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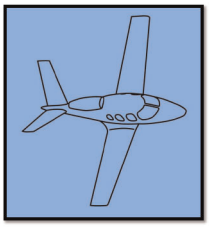

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Enhanced, Risk-Based FAA Oversight on Part 145 Maintenance Practices: A Qualitative Study

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Abstract

The purpose of this qualitative study was to examine the phenomenon of enhanced, risk-based Federal Aviation Administration (FAA) oversight of Part 145 repair stations in Oklahoma that performed aircraft maintenance for Part 121 air carriers. Specifically, this research was utilized to explore the lived (personal) experiences of Part 145 repair station managers concerning operational changes in air carrier maintenance practices. The researchers' intent was not to examine the effectiveness of changes implemented by the FAA; instead, to explore how management has experienced the enhanced changes in their Oklahoma-based Part 145 repair stations. Forty-two percent of the participants indicated a weak FAA oversight system that has hindered the continuous process improvement program in repair stations. Some of them were financially burdened after hiring additional full-time quality assurance inspectors to specifically manage enhanced FAA oversight. Notwithstanding, the participants of the study indicated that the FAA must apply its surveillance on a more standardized and consistent basis. They want to see standardization in how FAA inspectors interpret regulations and practice the same quality of oversight for all repair stations, particularly those that are repeat violators and fail to comply with federal aviation regulations. The participants believed that when the FAA enforces standardization on a consistent basis, repair stations can become more efficient and safer in the performance of their scope of work for the U.S. commercial air transportation industry.

Keywords: FAA, Part 145 repair stations, aviation maintenance

Introduction

A safe and trustworthy air transportation system is important for America's national security and economic success. The United States (U.S.) air transportation industry suffered a series of financial setbacks as a result of the 9/11 terrorist attacks, the Afghanistan and Iraq conflicts, and a sporadic U.S. economy; resulting in the escalation of jet fuel expenses and even higher costs of conducting in-house air carrier maintenance (Richardson, Park, Moore, & Pan, 2014). Experts estimated monetary losses in the U.S. air carrier industry between 2000 and 2009 were $54 billion (Borenstein, 2011; GAO, 2009). Those losses caused many U.S. air carrier managers to change their operational strategies by outsourcing all or most of their aircraft maintenance to Part 145 repair station industry and non-certificated repair facilities (Al-kaabi, Potter, & Naim, 2007).

Over 70% of U.S. air carrier maintenance has been outsourced to Part 145 repair stations, also known as maintenance, repair, and overhaul (MRO) facilities, to perform airline maintenance at a lower cost (Williams, 2012). Part 145 repair

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stations are aviation maintenance facilities that have been certified by the Federal Aviation Administration (FAA) under Title 14, Aeronautics and Space, Code of Federal Regulation (CFR) Part 145 (GPO, 2015). Outsourcing maintenance to repair stations and noncertified facilities has become economically viable for the success of the airline industry based on affordability; it has saved the airline industry up to 67% in (labor) costs (GPO, 2012; McFadden & Worrells, 2012; OIG, 2005).

The management concept behind the benefits of a FAA certificated Part 145 repair station is the perception that it will perform superior maintenance in comparison to a non-FAA certificated facility. However, it has been mostly Part 145 repair stations (not uncertificated facilities) that have been responsible for several airline mishaps due to outsourced maintenance errors (McFadden & Worrells, 2012). These mishaps have created national debate about the FAA and its ability to provide adequate oversight on those repair stations that pose the greatest safety risks.

Statement of the Problem

During the late 1990s, significant safety concerns ignited a national debate after a ValuJet DC-9 crashed in the Florida Everglades. Accident investigators discovered that ValuJet outsourced its aircraft maintenance to SabreTech, a repair station maintenance contract provider; SabreTech contractors were the primary contributors of the mishap. SabreTech failed to properly prepare, package, and identify unexpended oxygen generators (hazardous material) before placing them in the ValuJet's cargo compartment that led to an in-flight fire and subsequent crash (GAO, 1997). Aviation critics have stressed that additional FAA oversight is needed at Part 145 repair stations that perform outsourced aircraft maintenance for U.S. air carriers (McFadden & Worrells, 2012). After 9/11, many air carriers outsourced their in-house maintenance to repair station contractors to reduce operational (labor) costs, resulting in the occurrence of additional mishaps and incidents. This alarming trend has given rise to concerns about decreased levels of safety in the U.S. commercial aviation industry (GAO, 1997; McCartney, 2004; OIG, 2013).

