Rule Making (NPRM) was released June 21, 1999, to revise 14 CFR Part 145, and the industry was allowed 4 months to submit comments. Based on these comments, the NPRM was revised once again and released for public comment, the period for which ended January 29, 2002.

The following highlights the new requirements for repair stations [11]:

- Sets up some new definitions for accountable manager, article, directly in charge, and line maintenance.
- Requires a new repair station manual to be developed that explains how the repair station operates and its procedures to ensure the article worked on is properly approved for return to service.
- Requires a new quality control manual that is similar to the currently required inspection procedures manual.
- Allows for satellite repair stations as long as the satellite repair station is in the same country as the repair station that has managerial control over the satellite repair station.
- Allows limited-rating repair stations the option to develop a capability list that identifies articles by make and model that the repair station can approve for return to service. These articles must be listed on the repair station's operation specifications.
- Sets contract maintenance requirements (outside work), including work performed by a noncertificated person.
- Eliminates the limited rating for manufacturers.
- Rewrote the housing requirement for an airframe rating to require permanent housing that encloses the largest type and model of aircraft listed on its operations specifications.
- New FAA foreign repair stations may be issued a certificate based on certification of the civil air authority of the country where the repair station is located, if there is a bilateral agreement in effect.
- Training programs must be approved by the FAA and in place in 2 years.

Objections have been raised regarding the lack of distinction between repair stations that service the airlines and those that serve the nonairline, general aviation community. The National Air Transportation Association, whose membership includes a number of smaller fixed base operators (FBOs), argues that small repair stations do not have the financial or managerial resources to fulfill the proposed requirements.

2.3.4 Regulations Affecting Code Sharing With Foreign Airlines.

FAA involvement in commercial aviation code-sharing agreements has typically been minimal. However, the Korean Air (KAL) (a code-share partner of Delta Air Lines) freighter crash at Shanghai in mid-April 1999 prompted the U.S. Department of Defense (DoD) and DOT to summon major U.S. carriers to perform operational reviews of their international code-share partners. Following the KAL crash, Delta Air Lines was asked to show how it knew KAL was in compliance with International Civil Aviation Organization (ICAO), FAA, Joint Aviation Authorities (JAA), or South Korean aviation authority requirements. In addition, a DOT inspector general's report concluded that code-share agreements are judged primarily by economic criteria ahead of safety, and that the FAA provides minimal oversight of the arrangements.

U.S. carriers were instructed to develop and implement a review program and conduct operational audits and reviews on their partners within 12 months. Rather than face new regulations, the carriers began conducting operational reviews on their own in July. Some airlines sent out audit teams comprised of their own employees using checklists developed within the airline, some used their own auditors and DoD-developed checklists, and others used third-party consultants they believed gave them an outsider's view of the partnership and presented the government with fewer conflict-of-interest questions.

The audit encompasses all aspects of an airline's operation. In terms of maintenance, a team will examine the international carrier's quality assurance practices, record-keeping systems, which repair and modification data sources the carrier uses, facilities, equipment, staffing, and training along with additional areas that are similar to a National Aviation Safety Inspection Program assessment in the U.S.

Since some code-share partners may be certified under regulations other than the FAA's 14 CFR Part 129, reviews may also be conducted based on ICAO, JAA, or local civil aviation regulations. One question that remains to be answered is how far down the chain a code-share review must travel, and thus, whether U.S. carriers should have to review any third-party maintenance shops its partners use.

2.4 OTHER RELATED RESEARCH EFFORTS.

The section provides a summary of the information regarding outsourcing of aircraft maintenance on the FAA Human Factors website (<http://hfskyway.faa.gov>). There are three major reports on the web site that have specific and detailed references related to outsourcing of maintenance. One report, Goldsby [12], deals with the comparative training and qualification of personnel in airlines and repair stations. The other two reports deal with the information and

documentation flow, Drury [13], and oversight procedures, Goldsby [14], between in-house and outsourced maintenance.

2.4.1 Why Outsource.

Some major reasons for outsourcing are

- Outsource maintenance requirements in excess of baseline capacity.
- Outsource maintenance for specific aircraft type—e.g., outsource maintenance for aircraft will constitute a small part of the airlines fleet.
- Outsource maintenance for a specific maintenance function—e.g., outsource engine overhaul.

Some factors used to determine which repair station should undertake the repair work are reported as

- Repair station abilities, quality—labor turnover, use of contract labor, multiple document formats, etc.
- Location of potential facilities.

2.4.2 Outsourcing Process.

Drury [12] produced a report that investigated the process of outsourcing, and in particular, how information flows change. Figures 2-1 and 2-2 indicate how the flow of information changes from in-house to outsourcing maintenance operations:

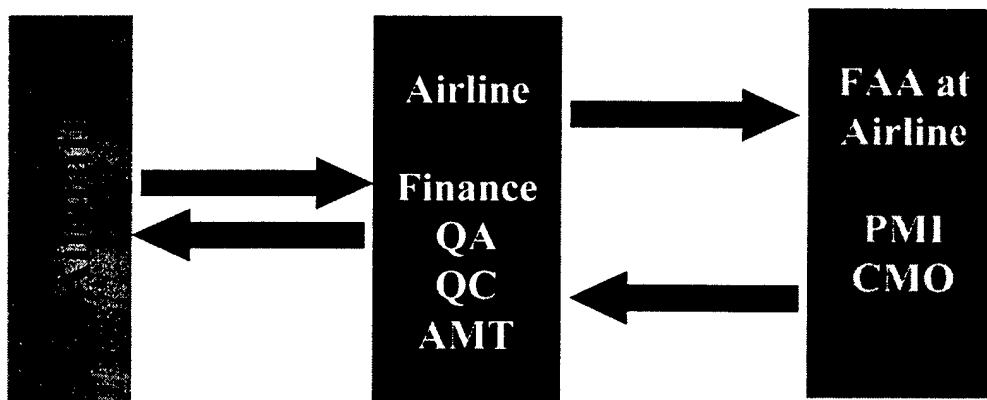


FIGURE 2-1. MAINTENANCE PERFORMED IN-HOUSE PROCESS DIAGRAM [13]

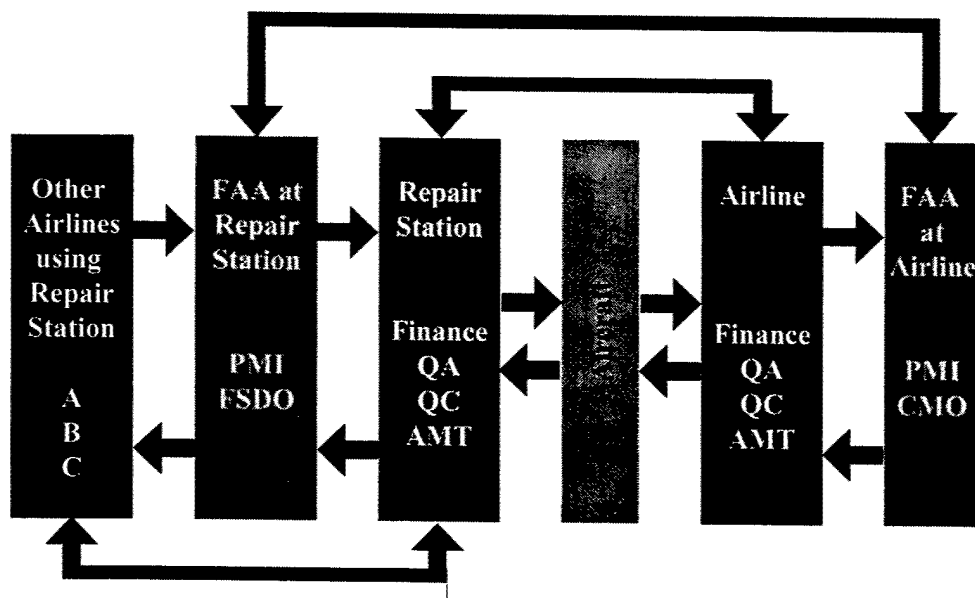


FIGURE 2-2. MAINTENANCE OUTSOURCED PROCESS DIAGRAM [13]

The above diagrams highlight the increase in complexity as airlines outsource their maintenance to repair stations. The communications channels become much more complex, and hence, there is greater chance for error. Drury claims that introducing any interface between those who operate the aircraft and those who perform the maintenance must introduce an error potential, which is absent in in-house operations.

Drury found that information and documentation was a significant problem at repair stations. Repair stations had to deal with many customers, and this forced aviation maintenance technicians (AMTs) to switch between different styles of workcards and nonroutine repair reports. Repair stations are required to have their own General Maintenance Manual (GMM) but are also required to comply with each customer's unique set of documentation (each customer will have its own GMM that governs all procedures to be followed). Drury found that in dealing with different airlines, AMTs had to change to work with differently designed documents, e.g., workcards had different layouts, levels of detail, wording, overall quality, flow of steps, progression, etc. Repair stations also often rely on the airline for technical data because only the airlines have a direct link to OEMs. Both these factors can lead to errors because an AMT constantly has to change the way they operate (e.g., like a driver using different rental cars frequently). Goldsby found that some airlines now have sections in their GMM that specifically states who, what, when, and how work is to be conducted by contract maintenance providers.

Drury found that all repair stations attempted to keep AMTs and inspectors dedicated to one airline at repair stations to keep them consistent in using documentation of that airline. This not only helped minimize the potential for errors, but it also avoided extra training. The practice, however, was not always commercially possible—given the changing schedule of aircraft operations.

Drury raised the idea that if outsourcing continues to increase, the repair stations themselves may have a large role to play in standardizing documentation between airlines, as errors involving change between documents can be seen by customers as a source of human error reduction potential.

Drury found that on-site representatives held by airlines at most repair stations played a valuable role in assisting information flow. But Drury stresses that the representatives in many cases were only an avenue for airlines to express their dissatisfaction with the cost or delivery schedule of the repair station—as opposed to being in place to facilitate quality operations or keep an eye on quality of work performed by the repair station.

Repair stations also face other difficulties due to the variety of aircraft types they serve. The variety makes it difficult to stock aircraft parts and special tooling at repair stations. In particular, the type specific maintenance scaffolding systems popular with airlines are more rarely seen at repair stations.

Drury's report found that the comprehension of workcards was significantly correlated to good document design methods. Following human design factors, good practice in document design was shown to have a large impact on errors of comprehension. If an error on a workcard was discovered at the repair station, definite guidance is needed by the airline. Even if the fix is obvious to the experienced AMT, it would be dangerous to attempt to work around the error. But AMTs usually wish to help the client airline, and hence, may be tempted to do the obvious, rather than follow the wording exactly.

Drury also found that changes in workcards at airlines were claimed by AMTs to occur at glacial speed of change. Conversely, when AMTs at a repair station request changes to airline workcards, the changes tended to flow relatively quickly—possibly implying that the airlines are concerned with third parties operating under workcards with potential errors—whereas practices in house could be greater controlled.

Interestingly, Drury's research found that error detection was generally done at different stages (between work done at an airline in-house compared with work done at a repair station). Most errors tended to be either a lack of knowledge or deliberate flouting of procedures by the individual. Thus, root causes were generally seen as inadequate motivation or poor training.