Background and Significance of the Problem

The U.S. air carrier industry has experienced long-term financial hardships since the 9/11 2001 terrorist attacks, ensuing wars in Afghanistan and Iraq, and high jet fuel costs (Richardson et al., 2014). As a result, Borenstein (2011) said the air carrier industry lost billions of dollars of revenue between 2000 and 2009. These events have prompted U.S. air carriers to outsource their in-house maintenance to contract maintenance providers (Part 145 repair stations and non-certificated repair facilities) in excess of 70% (Williams, 2012). McCartney (2004) and McFadden and Worrells (2012) said that even though airlines have become more reliant upon repair stations to perform outsourced maintenance to reduce labor costs by 67%, the FAA has not increased its surveillance across the full spectrum of repair station and non-certificated repair facility operations (GAO, 1997; GPO, 2012; OIG, 2007, 2010, 2013).

By 1997, the Government Accounting Office (GAO), a governmental watchdog agency over the FAA, discovered that FAA inspectors used outdated regulations to evaluate repair stations with concepts that were developed during the infancy of the aviation industry. The GAO discovered that since 1962, federal regulations had not been properly updated to reflect airframe, powerplant, and component design changes to include alteration concepts and new technology. They also identified 86 out of 86 (100%) FAA safety inspectors who admitted that they used outdated regulations to inspect contract maintenance providers at Part 145 repair stations. These findings, as well as other safety concerns, prompted the FAA to spend over $30 million to develop the Air Transportation Oversight System (ATOS) as its new surveillance program to improve the oversight of repair stations (GAO, 1997; McFadden & Towell, 1999; OIG, 2002, 2003). The purpose for ATOS was to spot safety trends before accidents occur, as well as creating inspection plans specific to an airline's strengths and weaknesses.

In October 1998, the FAA began implementing ATOS in the U.S. aviation maintenance industry, focusing inspections on the areas of highest risk (OIG, 2003). An area of high risk could be a repair station that has repeat violations or performs maintenance on flight safety sensitive components such as engines or flight controls that—if repaired, rigged, or overhauled incorrectly—could result in an aircraft mishap.

Five years later during 2003, the FAA's inadequate oversight of contract maintenance providers was apparent again after the Office of Inspector General (OIG), another governmental watchdog agency over the FAA, discovered 18 out of 21 (86%) repair stations that had repeat findings, improper parts, and faulty equipment, partially due to inadequate FAA oversight. In response to this (2003) OIG report, the FAA began to create and implement a new risk-based process intended to provide comprehensive and standardized oversight of repair stations. However, even though the FAA moved its safety oversight toward a risk-based process, it still relied too heavily on air carriers' oversight procedures, which was not always sufficient.

Since implementing risk-based oversight process, the FAA developed a tool for inspectors, called the Repair Station Assessment Tool (RSAT). Initiated in 2007, the RSAT, while developed as an enhancement to assist inspectors with planning surveillance and analyzing risk, has resulted in limited effectiveness due to its original design. Thus, inspectors can only complete the RSAT once a year and

cannot update changes in risk assessments until the following year. As a result, the RSAT has not proven useful for the inspectors attempting to monitor changes in risk levels occurring throughout the year; it has hindered the FAA's ability to conduct effective risk-based oversight (OIG, 2013).

Purpose of Study

Even after the efforts of the FAA in implementing new surveillance and risk-based oversight processes, three additional U.S. air carrier mishaps occurred between 2000 and 2003 due to outsourced maintenance errors. Trends analysis data by the FAA have indicated the possibility of future mishaps based on 34 air carrier flights that resulted in declared emergency landings after engine and landing gear malfunctions due to outsourced maintenance errors; those errors were considered widespread after 19 declared emergency landings from engine failures and 15 landing gear malfunctions between 2007 and 2014 (FAA, 2015a).

The OIG has continued to uncover systematic and repeat findings concerning unsafe maintenance practices (inadequate training and maintenance, and improper equipment and parts) by contract maintenance providers due to inadequate FAA oversight (OIG, 2013). Nevertheless, airlines are legally responsible by federal regulations for their aircraft deemed not airworthy, even if the maintenance was performed by contractors (GPO, 2015).

Even though the FAA has made attempts to upgrade its safety oversight with a risk-based system (ATOS) and an assessment tool (RSAT) to further enhance the risk-based oversight process (Table 1), the FAA has continued to place more emphasis on in-house airline maintenance facilities, where less than 30% of the maintenance has been accomplished, in comparison to the 70% that was outsourced to other (external) repair facilities.

There is no literature concerning the personal experiences of Part 145 repair station managers who have overseen outsourced U.S. air carrier maintenance in Oklahoma after the FAA changed procedures with its risk-based oversight system in 2007. Therefore, the purpose of this study was to explore the actual (professional) experience of Part145 repair station managers concerning changes in outsourced Part 121 air carrier maintenance practices between 2007 and 2014 after the FAA enhanced its risk-based oversight system in 2007.

The researchers' intent was not to examine the effectiveness of changes implemented by the FAA or to conduct an inquiry of non-certificated repair facilities; instead, it was to explore how management has experienced the enhanced changes in their Oklahoma-based Part 145 repair stations.