2.4.3 Training and Qualifications [12] and [14].

In undertaking maintenance operations, both airlines and repair stations must comply with relevant FARs. Air carriers operate under 14 CFR Part 121 regulations. Maintenance providers and repair stations operate under 14 CFR Part 145.

Under 14 CFR Part 121, airlines have specific requirements for certification, training, and qualification of maintenance personnel. Operating under 14 CFR Part 145, repair stations do not have the same level of specific and detailed requirements for certification, training, maintenance programs, documentation, workcards, and organizational structure as air carriers that operate under 14 CFR Part 121.

Goldsby [12] concluded that the best the maintenance community had to offer was only available at the OEMs and the larger, successful air carriers. The maintenance operations of repair stations operating under 14 CFR Part 145 were generally inferior to that of the carriers operating under 14 CFR Part 121.

The repair stations have considerably less computerization and automation. In many cases, records of training and qualification are manually kept. It was found that, in some third-party repair stations, personnel safety procedures and hanger equipment used were well below the standards of air carrier maintenance. The repair stations are not nearly as far along as the airlines in developing maintenance human factors and maintenance resource management programs.

Goldsby [14] also commented that FAA personnel at airline facilities are Certificate Management Office personnel, who are usually responsible for a single carrier. Certified repair stations, however, operate under the Flight Standards District Offices (FSDO)—office inspector system. FSDOs were often staffed by personnel most experienced with general aviation, with only a few of the offices having experience in large air transport operations.

In general, it is claimed that the day-to-day operational maintenance requires technicians who are generalists—A&P mechanics with the knowledge and skills necessary to ensure aircraft operational safety. Maintenance that is completed when aircraft are out of service—heavy maintenance checks, detailed inspections, major repairs and alterations—are mostly completed by specialists. Although the majority of the specialists are A&P certificated, many are uncertified and perform under the supervision of certificated individuals.

Repair station maintenance staff differs significantly from those in air carriers in that the majority of those working in repair stations are specialists of whom only half are A&P certified. Another element of repair station staffing is due to the fluctuating workloads; there is a large pool of maintenance personnel who work for temporary placement organizations. These organizations supply technicians to repair stations, allowing them to meet peak workloads. These contractors move from one organization to another as needed and have become a significant work force in the third-party maintenance environment.

Maintenance workload is more predictable at the air carrier environment than at a third-party repair station. An airline has control over all aspects of its fleet—such as maintenance plans and aircraft routing. A third-party repair station has limited or no control over these elements. Thus, the workload varies due to airline scheduling demands. Staffing is, therefore, variable at repair stations, as is facility use and management.

There is a significant amount of temporary workers at repair stations that are provided by fourth-tier aviation maintenance support contractors. This brings another complexity into the already complex puzzle. Temporary workers, shifting from repair station to repair station, will have to learn a new set of procedural tasks every time they change contract. This could potentially lead to errors.

With respect to training, Goldsby [12] observes that in the competitive environment of today's air transport industry, operators and maintainers were inclined (in general) to only perform

training that was government mandatory. Under the current regulations, AMTs have no annual recurrent training requirements beyond what is specified for a few with special task requirements. There is no system in which the FAA can communicate with A&P certified mechanics to pass on regulatory information, recent safety issues, accident reviews, breakdowns in the system, or human factors issues that could adversely affect aviation safety if not remedied.

Drury mentions a few comments on the rate of labor turnover and the impact on training:

- Repair stations are affected more by AMT shortage than airline carriers.
- As 14 CFR Part 121 carriers have downsized internal maintenance operations, much of the experience has been lost to the industry altogether, as experienced members have gone outside aviation or retired early.
- The industry seems to exhibit a migratory workforce, as workers move easily for small changes in conditions. Repair stations report a turnover of around 30%-50% for AMTs and up to 100% for managerial staff.
- Most AMTs at repair stations are contractors, therefore, there is an economic pressure to minimize training for temporary personnel. Some repair stations, in an attempt to maintain continuity, attempt to limit the number of contract personnel in the repair station to about 20%.

3. RESEARCH METHODOLOGY.

This section outlines the methodology used to conduct this study. To ensure consistent collection of data, a formal interview process was developed. This process consisted of developing a standard list of questions and an interview protocol. After collecting the interview data, it was entered into a database and subsequently analyzed. The results of the analysis were synthesized into performance measures for repair stations.

3.1 INTERVIEW DEVELOPMENT.

The information being sought in this study is gathered primarily from the perspective of aircraft maintenance personnel. The target interview respondent was an airline representative working in the maintenance area, primarily in a quality control/assurance capacity.

The interview questions were developed to map the process of how an airline outsources any maintenance function. The interview document is comprised of four sections:

- Background Information

This section sought to gain background information about the airline for which the respondent works. The questions focused on the size of the airline and the practices of the maintenance department, e.g., how much maintenance is outsourced, typical maintenance functions outsourced, and which types of vendors the airline contracts.

- Criteria for Third-Party Vendors

This section focused on how airlines identify potential vendors, e.g., the requirements of both the airline and the vendor for each other, and how contracts are awarded.

- Monitoring and Assessing Vendor Performance

This section focused on what an airline monitors in terms of vendor performance and how that is done. In addition, this section sought information about the process of contract renewal or termination.

- Oversight by Other Entities

The questions in this section sought information regarding the airlines' relationship with CASE, industry groups, and the FAA.

For the repair stations that were interviewed, six broad areas were investigated:

- Background Information

This section sought information about the repair station for which the respondent is employed.

- Labor and Management Issues

This section focused on the organization of the repair station and staffing and personnel issues related to the maintenance workforce.

- Certification/Regulatory Issues

The questions in this section focused on how the repair station ensures compliance with both FAA and client requirements and sought reaction to the proposed changes to 14 CFR Part 145.

- Relationships with Clients

This section sought information regarding how contracts are managed with the clients and what information flows between the two entities.

- Use of Subcontractors

This section sought information about the process and practices of repair stations using subcontractors to complete work.

- Quality Control Issues

The questions in this section focused on how quality control is maintained for clients in the repair station environment.

A complete listing of questions in each section is provided in appendix A. The interview was designed to take about an hour to minimize disruption to the schedule of the respondents.

3.2 PROTOCOL.

A protocol in dealing with the survey respondents was developed. The protocol ensures that the information was collected consistently from each respondent.

As most airlines vary in terms of organization, the actual job title of the respondent was expected to vary as well. However, the interview was designed to be answered by a representative from the maintenance division. Ideally, the respondent would be the overall manager of outsourced maintenance. If there was a team of people across several departments that were involved in the outsourcing process, the representative from the quality control division of the maintenance department was contacted.

The airlines and repair stations that participated in this study were identified primarily by contacts from previous research. Additional contacts were identified by the Repair Station Expert Panel, and in most cases, a contact at the newly identified airline was furnished by the panel member. All potential respondents were contacted initially by telephone and were provided with a brief summary of the study objectives and requirements. During this initial

discussion, the involvement of the respondent was requested, arrangements were made to meet, and a follow-up letter was sent to confirm the arrangements.

All interviews were conducted in person to ensure consistent application and interpretation of the questions. Each question that was applicable to the airline of each respondent was asked. After each interview was completed, a follow-up letter was sent, thanking the respondent for their participation.

To ensure a nonthreatening environment for the respondent, specific responses to the interview questions were considered confidential. Neither the airline nor the individual participating in the interview are referenced specifically in this report.

3.3 ANALYSIS.

To store the information collected from each respondent, a database was developed using Excel. This method allowed easy comparison of responses to each question from each airline in the sample. In addition, graphical depictions of the responses could be easily generated and appropriate statistical analysis of the data could be performed. While some quantitative data was collected from each respondent, the bulk of the information sought was qualitative.

3.4 PERFORMANCE MEASURES.

The results from the analysis were synthesized to generate performance measures in order to rate certain characteristics of repair stations. The focus was to determine when a repair station may be operating in a manner that might result in an unfavorable condition. This was accomplished by grouping similar or insightful responses that indicate certain portions of the repair station should be monitored.

3.5 VALIDATION.

To validate the results, a select group of those interviewed from both the airlines and repair stations were presented with the performance measures. Each respondent provided a relative criticality rating for each and relating it to its importance to repair station operation. Considering these responses, a composite criticality rating was assigned.



4. ANALYSIS OF AIRLINE INTERVIEW RESULTS.

4.1 INTRODUCTION.

The primary objective of this study was to determine what criteria airlines use to select a vendor to perform outsourced maintenance functions. Based upon this information, performance measures to monitor the quality of vendor work are to be developed. The analysis of the interview data is presented in such a manner to facilitate the process of developing these performance measures.

4.2 DESCRIPTION OF AIRLINES INTERVIEWED.

A total of ten interviews were completed. This sample includes two major airlines, three regional airlines, and five niche airlines. In addition, select questions were asked during a visit by another researcher of a major, European-based airline.

The job titles of the respondents that were interviewed varied. At the major airlines, the job titles of the respondents were manager of contracted maintenance and manager of the quality control division. At the regional airlines, one respondent was the director of quality control, while another was the manager of warranties in maintenance. At the niche airlines, the title of the respondents included the director of maintenance, the vice president of technical operations, and the director of quality control.

4.3 BACKGROUND INFORMATION.

All the airlines that participated in this study outsourced at least part of their maintenance function; in one case, the airline was in the process of outsourcing a complete overhaul of an airplane. While most respondents indicated that costs were a major reason for outsourcing their maintenance function, they also cited several additional, interrelated cost drivers that were taken into account. Figure 4-1 depicts some considerations that the sample of respondents made when deciding to outsource maintenance tasks.

Reliability and adherence to work schedule are two such factors. One respondent stated that the potential revenue loss for an aircraft that exhibits poor reliability is always greater than any cost savings achieved from outsourcing the maintenance in the first place.

The other cost-driving factors are labor considerations and the need for specialized equipment. The labor consideration deals with training and expertise of the workforce to complete certain tasks. Many respondents commented that a repair station often had the expertise in their facility to complete specialized tasks. Furthermore, repair stations also possessed specialized tooling required to complete MRO tasks. These tools may be cost prohibitive for an upstart or small airline. The capabilities of the repair station also came into play with these considerations. A repair station may be able to complete the work more quickly because of its expertise in a certain area. This translates to a cost savings to the airline in terms of decreased downtime of an aircraft.

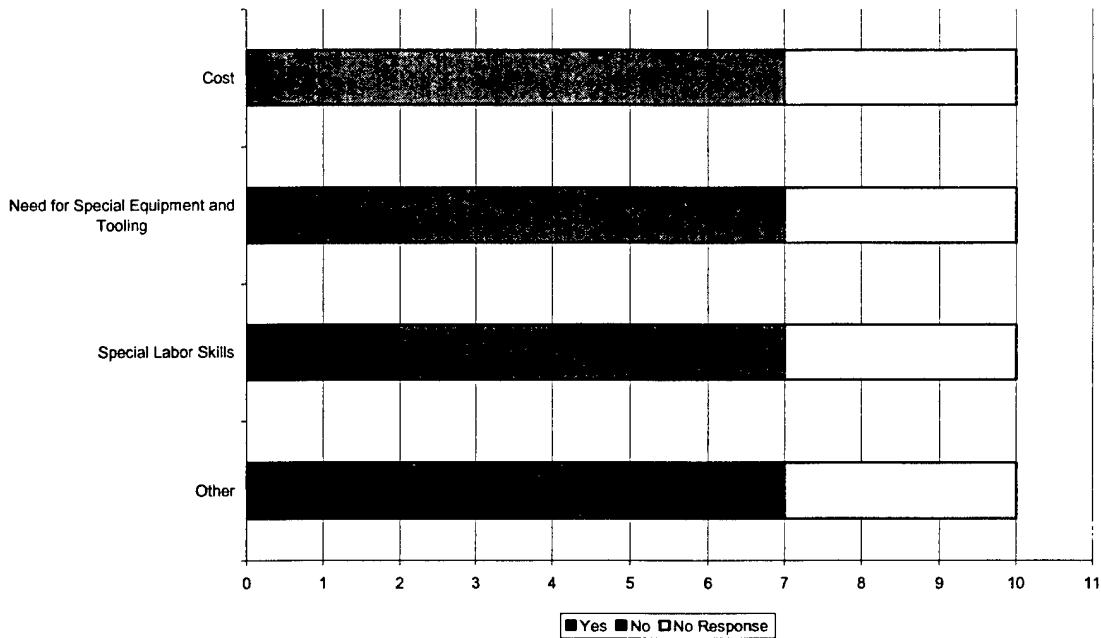


FIGURE 4-1. FACTORS CONSIDERED WHEN MAKING OUTSOURCING DECISIONS

The scale of outsourcing within the sample of airlines interviewed also varies. Figure 4-2 shows how many of the airlines outsourced some common maintenance functions. Line maintenance functions were typically outsourced at the stations away from their bases or overseas. The niche airlines were the only respondents in the sample to outsource their light-scheduled checks (A and B). Niche airlines also outsourced their heavy-scheduled checks (C and D). However, other airlines also reported that they outsourced their heavy checks as well.

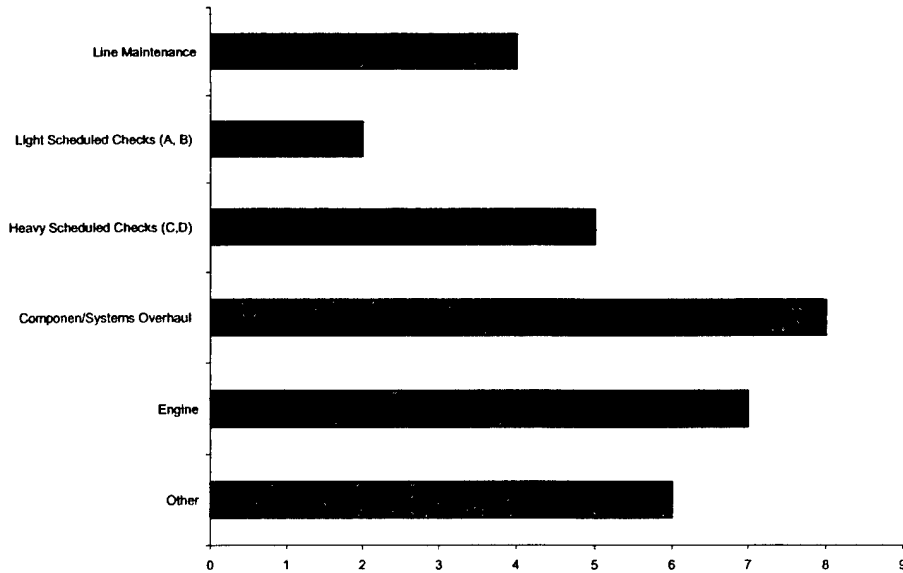


FIGURE 4-2. TYPICAL MAINTENANCE FUNCTIONS OUTSOURCED

Almost all the respondents stated that they outsourced at least some of their component overhaul to repair stations. The primary reason for this was the lack of expertise and tooling in-house. Engine maintenance was most likely to be outsourced for the same reasons. Likewise, all respondents stated that other maintenance was performed by a third party. This included such items as propeller overhaul, painting of aircraft, composites, and specialized avionics work.

Figure 4-3 depicts the types of outsourcing providers that the respondents currently used. All except one of the respondents stated that they employed repair stations. One respondent was careful to note that the term repair station referred to facilities that hold a 14 CFR Part 145 repair station certificate. All except two respondents had contracts with component shops. Only two respondents used FBOs and only in the case of on-call maintenance at out stations. Five of the seven respondents mentioned that they contracted with other airlines to perform some of their maintenance-related tasks.

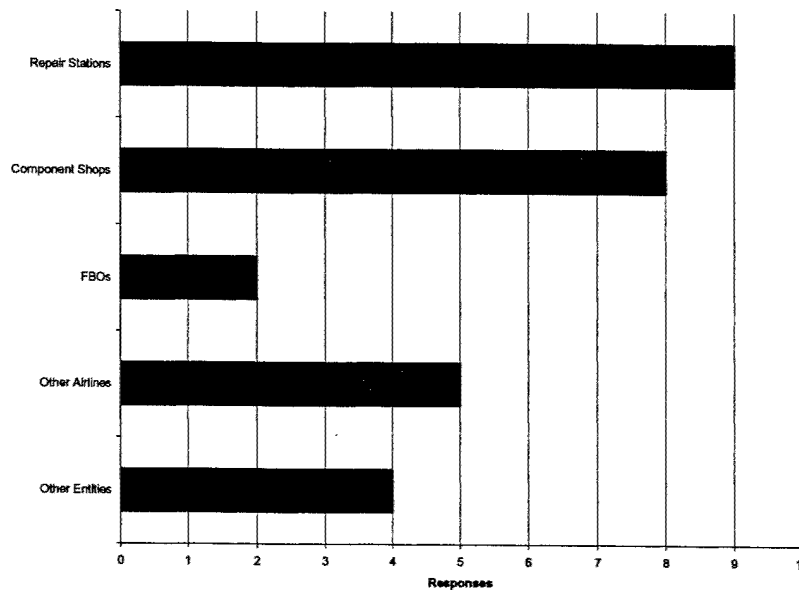


FIGURE 4-3. TYPES OF OUTSOURCING PROVIDERS

Of the ten respondents, only one airline had a company-imposed limit regarding the percentage of their maintenance responsibilities that could be outsourced (figure 4-4). In this case, the limit is set at 20% of the total maintenance function, which is a constraint that was imposed by the union contract. This particular respondent also noted that their airline only outsourced 10% of the maintenance functions at the current time. Other respondents that were unionized mentioned that the union is sensitive to issues related to outsourcing, but that there was no formal limit stipulated in their contract.

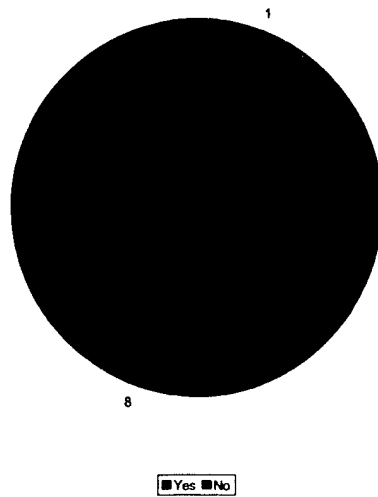


FIGURE 4-4. LIMITATIONS ON OUTSOURCING

4.4 CRITERIA FOR THIRD-PARTY VENDORS.

In identifying potential maintenance providers, the respondents relied heavily on reputation and recommendations from other users of maintenance services (figure 4-5). One respondent had a fleet of one type of aircraft. In organizing their maintenance department during the start-up period, they simply identified the vendors that had known capabilities for their particular fleet of aircraft. Other respondents relied on information obtained at trade shows or operators' conferences.

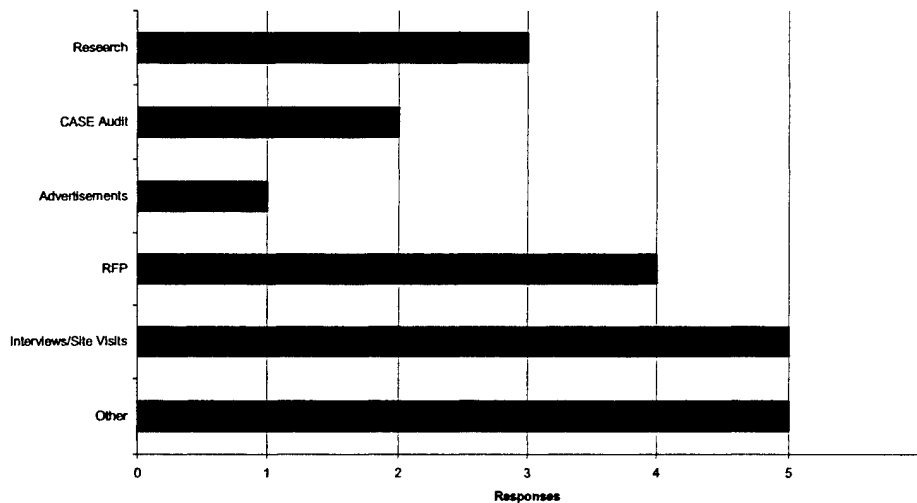


FIGURE 4-5. METHODS USED TO IDENTIFY POTENTIAL MAINTENANCE PROVIDERS

Most respondents that were outsourcing larger projects issued request for proposals (RFP) and conducted on-site interviews with the vendors being considered. The respondents that did not issue RFPs or conduct interviews typically were outsourcing smaller projects, primarily component overhaul.

Five of the respondents were members of CASE. Only two of the respondents stated that they used CASE audits as a source of identifying information when identifying potential providers.

Three of the ten respondents commented that they consulted the principal maintenance inspector (PMI) of the repair station of a potential provider (figure 4-6). One respondent then qualified this response by stating that this is done indirectly as part of their audit of the repair station. Another respondent said that they would only consult the PMI if they discovered an enforcement action that was considered significant.

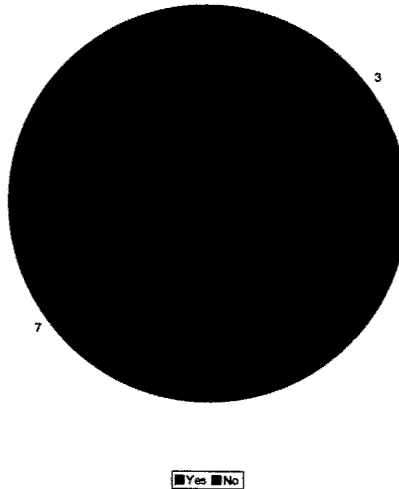


FIGURE 4-6. RESPONDENTS THAT CONSULT THE PMI OF A POTENTIAL PROVIDER

In the process of identifying potential maintenance providers, the respondents stated that foreign repair stations were considered differently than domestic repair stations. The primary reason for considering foreign repair stations differently than domestic is geography and the related time and costs in dealing with a vendor that is located far away. One respondent mentioned that foreign repair stations would have to complete work more quickly to be competitive with domestic repair stations due to the increased travel time to reach the repair station. When asked if foreign repair stations required any special oversight by the firm, all respondents answered no.