Methodology

Since the methodology of this study consisted of a qualitative field study, a small sample of managers from the Oklahoma Part 145 repair station industry were interviewed with seven semi-standardized, open-ended questions (Appendix A). The interview questions were used to generate data and comprehend the intricacies of enhanced, risk-based FAA oversight and outsourced maintenance practices at repair stations.

Research Question

The central research question of this study consisted of the following: What are the actual (professional) experiences of Part 145 repair station managers in Oklahoma

Table 1
Overview of FAA's risk-based oversight system.

Initiative	Narrative	Initiated
Risk-based oversight system (ATOS)	An FAA risk-based system arranged by data analysis (U.S. air carrier operations and maintenance data) to focus on oversight areas that pose the greatest safety risks to effectively maximize the agency's use of limited inspection resources.	1998
Enhanced, risk-based oversight system (RSAT)	The FAA enhanced its risk-based system with a risk assessment tool to aid in the surveillance of U.S. repair stations that perform outsourced aircraft maintenance for the U.S. air carrier industry.	2007[a]

Notes. Prior to 1998, the FAA inspection program was compliance-based and did not focus on risks. During 2015, the FAA started replacing ATOS with its new Safety Assurance System (SAS) in an attempt to correct the administration's flawed oversight system of the U.S. air transportation system. As of 2015, there were 474 Part 145 repair stations in Europe that performed work on U.S. registered aircraft and components. The FAA has not provided adequate training for its inspectors to conduct surveillance at European repair stations with foreign authorities. Adapted from "Advancing FAA's Risk-Based Oversight Systems" by the Office of Inspector General, 2002, *FAA Oversight of Passenger Aircraft Maintenance*, Report Number: CC-2002-146, p. 7; "FAA Developed Risk-Based Inspection Tools, but the Tools Are Ineffective and Inspectors Do Not Use Them" and "Agency Comments and Office of Inspector General Response" by the Office of Inspector General, 2013, *FAA Continues to Face Challenges in Implementing a Risk-Based Approach for Repair Station Oversight*, OIG Report Number: AV-2013-073, pp. 6 and 16; and "FAA's Monitoring of EU-Based Repair Stations is Impeded by Training, Procedural, and Data Quality Weaknesses" by the Office of Inspector General, 2015, *FAA has not Implemented Repair Station Oversight in the European Union*, OIG Report Number: AV-2015-066, p. 8.

[a]Since 2007, the FAA has incorporated a risk assessment tool known as the Repair Station Assessment Tool (RSAT) to enhance the risk-based oversight process.

concerning changes in outsourced Part 121 air carrier maintenance practices between 2007 and 2014 after the FAA enhanced its risk-based oversight system in 2007?

Sample and Population

The FAA is responsible for the safety oversight of 4,062 U.S. Part 145 repair stations (OIG, 2013). Of those 4,062 repair stations, 127 are located in Oklahoma where approximately 42 (33%) provide MRO services for the U.S. airline industry (FAA, 2015b). Part 145 repair station managers who oversaw outsourced aircraft maintenance for domestic air carriers were randomly sampled and interviewed from the pool of 127 repair stations in Oklahoma. These managers normally have the highest level of knowledge of the organization and interaction between FAA inspectors and their repair station employees.

The researchers utilized the Stat Trek website as an analytical tool to generate a table of 127 random numbers (Stat Trek, 2015). Next, the snowball sampling method was utilized to select Part 145 repair station managers who had at least five years of experience overseeing outsourced Part 121 air carrier maintenance. The researcher randomly sampled and interviewed managers from a pool of 127 repair stations in Oklahoma where they performed high-risk outsourced air carrier maintenance on various airframe, powerplant, radio, instrument and accessory components, and metal plating; data saturation occurred with the twelfth participant of the study.

Dawson (2009) said a sample size should be limited to a saturation point when no new explanations or ideas have appeared from the study. Saturation occurs when repetition of the data from multiple sources of data becomes apparent with repetition in the information obtained and with confirmation of previously collected data. The twelve repair station managers interviewed provided the level of repetition and saturation necessary to adequately address the seven open-ended interview questions, as well as the central research question of this study.

Instrumentation for Data Collection

The primary instrument used to gather data for this study consisted of semi-structured, open-ended questions. These interview questions were created to specifically probe the participants for their actual (professional) experience of enhanced, risk-based FAA oversight. Before interviews could be conducted, the researchers employed the Delphi method. It consisted of questionnaires to evaluate the clarity of the research questions by a panel of three experts (Table 2) from the FAA, Part 145 repair station industry, and Oklahoma Aeronautics Commission.