Figure 4-7 depicts some of the criteria that the respondents considered regarding the provider's workforce. Most respondents did not consider the makeup of the labor force of the potential provider. Only one respondent critically looked at these issues. This respondent commented that all leads and inspectors must have an A&P, and they also evaluated the number of contract versus permanent employees. The contract employees were considered an issue since it was felt that as the number of contract employees increases, so does the likelihood of inconsistent

training and potential problems. Average experience of employees was also a factor that was considered. Wages were considered by two of the respondents, with one response qualified with the statement that most repair station wages are in a similar range.

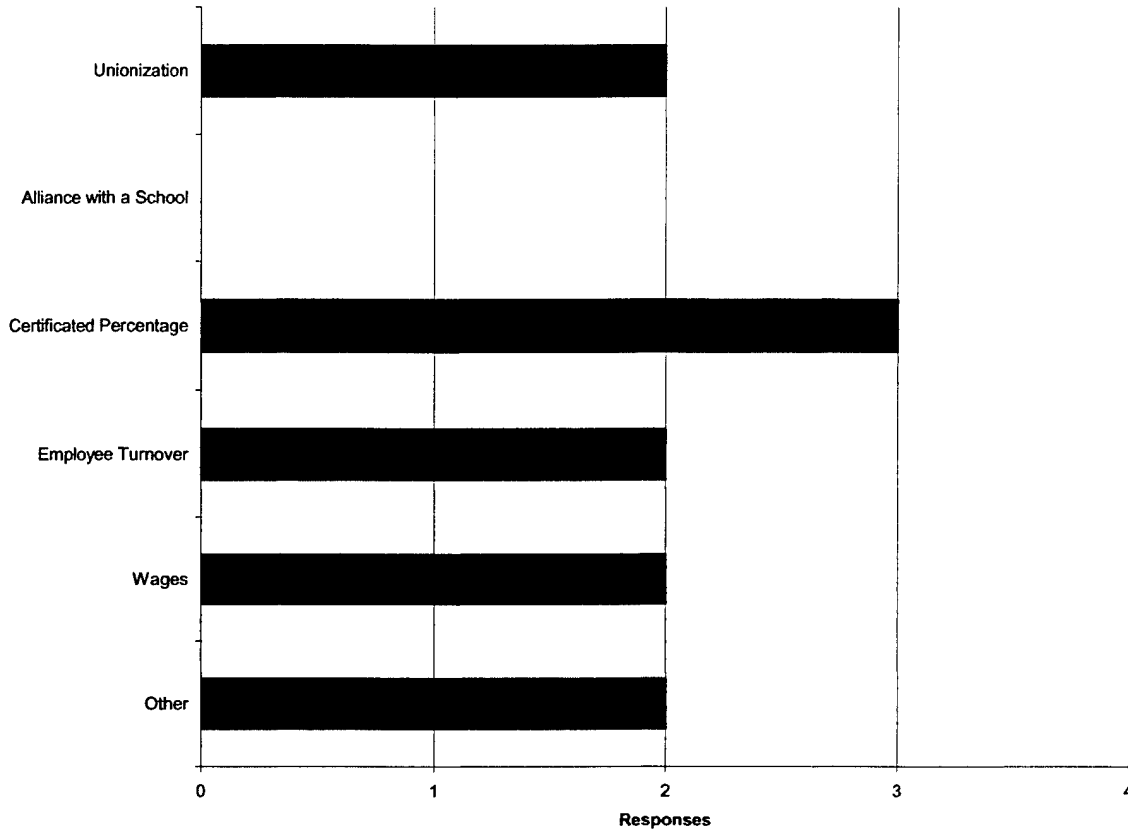


FIGURE 4-7. WORKFORCE CONSIDERATIONS FOR REPAIR STATIONS

Financial status of the provider was a consideration for most of the respondents. However, only one of the respondents stated that a credit check was actually performed, while two respondents stated that they consulted publicly available financial information about the potential provider.

When queried about any specific requirements that the respondents may have for their potential maintenance providers, most respondents provided examples that are standard. For example, the appropriate documentation, including maintenance manuals, must be provided. Only one respondent replied that they required any special insurance beyond what they considered the industry norm. This respondent also stated that the vendor would also require special insurance coverage.

In making the final decision to accept a proposal from a potential contractor, the respondents stated that performance and cost were the two most important criteria in comparing bids from potential providers. All respondents stated that it was an equal balance between these two criteria. Guarantees were not stated as important in the initial decision to award a contract to a vendor. However, on-time performance is explicitly written into the contract to ensure

satisfactory performance on the part of the vendor. Contract periods also vary according to the specific bill of work, which varies by the number of aircraft and the complexity of the task. Specific answers varied from 18 months to 3 years, with three respondents stating 3 years. Most respondents stated that contracts are often modified to reflect changes in scale and scope that is usually mutually agreed upon by both parties.

4.5 MONITORING AND ASSESSING VENDOR PERFORMANCE.

Most respondents said that company personnel are on-site at a vendor for some period of time (figure 4-8). When company personnel are on-site with a vendor, they function as a liaison between the airline and the vendor and as a resource to the vendor. With larger contracts, the respondents stated that company personnel are on-site full-time. The number varies from one to seven people, depending on the scope and scale of the particular contract. All but one respondent said that on-site personnel were company personnel. In the case where the on-site personnel were contracted, the contractor has actually been a previous employee of the vendor.

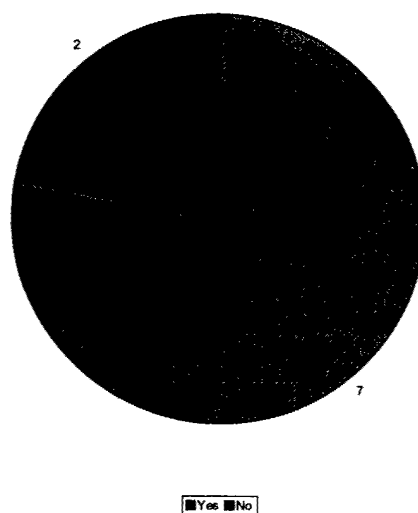


FIGURE 4-8. COMPANY PERSONNEL ON-SITE AT A VENDOR

The on-site personnel function as advisors to the jobs and keep track of progress and problems. They are usually maintenance personnel with a variety of experience. They also audit the work that is being performed by the vendor.

The respondents reported a variety of data that is collected by the airline about work being performed by a vendor. The sources of this information include billings and invoices, required FAA documentation, discrepancy reports, and installations and removals reports.

All respondents stated that quality assurance measures that apply for all work done by the airline also apply to the work performed by any vendor. Most respondents said they did not perform any special audits on the work performed by vendors. Three respondents said if they did audit

any work, it was done because someone discovered something out of the ordinary and suspected further problems.

Five of the ten respondents said they had procedures that were completed after the aircraft had been returned from a vendor. This most frequently involved what one respondent defined as a conformity/acceptance check. This type of check involved reviewing the documentation to ensure that all paperwork was in order and that all procedures had been properly followed. One respondent stated that they performed a special 7-day monitoring of the aircraft after it had been returned from the vendor. Another respondent stated that any work that had been outsourced was reflected in their internal paperwork and was tracked to see if there were any differences between what services had been purchased and what work had actually been completed.

Five of the ten respondents mentioned that a change in management at a vendor can potentially cause problems. One respondent stated that maintaining partnerships is important for completion of the work and constant turnover stands in the way of this. Likewise, all respondents stated that the bankruptcy of a vendor is a great concern. The bankruptcy proceedings of a vendor sometimes come as a surprise and can pose significant risk and operating challenges to the airline. In addition to the difficulty of repossessing company property at the vendor, often the FAA revokes the certificate of the repair station and requires the work that has already been completed by the repair station to be reinspected.

On the other hand, extensive growth of a vendor was of concern to six of the respondents. One respondent suggested that problems from extensive growth are likely reflected in the quality of the work. Another respondent suggested that this may be due primarily to new personnel who may not be experienced as existing personnel. There might also be paperwork problems. Another respondent commented that this may cause a dilution in the management staff of the vendor.

When it is time to renew a contract with a vendor, all the same criteria used in the initial decision to award the original contract apply. However, one respondent pointed out that in the renewal process there is an experience base from which to work, and that the airline is in a greater position to deal with concerns. Cost becomes less of an issue when renewing a contract because there is already an established relationship between the vendor and the airline.

Two respondents stated that they had never terminated a contract. The respondents offered several reasons for terminating contracts. These include flagrant quality problems, longer cycle times than originally stipulated in the contract, or the vendor exceeded their capabilities.

4.6 OVERSIGHT BY OTHER ENTITIES.

Most respondents felt that the industry alphabet groups, such as the Air Transport Association and the Regional Airline Association, did not necessarily provide a forum for discussing issues related to outsourcing maintenance. Two respondents said that they have gleaned general maintenance information at operators' conferences that were in some cases sponsored by the alphabet groups.

Five respondents stated they belong to CASE, while one respondent was previously an associate member. Most CASE respondents used CASE audits, but only supplementally to their own. One respondent said they report any violations by a repair station or any contract terminations to CASE. While all respondents accepted CASE audits as a standard, they also mentioned they usually went over and above those standards for their own internal purposes.

All respondents reported that there was very little coordination between the PMI of the vendor and the airline. The only communication that generally occurs is in the case of a problem. None of the respondents said that they were involved when the FAA conducts inspection of a vendor. Most respondents are not notified when FAA revokes a 14 CFR Part 145 certificate of a vendor.

5. ANALYSIS OF REPAIR STATION INTERVIEWS.

5.1 INTRODUCTION.

To provide a balanced view of the entire system of the outsourcing process, representatives of a small set of repair stations were interviewed. The questions asked served to provide an additional perspective on the issues identified by airline representatives as important. In addition, pressing issues that are facing repair stations were also identified. The analysis of the results of the repair station interviews also provided input for the development of the performance measures.

5.2 DESCRIPTION AND STRUCTURE OF REPAIR STATIONS INTERVIEWED.

A total of six repair stations were involved in the study. The director of quality assurance was most often the primary contact at the facility and was subsequently interviewed. In one instance, the vice president of the repair station served in this capacity.

All of these repair stations were considered larger facilities, i.e., having significant revenue generation, hangar capacity for multiple aircraft, and the ability to handle multiple components. Three of the facilities were OEMs—two of the facilities working on components and one was a nose-to-tail provider. Two repair stations were independents, both offering nose-to-tail services. The remaining repair station was previously the maintenance department for a regional airline that had been spun off as an independent repair station.

The date of certification of the repair stations was varied. In one instance, it was in the 1950s and the latest instance was in 1996.

All of the repair stations ran two shifts, with most running three or more. A typical workweek for an employee at a repair station was at least 40 hours a week and often included some overtime. Half of the repair stations involved in this study were unionized.

5.3 LABOR AND MANAGEMENT ISSUES.

One of the areas of interest to some of the airline respondents in this study was the makeup of the labor force of the repair stations that they were evaluating. To a large extent, the labor force determines the capability of a repair station.

Sources of labor for new hires ranged from other repair stations, to graduates of A&P schools to retired military personnel. One respondent reported that they kept cognizant of where layoffs were occurring at other repair stations and were certain to step up recruiting efforts in the area. While all respondents said previous work experience was preferred for new hires, in many cases, it was not a requirement. Often, the human resources department handled background checks at the facilities interviewed. While most respondents specifically stated that being able to communicate with the English language was essential, in only one case was it explicitly a requirement for any position.

The range of certificated labor was from 20% to 90%. This includes any type of certification, including A&P or repairman certificate. OEMs that focused on components had a lower percent of certificated labor. With one exception, the repair stations that performed nose-to-tail services had a higher percentage of certificated labor, which included mostly A&Ps. As shown in figure 5-1, the range of the ratio of workforce assigned to each inspector varies considerably across the repair stations interviewed.

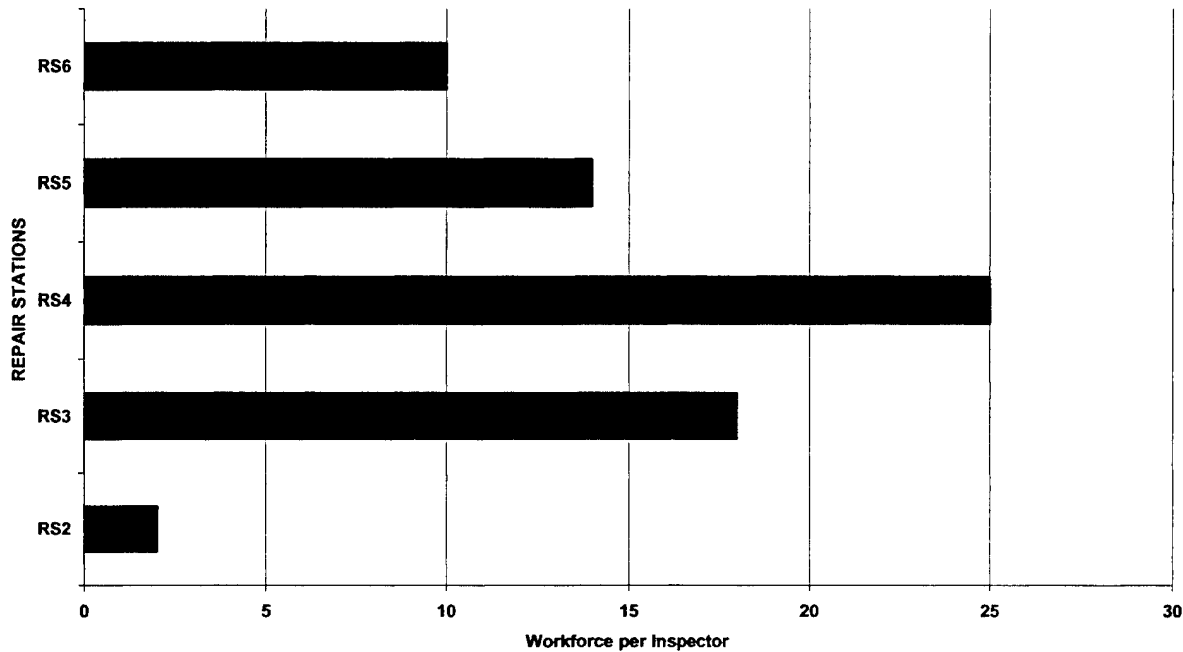


FIGURE 5-1. WORKFORCE PER INSPECTOR AT REPAIR STATIONS

Temporary or contracted labor was not used at three of the facilities. At the facilities that employed temporary labor, the percentage of the workforce that was temporary did not exceed 20%. All of the respondents stated that this was the maximum value they preferred to have at their facilities. However, some respondents did claim that this value was exceeded on certain occasions, primarily during surges in the workload.

The average hourly rates for maintenance personnel are shown in figure 5-2. The range is fairly close and low variability may be due to the geographic locations of the repair stations. One respondent noted that the hourly wages for maintenance personnel are fairly similar.

All of the facilities with a unionized workforce had to hire within the company and promoted based on seniority policy. Most of the nonunionized facilities did mention that promotions were based upon merit, more than seniority. Regardless of union status, most of the respondents reported that management positions required bidding.

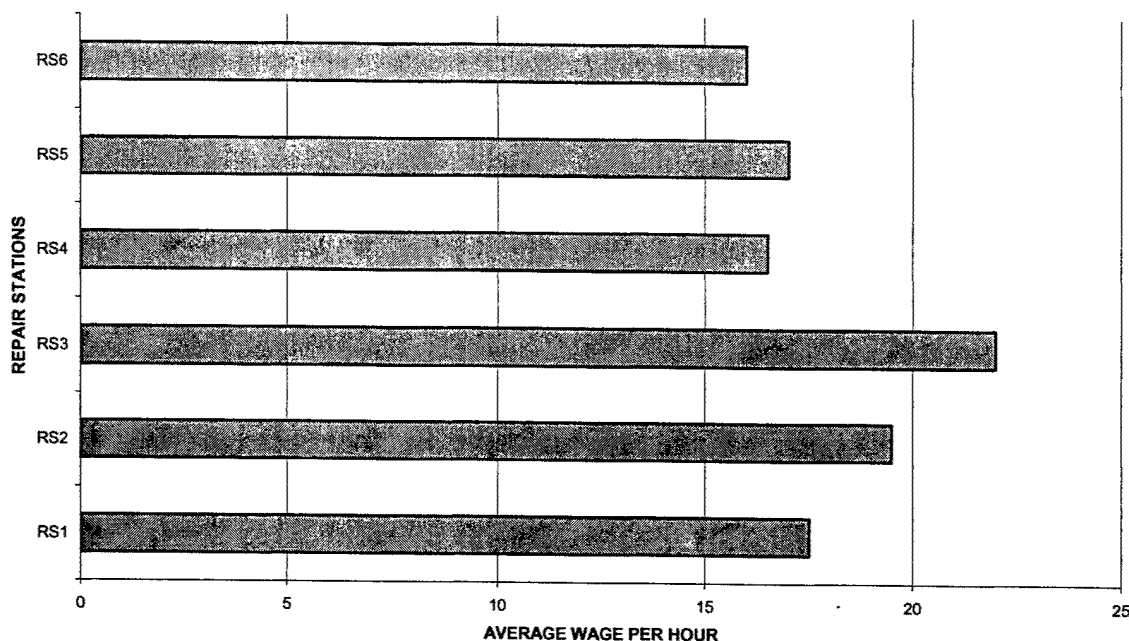


FIGURE 5-2. REPORTED AVERAGE WAGE PER HOUR

Training programs and their structure varied significantly throughout the repair stations that were interviewed. One facility's training program was strictly on-the-job training. Another respondent contracted a majority of its training to flight safety. Still another respondent reported that their goal is to provide, on average, 80 hours of training per year to each AMT. At this repair station, the content of the training was dependent upon the position and experience of the employee.

All respondents at repair stations reported a shortage of personnel. Two facilities reported their turnover rate for maintenance personnel exceeded 100% per year. On the other hand, three facilities reported their turnover rate was low, and in one case, it was reported to be 1%-2%. Similarly, the number of open positions at two repair stations interviewed approached 25% of the current maintenance workforce. At two other repair stations, there were no open positions. However, at these two facilities, this was a decision that was made by management, and there were plans to begin hiring.

Turnover of management was fairly common at the repair stations interviewed. Most respondents reported that in the last 5 years, there had been at least one fairly sizable turnover in upper management. One respondent stated that while there had been a change in upper management, the production control staff had remained intact, which provided some degree of stability to the facility.

5.4 CERTIFICATION AND REGULATORY ISSUES.

Most respondents stated that the differences that occurred was due to the different authorities and regulations (i.e., FAA regulations versus JAA regulations) under which the work was performed.

However, those issues are transparent to those working on the shop floor level. Similar sentiments were expressed when asked about completing the same work for different customers. Most respondents reported that differences were handled or rectified at a management level, specifically by either the quality control, planning, or engineering departments.

The most common complaint of the respondents concerning oversight by a cognizant agency (e.g., FAA or JAA) was that the interpretation of the rules and regulations often varied from inspector to inspector. The root of this difficulty is that the regulations contain too many gray areas that are open to interpretation and are not specific or direct enough. This situation frequently led to conflict between the inspector and the repair station. Others felt that they had little trouble with the relationship with their inspector.

5.5 RELATIONSHIPS WITH CLIENTS.

As with the airline interviews, the respondents at the repair stations reported that their typical contract period varied widely and was dependent upon the work that was performed. One respondent stated that their standard boilerplate contract was 1 year. Only one respondent reported that their repair station terminated a contract from their end. However, in this case, it was considered a business decision.

There was variation in the responses as to whether the repair station required a representative from an airline to be on-site at the repair station. Two of the overhaul component facilities stated that this was not required due to the scope of the work that they perform, while the remaining component overhaul claimed that often an on-site representative was required for the same reason. The nose-to-tail facilities said that frequently an on-site representative was present. However, in some cases, it was a requirement, while in others it was not.

5.6 USE OF SUBCONTRACTORS.

All respondents stated that they used other vendors as subcontractors. However, the reasons for using subcontractors varied according to the function of the repair station. All respondents reported that they used subcontractors for areas in which they possess little or no expertise. In one case, this occurred at the request of the client, specifically to involve the manufacturer of certain components on an aircraft. Two of the respondents stated they use subcontractors to even out surges in their work. All respondents stated that the subcontractors they use are always FAA-certificated facilities.

Two of the respondents stated specifically that they informed the customer if they use subcontractors while performing work for that customer. However, the method of communication was via the paperwork for that particular aircraft or component.

5.7 QUALITY CONTROL ISSUES.

Most respondents stated that they audit their vendors or suppliers at least once a year. In one instance, one respondent reported that they audit their primary vendors once every other year. This was dependent upon the scale and scope of work performed by the vendor. In most cases, if the vendor was considered one which was primary and performed substantial work, an audit was done on-site by a representative of the respondent. If the work was not considered substantial, a questionnaire was mailed out to be completed by the vendor.

Internal audits were reported as being completed daily by the quality assurance department at each repair station interviewed. A quality assurance department existed at all repair stations in the sample.

FAA audits were performed regularly on each of the repair stations in the sample. The frequency of these audits varied from once a month to once a year. The reasons for this difference in frequency depended upon the size of the facility and the relationship with the cognizant PMI. Variability was also reported as to the frequency of audits by clients, which ranged from never to once every few years. In some cases, the inspector was from CASE on behalf of the client. Three respondents stated that a new client usually inspected the facility. Occupational Safety and Health Administration (OSHA) was reported as another government agency that performed inspections, but none of the respondents claimed they did so frequently. Two respondents reported that they were audited by the JAA once every 1 to 2 years.