The Delphi method was used to research and gather expert opinions for rich details through the experts' voices (Boje & Murnighan, 1982; Delbecq, Van de Ven, & Gustafson, 1975; Patton, 2015). In this study, the Delphi method consisted of three rounds with three expert panelists who reviewed, revised, and authenticated the open-ended research questions. Round one involved the preliminary feedback by these experts to validate if the research questions would clearly invoke an open-ended response. Round two resulted in several revisions by the panelists to streamline the research questions, resulting in 42% of the questions being eliminated or streamlined. Round three was the final session. All three panelists agreed the remaining seven research questions were sufficient for the study and would clearly evoke an open-ended response by participants of the study.

Table 2
Expert panelists.

Name	Aerospace Experience in Oklahoma	Total Years
Panelist 01	Part 145 repair station quality director 13 years in RS 27 years in aviation	27
Panelist 02	FAA FSDO ASI 12 years in FAA 20 years in aviation	20
Panelist 03	Oklahoma Aeronautics Commissioner 5 years in OAC 42 years in aviation	42

Notes. RS = Repair station. FSDO = Flight Standard District Office. ASI = aviation safety inspector. OAC = Oklahoma Aeronautics Commission. Panelists 01, 02, and 03 had extensive experience, knowledge, and training related to aircraft maintenance management and human factors; thus, they were considered experts in their current occupations. Panelists 01 and 02 had significant knowledge of Part 121 air carrier and Part 145 repair station operations while Panelist 03 had limited knowledge of Part 121 and Part 145 to increase the likelihood of a non-biased view of the FAA and repair stations under FAA security. Panelist 03 was a governor-appointed Oklahoma Aeronautics Commissioner who had extensive knowledge of aerospace management concepts to include aeronautical safety and development and frequent coordination with the FAA to develop a national system of civil aviation.

Validity and Reliability of the Study

Triangulation was used in a four-step process to increase the validity and confidence of this study. Patton (2015) found that triangulation will strengthen a study by combining methods, as well as used to improve the trustworthiness of a researcher's analysis. Step one involved the investigator triangulation of three expert aviation members who investigated, revised, and authenticated the research questions. Step two consisted of a mock interview with a quality director at a Part 145 repair station in Oklahoma. The purpose of a mock interview was to receive additional feedback to increase the credibility of the data (Seidman, 2006). Step three was comprised of the data triangulation of one GAO audit report and 11 OIG audit reports, 12 participant interviews, four NTSB accident reports, and the Accident and Incident Data System (AIDS) and Aviation Safety Information Analysis and Sharing (ASIAS) database. Step four consisted of investigator triangulation with three triangulating

analysts (researcher, and evaluators A and B) and one peer reviewer to evaluate the consistency of the data.

Findings

Demographics

Table 3 briefly lists the professional background of the 12 participants from the repair station industry in Oklahoma.

Repair Station Participant Analysis

Interview Question 1 (IQ1). How long have you been associated or employed with the Part 145 repair station industry? The first interview question illustrates the years of professional experience each manager had in the Part 145 repair station industry. The quality of participant background and professional experience are directly related to the ability to obtain meaningful data for the study. The years of experience for each manager ranged between 7 and 40 years, with an average of 20 years for the 12 participants (Table 4).

Interview Question 2 (IQ2). What changes in Part 145 repair station aircraft maintenance practices have you observed before the FAA's implementation of its enhanced, risk-based oversight system in 2007? As the participants shared their professional experiences, an overwhelming majority of the participants (92%) indicated an unfavorable response with inconsistent levels of standards among FAA inspectors. The primary finding of this interview question specified that the FAA did not consistently apply a standardized surveillance process within the Part 145 repair station industry before 2007.

According to participants RSM01 and RSM06, the FAA failed to incorporate a standardized process to conduct routine repair station audits with checklists that would have facilitated a clear and structured inspection agenda. Participant RSM04 said the quality of FAA audits was lacking in comparison to primary legacy air carrier audits. FAA inspectors, according to participant RSM05, had placed less emphasis on human factors training before 2007 while participant RSM02 stated how Part 145 did not depend on

Table 4
Participants: Number of years in repair station.

Years	No. of Participants	Percentage
5–10	1	8%
11–15	4	33%
16–20	3	26%
21+	4	33%

Table 3
Repair station managers.