There was some variability as to the responsibility of returning the aircraft or component to service. Two repair stations reported that the airline for which they were performing work was involved in this process. A similar situation existed at one repair station for supplying parts. In this case, it was the responsibility of the client to determine part sourcing.

6. DEVELOPMENT OF RISK INDICATORS AND PERFORMANCE MEASURES.

6.1 INTRODUCTION.

Risk indicators provide a means to monitor the relative condition of an operation, while performance measures provide the means to rate the effectiveness of an operation. In the context of this study, risk indicators and performance measures should reflect the effectiveness of a repair station's operation. Ideally, the data required as input to the risk indicators and performance measures are already part of the FAA inspection process or can be gathered from readily available sources.

The analysis presented in the previous section provides the basis for developing the performance measures. The different areas of the repair station operation are identified by the respondents when seeking bids for work, and subsequently monitor, while a repair station is under contract. These items are then translated into risk indicators or performance measures.

6.2 IDENTIFICATION OF RISK INDICATOR AND PERFORMANCE MEASURES FOR REPAIR STATION OPERATION.

The interview results yielded three primary reasons an airline outsources to a repair station. These include less turnaround time to complete a particular task, lower and fixed cost, and less investment in labor and capital equipment (i.e., tooling and test equipment).

Based on the analysis, the areas of repair station operation that the respondents monitored can be grouped into three categories: capabilities, performance, and administration. Each category is discussed in greater detail below.

6.2.1 Capabilities of Repair Station Operation.

Obviously, it is important for a repair station to be able to deliver what was promised in its contracts. In other words, the repair station must actually possess the capabilities to deliver the services it says it is certified to perform. One respondent mentioned that while comparing bids for a contract, the evaluation of the bids focused on whether or not the repair station is operating within their FAA-approved capabilities. While most respondents stated that reputation guides this judgment, there are several points that can be measured to ensure that repair stations are operating within their capabilities.

In order for repair stations to operate within their capabilities, there are three components that can vary: labor, capital equipment, and certification of the repair station itself. Labor can vary in terms of number, years of experience, certifications, and qualifications. Labor may also be contracted from temporary labor services. All of these variables affect the performance of the work. Capital equipment can vary by the tooling and test equipment that the repair station possesses. In some cases, 14 CFR Part 145 clearly details what a repair station must possess. The regulation also explicitly states that personnel who operate this equipment must be properly trained. In terms of certification, the repair station must possess the proper rating to perform the work that they advertise as able to do. Ratings vary by aircraft types as well as particular sections of the aircraft.

Based on this scheme, table 6-1 identifies performance measures that quantify the capabilities of a repair station. The table includes the variable or unit that can be used as a data source, the significance of the performance measure related to repair station capabilities, the 14 CFR Part 145 reference for the performance measure, and the desirable range of values for the performance measure. Complete 14 CFR Part 145 references are listed in appendix B.

TABLE 6-1. PERFORMANCE MEASURES FOR REPAIR STATION CAPABILITIES

Performance Measure	Unit	Significance	14 CFR Reference	Criticality
Total number of employees	Number	Indicates ability to complete workload	145.39b	M
Technical personnel	Number	Indicates ability to complete workload	145.39b	M
Contract employees	Number	Possible lack of experience, training	145.43	M
Certificated employees	Number	Denotes qualification to legally perform work	145.43/ 65.89	M
Noncertificated personnel	Number	Denotes qualification to legally perform work	145.39a	M
Repairmen	Number	Denotes qualification to legally perform work	145.39d	M
Training of employees	List	Indicates qualifications of employees	145.43	H
Experience of employees	Average	Denotes expertise in area, stability of workforce	145.43	H
Tools and test equipment	List	Capability to legally perform work	145.49, 145.39	H
Ratings (Class, limited)	Number	Certification to perform work	145.31, 145.33	L
Length of certification	Years	Indicates experience of the operation	145.17	L
JAA listed	Y/N	Indicates ability of repair station to perform services in accordance with JAA	N/A	M

Most of these performance measures are based upon readily available data. Some of the data is already collected as part of FAA inspections.

6.2.2 Performance of Repair Station Operation.

Performance of repair station operation refers to the quality of work the repair station produces. While capabilities focus on what is possible for the repair station to do, performance focuses on what the repair station actually does. At a higher level, these attributes of a repair station are actually what the airlines monitor the most.

Based on this scheme, table 6-2 lists performance measures that relate to how well a repair station delivers on its work. The table includes the variable or unit that can be used as a data source, the significance of the performance measure related to repair station performance, the

14 CFR Part 145 reference for the performance measure, and the desirable range of values for the performance measure. Complete 14 CFR Part 145 references are listed in appendix B.

TABLE 6-2. PERFORMANCE MEASURES FOR REPAIR STATION PERFORMANCE

Performance Measure	Unit	Significance	14 CFR Reference	Criticality
Audit procedures in place	Y/N	Ability to detect and rectify errors in work	145.59, 145.63	H
Security measures	List	Possible security breach	145.35	L
Ability to meet turn times	Time diff.	May indicate working outside of capabilities	N/A	H
Number of work discrepancies	Number	May indicate poor performance	145.2	H
SUPs infractions	Number	Indicates poor suppliers of parts and parts tracking	145.45	H
Certification infractions	Number	Indicates repair station operating outside of its capabilities	145.31, 145.33	H
Legal actions	Number	Indicates possible difficulties in management	N/A	M
Number of contracts	Number	Indicates availability of repair station resources	145.39b	M

Data to support these performance measures may be more difficult to obtain in some cases. Many of these items are measured strictly by the airline and are considered proprietary information by both the airline and the repair station. In this case, it is unlikely that this data would be made publicly available or even made available to the FAA.

6.2.3 Performance of Repair Station Administration.

Administration of a repair station refers to the overall organization and operation of the repair station. Management issues are also included under this category.

Based on this scheme, table 6-3 lists performance measures that relate to repair station administration. The table includes the variable or unit that can be used as a data source, the significance of the performance measure related to repair station administration, the 14 CFR Part 145 reference for the performance measure, and the desirable range for the performance measure. Complete 14 CFR Part 145 references are listed in appendix B.

The data to support these performance measures will mostly be obtained from data sources outside current FAA inspections.

TABLE 6-3. PERFORMANCE MEASURES FOR REPAIR STATION ADMINISTRATION

Performance Measure	Unit	Significance	14 CFR Reference	Criticality
Discrepancies in billing	Number	Lack of attention to paperwork in other areas	N/A	L
Financial Status	Y/N	Bankruptcy is a problem; may indicate other larger problems	N/A	H
Employee turnover	Avg. exp Number of new emp.	May indicate lack of experience in certain areas	145.33	L
New employees	Number	Denotes growth of company; indicate potential training gaps	N/A	M
Wages	Dollar avg.	Lower wage, lower quality	N/A	L
Change in management	Y/N	May indicate change in procedures and focus of operations	145.43	H
Termination of contracts	Number	Possible inability to keep up with work	N/A	M

6.3 IDENTIFICATION OF PERFORMANCE MEASURES FOR AIRLINES WITH MAJOR CONTRACTS WITH REPAIR STATIONS.

As stated previously, the airline contracting a repair station for a major contract cannot simply state the specifications for the work and expect it to be completed in a satisfactory manner. The airline usually provides a fair amount of support to ensure proper completion of the job.

In analyzing the interview responses, it is apparent that there are certain actions that airlines take when outsourcing major maintenance. These primarily deal with how the airline provides oversight of the functions the repair station has been contracted to perform.

Table 6-4 lists the performance measures that are related to the airlines that may have an impact with repair station performance. The table includes the variable or unit that can be used as a data source, the significance of the performance, the 14 CFR Part 145 reference for the performance measure, and the desirable range of the performance measure. Complete 14 CFR Part 145 references are listed in appendix B.

The data to support these performance measures can be gathered from existing DOT and FAA sources or from FAA surveillance activities. For example, data to calculate the percent outsourced maintenance can be obtained from maintenance expense information provided by the air carriers to the DOT.

TABLE 6-4. PERFORMANCE MEASURES FOR AIRLINES WITH MAJOR CONTRACTS WITH REPAIR STATIONS

Performance Measure	Unit	Significance	14 CFR Reference
Percent Outsourced Maintenance	Dollar cost/ASM	Increased outsourced maintenance requires different organization structure	DOT Form 41 data
Company personnel at a repair station	Number	Airline oversight of operation	N/A
Use of foreign repair station	Y/N	Geographic location may require different oversight	N/A



7. SUMMARY AND CONCLUSIONS.

While the decision to outsource is primarily a cost-driven issue, the performance of the repair station ultimately dictates the cost savings to an airline. For example, while an airline may outsource heavier maintenance for a particular fleet type so as not to require investing in training personnel or obtaining the necessary tools and test equipment, savings may be offset by the loss of revenue due to cancelled flights because of poor quality work. Ultimately, factors related to the quality of work of the repair station dictate the cost savings.

There are over 3,000 repair stations currently operating in the United States. Due to the great deal of variability among these repair stations in terms of scale and scope of services offered, it is challenging to classify them into discrete categories. In addition, it is difficult to identify outsourcing practices of airlines. For example, a major airline that outsources auxiliary power unit overhauls will have a different arrangement with a repair station than does a start-up airline that outsources its heavy checks.

Likewise, it is difficult to provide boundary values for performance measures and risk indicators related to repair stations. In some cases, certain indicators may be normalized by expressing them as ratios (e.g., ratio of inspectors to workforce). Even then, complexity of the repair station may cause some variation in the interpretation of such a risk indicator.

The most important risk indicators and performance measures for each category include:

- Capability of Repair Station
 - Training of employees
 - Experience of employees
 - Tools and test equipment
- Performance of Repair Station
 - Audit procedures
 - Ability to meet turntimes
 - Number of discrepancies
 - SUPs infractions
 - Certification infractions
- Administration of Repair Station
 - Financial status
 - Change in management

Several other performance measures and risk indicators have been presented in this report. Many of them are correlated to one another. For example, number of certificated maintenance personnel and number of repairmen are different quantities, but they are highly related to one another considering the scope and scale of the work performed by a repair station. The relation of such measures is an area that requires further investigation.

While most of this information is collected by the FAA and other sources, the quality of the information may be questionable or not standardized. In addition, many of the performance measures are not directly obtainable since they are considered proprietary or confidential information. This further complicates the task of quantitatively rating repair station performance.

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APPENDIX A—INTERVIEW OUTLINES

Airline Interviews

Background Information

Size of Maintenance Operation

What is your total maintenance budget?

How is the budget subdivided?

For line service?

For scheduled checks?

For routine maintenance?

For non-routine maintenance?

What are the areas of major expenditures?

What does 80% of your budget consist of?

What percentage of the total budget is the maintenance budget?

What percent of the maintenance budget is outsourced?

Is there a limit as to how much maintenance can be outsourced?

If so, what is the limit, and who set it?

Typical maintenance functions outsourced

Which functions are likely to be outsourced?

Line service

Scheduled checks

Light (A,B)

Heavy checks (C,D)

Component/System Overhaul

Engine

Others?