RSM Participants			Education	Military	Aerospace Experience	Employees
Name	M/F	Cert	Degree	Br, Rnk, Per	(Executive Managers)	Total
RSM 01	M	A&P		U.S. Army	Quality director 13 years in RS 27 years in aviation	571
RSM 02	M	A&P		U.S. Air Force (contractor)	Accountable manager 40 years in RS 50 years in aviation	32
RSM 03	F	A&P	BS - Av Mgmt	U.S. Army major	Accountable manager 7 years in RS 21 years in aviation	5
RSM 04	M		BS - Mech Eng		Accountable manager 20 years in RS 28 years in aviation	50
RSM 05	M	A&P	BS - HR		Accountable manager 20 years in RS 28 years in aviation	4
RSM 06	F	A&P	BS - Acct		Quality director 16 years in RS 16 years in aviation	31
RSM 07	M	A&P	BS - Bus Admin		Accountable manager 13 years in RS 29 years in aviation	5018
RSM 08	M	RM			Quality director 22 years in RS 40 years in aviation	93
RSM 09	M				Quality director 11 years in RS 30 years in aviation	561
RSM 10	M			U.S. Navy PO2 6 years	Quality director 12 years in RS 30 years in aviation	63
RSM 11	M	A&P	MBA	U.S Air Force 4 years	Accountable manager 20 years in RS 39 years in aviation	322
RSM 12	M	A&P			Accountable manager 35 years in RS 35 years in aviation	7

Notes. Accountable manager = a designated (FAA mandated) duty position at Part 145 repair stations. RSM = repair station manager. A&P = Airframe & Powerplant certified mechanic rating by the FAA. RM = Repairman mechanic rating from the FAA. MBA = master of business administration. BS = bachler of science. RS = repair station. HR = human resource. AV Mgmt = aviation management. Mech Eng = mechanical engineer. Cert = Federal Aviation Administration Certificate. Bus Admin = business administration. Serv = service. Yrs = years. PO2 = Petty Officer Second Class. Br = branch (military affiliation). Rnk = rank (military rank). Per = period (military term of service).

other supporting documents such as Federal Aviation Regulation Part 43 that provides additional maintenance and preventive maintenance regulations.

Six of the participants (RSM06, RSM08, RSM09, RSM10, RSM11, and RSM12) had the same response as participant RSM07 who said FAA inspectors would haphazardly select low-risk repair stations to audit with little to no emphasis placed on efforts to identify high-risk repair stations, especially repeat offenders.

Interview Question 3 (IQ3). What changes in Part 145 repair station aircraft maintenance practices have you observed after the FAA's implementation of its enhanced, risk-based oversight system in 2007? Fifty percent (6 of 12) of the participants believed there were inconsistent standards among the FAA inspectors. The belief that the FAA has not been consistent with applying a standardized surveillance process at all participants' repair stations would become a significant finding of the study.

Of the six participants, participants RSM01 and RSM02 complained about ineffective FAA inspectors who had conflicting interpretations of federal regulations to define the significant meaning of overhauled and how it was linked to a required test because it was not clearly defined by the agency. For example, the participants said their repair stations were hindered by FAA inspectors who disagreed with other agency inspectors about the qualifying criteria that constituted an overhauled aircraft, component and subcomponent, and proper disposition of the required maintenance documentation.

One of the participants (RSM06) has become extremely frustrated with FAA inspectors who did not understand the basic concepts of chrome plating used in critical applications in the repair station, i.e., aircraft landing gear parts. Participant RSM09 mentioned how documented maintenance in the repair station has doubled since 2007, while participants RSM08 and RSM10 remembered multiple FAA auditors who conducted infrequent inspections and had conflicting interpretations of federal regulations.

Participants RSM11 and RSM12 discreetly agreed that any outcome of the risk-based FAA oversight change depended upon the FAA's approach to address it. They implied that redundant inspections have plagued the domestic Part 145 repair station industry because the FAA and other audit agencies did not communicate as a whole, and frequently duplicated their inspections within a six-month time period. Also, the frequency of FAA inspections has been remarkably lower at foreign Part 145 repair stations due to budgetary constraints by the agency to travel overseas. The participants said manpower constraints have prevented the FAA from conducting routine inspections at U.S. and foreign maintenance facilities that performed outsourced aircraft maintenance for the U.S. air carrier industry. During 2013, there were 449 foreign Part 145 repair stations and 474 in 2015 (OIG, 2015).

Participant RSM01 found it necessary to hire two additional quality assurance auditors to cope with the enhanced risk-based FAA oversight. These full-time auditors increased the efficiency of the organization by 94% after reducing its lost employee work days from 100 to six days. Aircraft maintenance damage incidents of dropped engines and sheet metal drilling errors were reduced from 63 to 4 events, and worker compensation costs decreased from $600,000 to less than $100,000 per year.

Interview Question 4 (IQ4). What advantages have you noticed from enhanced risk-based FAA oversight at your repair station between 2007 and 2014? An overwhelming majority (75%) of the participants indicated the efficacy of the enhanced FAA oversight, especially in the improvement of audits, quality, and safety within their organizations. Participants RSM11 and RSM12 stated the FAA began to replace the ATOS with the Safety Assurance System (SAS) during 2015 as its new risk-based system to advance the U.S. air transportation system. According to the participants, SAS should improve the efficacy of the FAA's oversight of Part 121, 135, and 145 operations with enhanced audits, improving the safety and quality of the U.S. air transportation system.

Interview Question 5 (IQ5). What disadvantages have you noticed from enhanced risk-based FAA oversight at your repair station between 2007 and 2014? Over half of the participants (67%) experienced excessive burden with the enhanced oversight. As a 40-year veteran, participant RSM02 said the majority of new-generation FAA inspectors have limited technical skills and favor non-critical administrative audits such as records management, as opposed to evaluating an aviation technician's performance of a critical maintenance task, to validate and verify regulatory compliance. This participant also said the majority of new FAA inspectors have limited hands-on Airframe and Powerplant (A&P) experience and lack the necessary practical knowledge to understand basic maintenance concepts, whereas the older generation inspectors are considered Subject Matter Expert by trade and are actively engaged in promoting civil aviation.

A personal experience was discussed by participant RSM05 who had become upset after the FAA Office of Aerospace Medicine Drug Abatement Division audited his drug program and issued him a $6,000 fine. In addition, three participants (RSM04, RSM08, and RSM09) agreed that their time was hindered by lengthy and wasteful audits by FAA inspectors who were not sufficiently prepared to conduct their inspections. Participant RSM07 said the lack of common sense by the FAA was a disadvantage and it has burdened the U.S. air transportation system when the agency does not understand and fully comprehend basic maintenance processes in the repair station.

The next two participants (RSM11 and RSM12) were hampered since the FAA does not normally share repair station audit results internally with their inspectors and externally with the civil aviation community for the purpose of trend analysis. They believe the FAA should place

more emphasis on high-risk repair stations or frequent offenders with a standardized process to share audit findings and systemic concerns with the Part 145 repair station industry. The remaining four participants (RSM01, RSM03, RSM06, and RSM10) did not acknowledge any disadvantages from the enhanced oversight by the FAA.

Interview Question 6 (IQ6). How do you feel about the argument to increase the frequency of FAA inspections at Part 145 repair stations to improve the safety of the U.S. air transportation industry? Participant RSM02 planned to fib to FAA inspectors if they resort to web-based desktop audits verses on-site repair station inspections based on the agency's limited resource of inspectors. And participant RSM03 said the FAA should hire more inspectors to provide better surveillance of the Part 145 repair station industry. The rest of the participants (RSM04, RSM05, RSM06, RSM07, RSM09, RSM10, RSM11, and RSM12) complained about the excessive amount of time spent on FAA inspections and other audit agencies since they are unwilling to share inspection data results; whereas, if they had shared data, those inspectors could have prevented redundant inspections and wasteful man hours.

Interview Question 7 (IQ7). What would you like to add as a further opinion that was not covered during this interview? Approximately forty percent (42%) of the participants (RSM05, RSM06, RSM08, and RSM12) said their continuous process improvement program was mired by inadequate FAA oversight at their Part 145 repair stations. For instance, they were concerned with the FAA's inadequate oversight of domestic air carrier maintenance after it has been outsourced to a Part 145 repair station that will often contract it to a noncertified maintenance facility to perform critical maintenance.

Inadequate training for inspectors was a concern to one-third of the participants (RSM01, RSM02, RSM03, and RSM04). Participant RSM01 was worried about the new generation of FAA inspectors who may have some college education or a degree; however, they would not possess the necessary A&P hands-on experience. Participant RSM02 wanted to see a change in the A&P certification process, requiring all aviation maintenance technicians (AMTs) who are employed by the Part 145 repair station to successfully complete an on-the-job training apprenticeship program. This training program, according to the participant, should include specific content about aviation standards, proper usage of tools, regulatory requirements, maintenance documentation, communication classes to improve the productivity of the aviation workforce, and techniques to improve the audit experience by reducing or eliminating personal stress levels associated with audits.

Summary and Conclusions

Since the 9/11 terrorist attacks, the U.S. air transportation industry has experienced significant hardships from high maintenance costs to operate air carrier jetliners. The OIG has become increasingly concerned with this rise in aviation maintenance outsourcing and decreased safety of domestic air carriers due to several U.S. airline mishaps, uncovering systemic gaps in the FAA's oversight system, which has hindered its ability to adequately monitor the increased practice of outsourced maintenance by the Part 145 repair stations (GAO, 1997; OIG, 2013). The OIG (2003, 2005, 2013) determined that more FAA oversight would possibly reduce the likelihood of additional accidents, as well as the FAA's issuance of several million dollars in civil penalties to domestic repair stations and U.S. air carriers found to be in violation of substandard aircraft maintenance. Not surprisingly, the FAA agreed with recommendations from the GAO and the OIG to correct significant gaps in the U.S. air transportation system to properly monitor outsourced aircraft maintenance for domestic air carriers at Part 145 repair stations (GAO, 1997; OIG, 2013).