Why are these functions outsourced?

Cost?

Special equipment/tooling required?

Special labor skills?

Others?

Outsourcing providers

What kinds of providers do you employ?

Repair Stations?

Component shops?

FBOs?

Other airlines?

Others?

Criteria for Third Party Maintenance Providers

Identifying potential providers

How do you identify potential providers?

- Research?
- CASE Audit?
- Advertisements?
- Request for bid?
- Interview/site visits?

Who do you consider the top-rated providers?

- For line service?
- For component overhaul?
- For engine shops?
- For heavy checks?
- Others?

Do you consider foreign repair stations the same as domestic ones?

- What are the differences between foreign and domestic repair stations?
- Do they require special oversight on your part?

Requirements of provider

Do you require special insurance coverage as part of the contract?

Do you consult the principal maintenance inspector of a potential provider?

- What type of information do you ask them?
- FAA actions?

Do you consider the make-up of the workforce?

- Union versus nonunion?
- If a school is connected to the provider?
- Certificated versus uncertificated?
- Percentage of certificated employees?
- Specialization (repairmen certificates)?
- Employee turnover?
- Workload?
- Wages?

How are regulations considered?

- EPA?
- OSHA?

What factors are considered for the aircraft while on site of the provider?

- Does the aircraft have to be kept in a hangar or can the work be performed outside?

Is security an issue?

Do you consider the financial status of the provider?

Credit check?

Solvency?

Requirements of contractor

Does the potential provider have any requirements of the contractor?

On-site personnel?

Documentation of aircraft?

Documentation of procedures?

Decision making process

What are the most important criteria in comparing bids from providers?

Cost

Performance

Guarantees

Awarding contracts

When a contract is awarded, what language is written into the contract to ensure performance of the provider?

What is the typical period of performance?

Number of aircraft the contract covers?

Is the contract ever modified?

Monitoring and Assessing Performance

Company Issues

How important is it to you if a contract maintenance facility is undergoing a change in management?

bankruptcy proceedings?

extensive growth?

Personnel

Are company personnel on-site at the third party provider?

If so, how large is the contract?

How many personnel?

Who are the personnel on-site?

Are the personnel on-site company employees?

What is their function while on-site?

If not, how is performance monitored?

Performance Measures

What data is collected from the provider, about the provider while under contract?

Physical/service oriented?

Economic?

Personnel?

Workload?

FAA actions?

What data would be useful to have, but is not collected?

What data is considered proprietary?

Which of the criteria used in deciding to award the contract to the provider is still monitored while the provider is under contract?

What documentation is required while the provider is under contract?

About the aircraft?

About procedures?

About compliance with company set policies?

About compliance with FAA regulations?

Other?

In what format is this documentation delivered?

Paper?

Electronic?

Other?

How is quality assurance monitored while the aircraft (or components of the aircraft) is at the facility of the provider?

How do you ensure proper materials are being used?

How do you ensure against suspected unapproved parts?

How do you ensure that established procedures are being followed?

Is the work of a provider audited?

If so, how?

Are there any special inspections or procedures that are completed after the aircraft has returned from the provider?

How is post delivery performance monitored?

Renewal of contract

What criteria are most important to evaluate when renewing a contract?

What criteria are least important when renewing a contract?

Termination of contract

For what reasons are a contract terminated?

Is a contract termination reported to the FAA or any other entity?

Oversight by Other Entities

CASE

How much do you rely on CASE audits for information about the performance of a third party provider?

What information do you still collect on your own?

Industry Groups

Do industry groups provide any guidance regarding outsourcing maintenance?

Do industry groups provide a forum in which to share information about repair stations and other third party providers?

FAA

How do you ensure compliance with FAA regulations?

Do you coordinate with the local PMI of the provider?

How are you involved if the FAA is conducting a routine or non-routine inspection of the providers facility?

Are you notified if the FAA pulls/revokes/suspends a 145 certificate? If yes, how soon?

Repair Station Interview

Background Information

Certification List (US) (checklist)

Non US Certifications and governing bodies held

Date of certification

Capacity (in terms of hangar space, ability to accommodate aircraft)

Number of employees (by certification)

Revenue generated (how do break this out?)

Makes of aircraft serviced

Components/systems serviced

Satellite locations (percent work within company divisions)

Geographic authorization

Non-certificated outside sources used and type of work?

Labor and Management Issues

Structure of operations

- How many shifts are currently scheduled?
- What are typical work hours?
- Is the workforce union or non-union?
- What is your average wage for personnel?
- What is your inspector to work-force ratio?

Qualifications of AMTs

- What percent of your workforce are certificated?
- What percent of your workforce is temporary?
- What is their typical experience, training, skills?
- How do you verify background?
- Is there a language requirement (English)?

Hiring AMTs

- What are sources of personnel (permanent)?
- What are sources of personnel (temporary)?
- What are the most important qualities for new AMTs?
 - Experience
 - Training
 - Certification

Promotion and retention of personnel

- What is the company policy on advancement into inspection/supervision?
- What training programs are provided?
- How do you track training or qualifications of personnel?

Turnover of labor and management

- Is there a shortage of personnel?
- What is the turnover rate of personnel? What are the reasons for this?
- How many open positions are there currently of
 - AMTs?
 - Inspectors?
 - Supervisors?
- How many management changes have occurred since being certified?

Certification/Regulatory Issues

- Differences between the manner maintenance is performed due to certification the work is being performed under?
- different customers?

Are documentation errors common?

Would a one manual concept between FAA/JAA increase quality and lessen documentation errors?

How often are inconsistent policy or regulatory interpretations made by the FAA or other cognizant agencies?

What are the most common difficulties?

Do you have any opinions regarding the proposed revision of FAR Part 145?

Can you suggest helpful changes in regulatory requirements?

What are the most controversial issues facing repair stations today?

What information could be provided by FAA or industry that would helpful to you?

Relationships with Clients

What is the typical contract period?

Have you ever terminated a contract prematurely?

Do you have any requirements of the client when under contract with them?

Do you require a representative from your client to be on-site?

If yes, when?

What is their function?

What information is passed between you and the client while under contract?

Use of Subcontractors

Do you use subcontractors?

In what instances?

What kinds of entities?

If uncertificated, in what instance?

How do you choose subcontractors?

How do you monitor their performance?

Do you ever consult their PMI?

Would your primary client ever be aware that you use a subcontractor?

Quality Control Issues

What are sources of technical information are available?

How do you reconcile documentation and/or procedures that may be different between clients or from company established procedures?

How many times are supplier/vendors audited?

Are they scheduled in advance?

What is the process for special audits?

How often are audits performed internally?

How is your quality assurance department organized?

What quality assurance systems in place?

SAE AS7103 and AS7104

ISO 9000

ASA 100

How often are you inspected by

FAA?

CASE?

Other government agencies?

Clients?

How is tracking of spare parts accomplished?

Please describe parts documentation system for the following:

Sources of parts

FAA Form 8130

JAA Form One

SUPs Detection

Parts scrapping programs

APPENDIX B—FAR PART 145 REFERENCES

(Note: This is the version of FAR Part 145 that is current as of February 28, 2002.)

Sec. 145.2 Performance of maintenance, preventive maintenance, alterations and required inspections for an air carrier or commercial operator under the continuous airworthiness requirements of Parts 121 and 127, and for airplanes under the inspection program required by Part 125.

(a) Each repair station that performs any maintenance, preventive maintenance, alterations, or required inspections for an air carrier or commercial operator having a continuous airworthiness program under Part 121 or Part 127 of this chapter shall comply with Subpart L of Part 121 (except Secs. 121.363, 121.369, 121.373, and 121.379) or Subpart I of Part 127 (except Secs. 127.131, 127.134, 127.136, and 127.140) of this chapter, as applicable. In addition, such repair station shall perform that work in accordance with the air carrier's or commercial operator's manual.

(b) Each repair station that performs inspections on airplanes governed by Part 125 of this chapter shall do that work in accordance with the inspection program approved for the operator of the airplane.

[Amdt. 145-7, 31 FR 10614, Aug. 9, 1966, as amended by Amdt. 145-17, 45 FR 67235, Oct. 9, 1980]

Sec. 145.31 Ratings.

The following ratings are issued under this subpart:

(a) Airframe ratings. (1) Class 1: Composite construction of small aircraft.

(2) Class 2: Composite construction of large aircraft.

(3) Class 3: All-metal construction of small aircraft.

(4) Class 4: All-metal construction of large aircraft.

(b) Powerplant ratings. (1) Class 1: Reciprocating engines of 400 horsepower or less.

(2) Class 2: Reciprocating engines of more than 400 horsepower.

(3) Class 3: Turbine engines.

(c) Propeller ratings. (1) Class 1: All fixed pitch and ground adjustable propellers of wood, metal, or composite construction.

(2) Class 2: All other propellers, by make.

(d) Radio ratings. (1) Class 1: Communication equipment: Any radio transmitting equipment or receiving equipment, or both, used in aircraft to send or receive communications in flight, regardless of carrier frequency or type of modulation used; including auxiliary and related aircraft interphone systems, amplifier systems, electrical or electronic inter-crew signaling devices, and similar equipment; but not including equipment used for navigation of the aircraft or as an aid to navigation, equipment for

measuring altitude or terrain clearance, other measuring equipment operated on radio or radar principles, or mechanical, electrical, gyroscopic, or electronic instruments that are a part of communications radio equipment.

(2) Class 2: Navigational equipment: Any radio system used in aircraft for en route or approach navigation, except equipment operated on radar or pulsed radio frequency principles, but not including equipment for measuring altitude or terrain clearance or other distance equipment operated on radar or pulsed radio frequency principles.

(3) Class 3: Radar equipment: Any aircraft electronic system operated on radar or pulsed radio frequency principles.

(e) Instrument ratings. (1) Class 1: Mechanical: Any diaphragm, bourdon tube, aneroid, optical, or mechanically driven centrifugal instrument that is used on aircraft or to operate aircraft, including tachometers, airspeed indicators, pressure gauges drift sights, magnetic compasses, altimeters, or similar mechanical instruments.

(2) Class 2: Electrical: Any self-synchronous and electrical indicating instruments and systems, including remote indicating instruments, cylinder head temperature gauges, or similar electrical instruments.

(3) Class 3: Gyroscopic: Any instrument or system using gyroscopic principles and motivated by air pressure or electrical energy, including automatic pilot control units, turn and bank indicators, directional gyros, and their parts, and flux gate and gyrosyn compasses.

(4) Class 4: Electronic: Any instruments whose operation depends on electron tubes, transistors, or similar devices including capacitance type quantity gauges, system amplifiers, and engine analyzers.

(f) Accessory ratings. (1) Class 1: Mechanical accessories that depend on friction, hydraulics, mechanical linkage, or pneumatic pressure for operation, including aircraft wheel brakes, mechanically driven pumps, carburetors, aircraft wheel assemblies, shock absorber struts and hydraulic servo units.

(2) Class 2: Electrical accessories that depend on electrical energy for their operation, and generators, including starters, voltage regulators, electric motors, electrically driven fuel pumps magnetos, or similar electrical accessories.