Consistent with the purpose of this study, the data findings provided a snapshot of the actual (professional) experience of Oklahoma Part 145 repair station managers who oversaw outsourced U.S. air carrier maintenance between 2007 and 2014. The 12 station managers who participated in this study had between 7 and 40 years of experience in the domestic Part 145 repair station industry. Cumulatively, they had an aggregate total of 6,757 employees and 236 years of repair station management experience.

The overwhelming majority (92%) of the participants agreed that the FAA's level of standardization established for the repair stations lacked overall consistency. Specifically, the participants believed that the FAA inspectors failed to follow a standardized surveillance process during their visits to Part 145 repair stations in Oklahoma, indicating that the FAA's policy of an enhanced risk-based oversight system, after 2007, was also lacking in terms of similar quality and effectiveness of oversight before 2007. The participants were frustrated with inadequate and ineffective oversight because the FAA inspectors continuously chose not to follow a mandated and consistent risk-based audit process. Furthermore, half of the participants voiced their concerns about inconsistent standards among all FAA inspectors, stating that when FAA inspectors interpreted federal regulations, they were frequently inconsistent with other FAA inspectors. According to the participants, some of the younger-generation FAA inspectors had a much different interpretation of federal regulations than the older-generation FAA inspectors. Several of the participating repair station managers agreed that if FAA inspectors collectively enforced policies of standardization and interpreted regulations accurately, their repair stations would be more productive and safer, as would all other repair stations associated with the U.S. air transportation system.

Atypically, FAA inspectors often relied on their own personal knowledge of repair stations to conduct audits and

communicate the results of those inspections. As a result, FAA's oversight of the repair stations lacked the standardized rigor needed to identify deficiencies and verify corrective actions. At the same time, according to the participants, the FAA has not developed or enforced a consistent and reliable process for placing its inspectors at repair stations that are more susceptible to risk or have a history of violations.

The findings also suggested that high operational costs at several Part 145 repair stations presented the opportunity for them to compromise safety at the expense of quality against probable financial consequences (loss of profits) due to inadequate FAA oversight. Revenue operations normally have the predisposition to value these things alike, which has the tendency to compromise safety. Therefore, when a premium is placed on time and money, safety can likely be neglected within the repair stations, even though most of the participants understood that their safety and quality management systems go hand-in-hand. Without these systems in place, it becomes extremely difficult to maintain a safe and airworthy aircraft.

Some of the participants stated that the OIG was rightly justified to promote their increased audits of the FAA due to its inadequate oversight of the Part 145 repair station industry. These participants also indicated they were burdened by FAA inspectors who did not initially perform standardized inspections, as well as the invasive nature of unproductive audits. However, some of the participants experienced some improvements with the efficacy of their repair stations from the enhanced risk-based FAA oversight. In addition, the participants agreed that the decision to increase audits was legitimate and helped their Part 145 repair stations improve their quality and safety systems to produce reliable products. Yet, some of the repair station mangers made it clear that the improvements were only possible after they hired their own additional quality inspectors to conduct more internal audits.

Although the FAA implemented an enhanced risk-based oversight system in 2007, under the umbrella of ATOS, to assist its safety inspectors in focusing on those Part 145 repair stations that posed a higher risk, findings from this study indicated that this current FAA oversight system does not guarantee timely and accurate risk assessments of the higher risk repair stations. And due to weaknesses in the oversight system, FAA inspectors are not effectively targeting surveillance to repair stations with the greatest risk.

In conclusion, outsourcing maintenance by the airline industry has been a good business practice as a whole for Part 145 repair stations or noncertified repair facilities to contractually inherit airline maintenance as their core business function. As McCartney (2004) and McFadden and Worrells (2012) previously stated, the FAA has not increased its surveillance across the full spectrum of repair station and non-certificated repair facility operations while the airlines have become more reliant upon the MRO industry to perform outsourced maintenance at a reduced (labor) cost (GAO, 1997; OIG, 2007, 2008, 2009, 2010, 2013). As repair stations have become an integral part of airline maintenance, the significant finding of this study indicated that the current FAA risk-based oversight system has not followed a standardized process and lacks the necessary training for their inspectors to effectively use the oversight system tools, further hindering the inspectors' ability to conduct acceptable repair station risk assessments (OIG, 2013). Until the FAA modifies its inspection program and follows a standardized process, additional lapses of FAA oversight will continue to occur in U.S. repair stations (Hung & Chen, 2013).

Recommendations for Future Research

The findings of this study produced some additional unanswered questions, calling for additional research. The following topics, in the opinion of the researchers, warrant further study:

Further Study #1:

Further research regarding FAA oversight on Part 145 maintenance practices beyond the state of Oklahoma should be conducted to determine if the perception patterns of Part 145 repair station managers, identified in this study, are limited to Oklahoma; research should examine the characteristics of domestic and foreign repair station managers who oversaw outsourced aircraft maintenance for domestic air carriers at U.S. and foreign Part 145 repair stations. Research should also examine the cost of business differential between U.S. and foreign repair stations.