(3) Class 3: electronic accessories that depend on the use of an electron tube transistor, or similar device, including supercharger, temperature, air conditioning controls, or similar electronic controls.

Sec. 145.33 Limited ratings.

(a) Whenever the Administrator finds it appropriate, he may issue a limited rating to a domestic repair station that maintains or alters only a particular type of airframe, powerplant, propeller, radio, instrument, or accessory, or parts thereof, or performs only specialized maintenance requiring equipment and skills not ordinarily found in regular repair stations. Such a rating may be limited to a specific model aircraft, engine,

or constituent part, or to any number of parts made by a particular manufacturer.

(b) Limited ratings are issued for--

- (1) Airframes of a particular make and model;
- (2) Engines of a particular make and model;
- (3) Propellers of a particular make and model;
- (4) Instruments of a particular make and model;
- (5) Radio equipment of a particular make and model;
- (6) Accessories of a particular make and model;
- (7) Landing gear components;
- (8) Floats, by make;
- (9) Nondestructive inspection, testing, and processing;
- (10) Emergency equipment;
- (11) Rotor blades, by make and model;
- (12) Aircraft fabric work; and
- (13) Any other purpose for which the Administrator finds the applicant's request is appropriate.

(c) For a limited rating for specialized services, the operations specifications of the station shall contain the specification used in performing that specialized service. The specification may either be a civil or military one that is currently used by industry and approved by the Administrator or one developed by the applicant and approved by the Administrator.

Sec. 145.35 Housing and facility requirements.

(a) An applicant for a domestic repair station certificate and rating, or for an additional rating, must comply with paragraphs (b) to (h) of this section and provide suitable--

- (1) Housing for its necessary equipment and material;
- (2) Space for the work for which it seeks a rating;
- (3) Facilities for properly storing, segregating, and protecting materials, parts, and supplies; and
- (4) Facilities for properly protecting parts and subassemblies during disassembly, cleaning, inspection, repair, alteration, and assembly;

so that work being done is protected from weather elements, dust, and heat; workers are protected so that the work will not be impaired by their physical efficiency; and maintenance operations have efficient and proper facilities.

(b) The applicant must provide suitable shop space where machine tools and equipment are kept and where the largest amount of bench work is done. The shop space need not be partitioned but machines and equipment must be segregated whenever--

- (1) Machine or woodwork is done so near an assembly area that chips or material might inadvertently fall into assembled or partially assembled work;

- (2) Unpartitioned parts cleaning units are near other operations;
 - (3) Fabric work is done in an area where there are oils and greases;
 - (4) Painting or spraying is done in an area so arranged that paint or paint dust can fall on assembled or partially assembled work;
 - (5) Paint spraying, cleaning, or machining operations are done so near testing operations that the precision of test equipment might be affected;
- and
- (6) In any other case the Administrator determines it is necessary.
 - (c) The applicant must provide suitable assembly space in an enclosed structure where the largest amount of assembly work is done. The assembly space must be large enough for the largest item to be worked on under the rating he seeks and must meet the requirements of paragraph (a) of this section.
 - (d) The applicant must provide suitable storage facilities used exclusively for storing standard parts, spare parts, and raw materials, and separated from shop and working space. He must organize the storage facilities so that only acceptable parts and supplies will be issued for any job, and must follow standard good practices for properly protecting stored materials.
 - (e) The applicant must store and protect parts being assembled or disassembled, or awaiting assembly or disassembly, to eliminate the possibility of damage to them.
 - (f) The applicant must provide suitable ventilation for his shop, assembly, and storage areas so that the physical efficiency of his workers is not impaired.
 - (g) The applicant must provide adequate lighting for all work being done so that the quality of the work is not impaired.
 - (h) The applicant must control the temperature of the shop and assembly area so that the quality of the work is not impaired. Whenever special maintenance operations are being performed, such as fabric work or painting, the temperature and humidity control must be adequate to insure the airworthiness of the article being maintained.

Sec. 145.39 Personnel requirements.

- (a) An applicant for a domestic repair station certificate and rating, or for an additional rating, must provide adequate personnel who can perform, supervise, and inspect the work for which the station is to be rated. The officials of the station must carefully consider the justifications and abilities of their employees and shall determine the abilities of its uncertificated employees performing maintenance operations on the basis of practical tests or employment records. The repair station is primarily responsible for the satisfactory work of its employees.
- (b) The number of repair station employees may vary according to the type and volume of its work. However, the applicant must have enough properly qualified employees to keep up with the volume of work in process, and may

not reduce the number of its employees below that necessary to efficiently produce airworthy work.

(c) Each repair station shall determine the abilities of its supervisors and shall provide enough of them for all phases of its activities. However, the Administrator may determine the ability of any supervisor by inspecting his employment and experience records or by a personal test. Each supervisor must have direct supervision over working groups but need not have over-all supervision at management level. Whenever apprentices or students are used in working groups on assemblies or other operations that might be critical to the aircraft, the repair station shall provide at least one supervisor for each 10 apprentices or students, unless the apprentices or students are integrated into groups of experienced workers.

(d) Each person who is directly in charge of the maintenance functions of a repair station must be appropriately certificated as a mechanic or repairman under Part 65 of this chapter and must have had at least 18 months of practical experience in the procedures, practices, inspection methods, materials, tools, machine tools, and equipment generally used in the work for which the station is rated. Experience as an apprentice or student mechanic may not be counted in computing the 18 months of experience. In addition, at least one of the persons so in charge of maintenance functions for a station with an airframe rating must have had experience in the methods and procedures prescribed by the Administrator for returning aircraft to service after 100-hour, annual, and progressive inspections.

(e) Each limited repair station shall have employees with detailed knowledge of the particular maintenance function or technique for which it is rated, based on attending a factory school or long experience with the product or technique involved.

Sec. 145.43 Records of supervisory and inspection personnel.

(a) Each applicant for a domestic repair station certificate and rating, or for an additional rating, must have, and each certificated domestic repair station shall maintain, a roster of--

(1) Its supervisory personnel, including the names of the officials of the station that are responsible for its management and the names of its technical supervisors, such as foreman and crew chiefs; and

(2) Its inspection personnel, including the names of the chief inspector and those inspectors who make final airworthiness determinations before releasing an article to service.

(b) The station shall also provide a summary of the employment of each person whose name is on the roster. The summary must contain enough information as to each person on the roster to show compliance with the experience requirements of this subpart, including--

(1) His present title (e.g., chief inspector, metal shop foreman, etc.);

(2) His total years of experience in the type of work he is doing;

(3) His past employment record, with names of places and term of employment by month, and year;

(4) The scope of his present employment (e.g., airframe overhaul, airframe final assembly, engine inspection, department, etc.); and

(5) The type and number of the mechanic or repairman certificate that he holds, and the ratings on that certificate.

(c) The station shall change the roster, as necessary, to reflect--

(1) Terminating the employment of any person whose name is on the roster;

(2) Assigning any person to duties that require his name to be carried on the roster; or

(3) Any appreciable change in the duties and scope of assignment of any person whose name is on the roster.

(d) The station shall keep the roster and employment summaries required by this section, subject to inspection by the Administrator upon his request.

(e) A domestic repair station may not use the services of a person directly in charge of maintenance or alteration unless it keeps current records on him as required by this section.

[Doc. No. 1157, 27 FR 6662, June 13, 1962, as amended by Amdt. 145-5, 31 FR 8585, June 21, 1966; Amdt. 145-15, 41 FR 47230, Oct. 28, 1976]

Sec. 145.49 Equipment and materials: Limited rating.

(a) An applicant for a limited rating (other than specialized services) under Sec. 145.33, must have the equipment and materials to perform any job function appropriate to the rating and class specified in Sec. 145.47 for the rating he seeks. However, he need not be equipped for a function that does not apply to the particular make or model article for which he seeks a rating, if he shows that it is not necessary under the recommendations of the manufacturer of the article.

(b) An applicant for a rating for specialized services or techniques under Sec. 145.33 must--

(1) For magnetic and penetrant inspection, have the equipment and materials for wet and dry magnetic inspection techniques, residual and continuous methods, and portable equipment for the inspection of welds both on and off the aircraft;

(2) For emergency equipment maintenance, have the equipment and materials to perform inspections, repairs, and tests of all kinds of inflated equipment, the re-packing, re-marking, re-sealing, and re-stocking of life rafts, and the weighing, refilling, and testing of carbon dioxide fire extinguishers and oxygen containers;

(3) For rotor blade maintenance, have the equipment, materials, and technical data recommended by the manufacturer; and

(4) For aircraft fabric work, have the equipment and materials to apply protective coatings to structures, machine stitch fabric panels, perform covering, sewing, and rib stitching operations, apply dope and paint using

temperature and humidity control equipment, install patches, grommets, tapes, hooks, and similar equipment, and refinish entire aircraft and aircraft parts.

Sec. 145.45 Inspection systems.

(a) An applicant for a repair station certificate, and rating or for an additional rating, must have an inspection system that will produce satisfactory quality control and conform to paragraphs (b) to (f) of this section.

(b) The applicant's inspection personnel must be thoroughly familiar with all inspection methods, techniques, and equipment used in their specialty to determine the quality or airworthiness of an article being maintained or altered. In addition, they must--

(1) Maintain proficiency in using various inspection aids intended for that purpose;

(2) Have available and understand current specifications involving inspection tolerances, limitations, and procedures established by the manufacturer of the product being inspected and with other forms of inspection information such as FAA airworthiness directives and bulletins; and

(3) In cases where magnetic, fluorescent, or other forms of mechanical inspection devices are to be used, be skilled in operating that equipment and be able to properly interpret defects indicated by it.

(c) The applicant must provide a satisfactory method of inspecting incoming material to insure that, before it is placed in stock for use in an aircraft or part thereof, it is in a good state of preservation and is free from apparent defects or malfunctions.

(d) The applicant must provide a system of preliminary inspection of all articles he maintains to determine the state of preservation or defects. He shall enter the results of each inspection on an appropriate form supplied by it and keep the form with the article until it is released to service.

(e) The applicant must provide a system so that before working on any airframe, powerplant, or part thereof that has been involved in an accident, it will be inspected thoroughly for hidden damage, including the areas next to the obviously damaged parts. He shall enter the results of this inspection on the inspection form required by paragraph (d) of this section.

(f) At the time he applies for a repair station certificate, the applicant must provide a manual containing inspection procedures, and thereafter maintain it in current condition at all times. The manual must explain the internal inspection system of the repair station in a manner easily understood by any employee of the station. It must state in detail the inspection requirements in paragraphs (a) to (e) of this section, and the repair station's inspection system including the continuity of inspection responsibility, samples of inspection forms, and the method of executing them. The manual must refer whenever necessary to the manufacturer's

inspection standards for the maintenance of the particular article. The repair station must give a copy of the manual to each of its supervisory and inspection personnel and make it available to its other personnel. The repair station is responsible for seeing that all supervisory and inspection personnel thoroughly understand the manual.

[Doc. No. 1157, 27 FR 6662, June 13, 1962, as amended by Amdt. 145-15, 41 FR 47230, Oct. 28, 1976]