Further Study #2:

Beginning in January 2016, the FAA SAS became the new oversight program for Part 145 repair stations**,** providing inspectors with standardized protocols to evaluate the certificated stations. SAS was designed to take a data-supported/risk-based approach for routine operator surveillance, providing FAA inspectors with the capability to determine potential safety issues, assess and analyze the root cause of safety concerns, and take appropriate action with perceived safety-related risks.

A future research study could examine the FAA's replacement of its ATOS with SAS and determine if the new safety system has improved the sharing of safety data between the FAA and the aviation maintenance community, focusing on how to better assess and mitigate safety concerns or risks associated with U.S. and foreign repair stations.

Further Study #3:

On April 6, 2006, all U.S. certificated repair stations were required to have and use an employee training program approved by the FAA that consisted of initial and

recurrent training (Legal Information Institute, 2014). This required FAA training program was implemented to ensure each employee could perform their assigned maintenance and preventive maintenance, alteration, and inspection tasks. In an effort to assist the stations in complying with this requirement, the FAA provided the necessary guidance and recommendations for establishing this new training program. However, the FAA's attempt to compromise on training requirements at smaller, less complex repair stations without reducing the training offered by the larger repair stations could cause legitimate concern with how these training program requirements are being interpreted within the aviation maintenance industry (O'Brien, 2006).

It became apparent during this study that the number of trained, certified, and experienced AMTs from Part 145 repair stations may not be keeping pace with the expansion of the aviation maintenance industry such as the development and implementation of newer technologies regarding aircraft design and performance. During 2015, 6,009 of 11,340 (53%) noncertified AMTs were employed throughout 127 repair stations in Oklahoma (Table 5). The OIG (2013) has identified systemic and repeat findings of insufficient mechanic training of noncertified AMTs throughout the U.S. repair station industry. The FAA does not require AMTs to have an FAA mechanic certificate unless they inspect or supervise maintenance (FAA, 2003,2015b).

Additional research studies focusing on the elements and functions that constitute an effective training program for repair station employees, including the recommended amount of training, could provide the necessary data to assist repair station managers, and those responsible for ensuring safe and airworthy aircraft are complying with all FAA regulatory requirements.

Table 5
Part 145 repair station AMTs in Oklahoma.

Certified Mechanics	Repairman	Noncertified Mechanics	Total Employees
1,608	652	6,009	11,340

Notes. Certified mechanics = AMTs who were issued an FAA airframe or powerplant rating, or both, and certified to practice maintenance at a Part 121 air carrier, Part 145 repair station, or non-certificated repair facility. The FAA oversees the training and certification of AMTs based on two ratings: airframe and powerplant. An airframe rating allows a mechanic to maintain and repair all systems associated with the airframe of an aircraft while a powerplant rating incudes the engine and all associated equipment. A certified aircraft technician with both ratings is known as an A&P mechanic. Repairman = a repair rating is only valid at a Part 145 repair station or Part 121 air carrier. Noncertified mechanics = an AMT who does not hold a valid FAA mechanic certificate with either an aircraft or powerplant rating, or both to include a repairman rating. Adapted from "Practices and Perspectives in Outsourcing Aircraft Maintenance" by the FAA, 2003, *2.3 Issues Facing Repair Stations*, Report Number: DOT/FAA/AR-02/122, pp. 2-4 and 2-5.

Appendix A

Interview Questions

1. How long have you been associated or employed with the Part 145 repair station industry?
2. What changes in Part 145 repair station aircraft maintenance practices have you observed before the FAA's implementation of its enhanced, risk-based oversight system in 2007? Clarification: Describe what a typical FAA inspection looked like before 2007 and how FAA oversight impacted your repair station (i.e., compulsion to hire additional personnel or modify management practices).
3. What changes in Part 145 repair station aircraft maintenance practices have you observed after the FAA's implementation of its enhanced, risk-based oversight system in 2007? Clarification: Describe what a typical FAA inspection looks like today and how FAA oversight impacts your repair station (i.e., compulsion to hire additional personnel or modify management practices).
4. What advantages have you noticed from enhanced, risk-based FAA oversight at your repair station between 2007 and 2014?
5. What disadvantages have you noticed from enhanced, risk-based FAA oversight at your repair station between 2007 and 2014?
6. How do you feel about the argument to increase the frequency of FAA inspections at Part 145 repair stations to improve the safety of the U.S. air transportation industry? Clarification: The Office of Inspector General (OIG) has been advocating for an increase in FAA surveillance of repair stations since 1998. Recent reports by the OIG indicate that future increases in surveillance will be necessary.
7. What would you like to add as a further opinion that was not covered during this interview?

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