GENERAL AVIATION AIRPORT PAVEMENT MAINTENANCE IN THE FAA SOUTHWEST REGION: PLANNING, FUNDING, AND PRACTICE

by

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CHAPTER 1

INTRODUCTION AND BACKGROUND

Technological advancements in aviation have allowed for the creation of planes that can fly farther than ever before, use fuel more efficiently, and have less of an impact on the environment. Hundreds of thousands and even millions of dollars are spent on these aircraft, not to mention the research and development that go into producing them. There is an effort being made to catch up on the ground, in terms of more well-designed pavement and pavement management systems. This also requires the potential investment of substantial amounts of money, a resource increasingly harder to come by everywhere, including at airports. Pavement deteriorates quickly, and even the largest airports can have issues keeping up with maintenance on their airfield pavements. Large airports such as Dallas-Ft. Worth, Chicago-O'Hare, and New York's JFK and La Guardia, just to name a few, have full time engineers on staff overseeing their operations and maintenance departments, and the Federal Aviation Administration (FAA) has developed software that can help airports of any size plan maintenance and construction activities years out.

1.1 Background

Airfield pavements have been evolving over the last 30 years. This is due in part to natural advances in pavement knowledge, but is especially attributable to the quickening development of aircraft. Specifically, the Boeing B-777 and the work it inspired in the Federal Aviation Administration's (FAA) Airport Pavement Research and

Development teams 1993 report "Airport Pavements – Solutions for Tomorrow's Aircraft" (FAA, 1993). It was as a result of this plan that the National Airport Pavement Test Facility (NAPTF) was built, allowing for more precise testing and therefore greater predictive modeling for airfield pavements. One of the major goals of this test facility was to gather better data for use in the creation and improvement of several FAA software programs to assist in the design and implementation of airfield pavements better capable of handling the growing array of aircraft wheel configurations being utilized on airports in the United States.

Initially, this applied strictly to commercial and cargo airports, as these were the airports receiving larger jets with modern configurations. However, as air traffic has increased, the pavement concerns that come with new aircraft have also reached Reliever and General Aviation airports. Among these are deterioration, weight tolerances, and runway length. In 2012, the FAA released a different report, "General Aviation Airports – A National Asset" (FAA, 2012a), discussing the role of the nation's some 2,952 GA facilities. Since the 378 larger primary airports have engineers on staff, and are regularly inspected per their classification and certification, it is GA airports which have been the focus of ongoing research regarding extending pavement life using routine maintenance and proactive approaches to pavement monitoring systems. Often, these airports have older pavement, built in the 1950's-70's, prior to today's more complex wheel configurations and not accounting for redesigned weight distributions. Tight budgets have made it unrealistic for every runway at every airport to be completely tested and reconstructed as needed to bring all airports up to ideal standards for modern aircraft.

Moving forward, it is the goal of the FAA to invest in more sustainable practices for extending the life of asphalt pavements. The FAA's 10 year research and development report, "Airport Technology Research Plan – For the NextGen Decade," discusses the difference between pavement functional life and pavement structural life (FAA, 2012b). The relationship between pavements functionality and its underlying structure is addressed; For example, cracking pavement will allow water penetration, which will impact the base and subgrade, causing structural failure. The ideal structural life of a pavement, then, is 20+ years, with NO major rehabilitation work being required before then. Surface maintenance is crucial to pavement functional life, which it follows, must be at least 20 years. In order to begin to implement new strategies for increased pavement life at smaller facilities, there needs to be some understanding of the current state of pavement maintenance practices at GA airports.

1.2 Problem

There are national standards for the condition of the pavement on airfields. These standards apply to all airports in the FAA's National Plan of Integrated Airport Systems (NPIAS). The NPIAS identifies airports which are of particular value to the nation's infrastructure, including General Aviation (GA) airports. While GA airports do not have the facilities to serve large jets and commercial flights, they serve several other important functions, as outlined by the FAA's 2012 report "General Aviation Airports: A National Asset" (FAA, 2012a). These functions include: facilitation of emergency response to natural disasters, such as hurricanes and wildfires; and emergency medical movements; agricultural support; law enforcement; corporate traffic; and oil and mineral exploration and survey. Given the potentially critical nature of these facilities, it is of the utmost importance that they maintain their pavements on a regular basis to keep them functional.

The FAA contributes to this by designating that every airport which receives federal money (those on the NPIAS) for major maintenance, rehabilitation, or reconstruction, must have at least a pavement maintenance plan, but preferably a pavement maintenance system, in place which meets some minimum requirements. These minimum requirements include:

- A Pavement Inventory which shows the location, dimensions, and pavement types of all runways, taxiways, and aprons; as well as the year of construction and most recent major rehabilitation.
- An Inspection Schedule, with annual detailed inspections and monthly drive-by inspections.
- A Record Keeping (Documentation) system, including: "Complete information on all inspections and maintenance performed must be recorded and kept on file for a minimum of five years. The types of pavement distresses, their location, and remedial action scheduled or performed, must be documented. For drive-by inspections, the date of inspection and any maintenance performed must be recorded. The minimum information to be recorded is: Inspection Date; Location; Distress Type; and Maintenance Scheduled of Performed" (Texas Department of Transportation [TxDOT], 2000, p. 6).
- The ability to perform Information Retrieval, of which the wording is important, "An airport sponsor may use any form of record keeping it deems appropriate, as

long as the information and records may be retrieved to provide a report to the FAA as may be required" (TxDOT, 2000, p. 7).

It is up to the airports, with assistance from the states, to implement a routine maintenance program up to those FAA standards. As indicated in point 4 above, how each state does this is up to them, the FAA does not mandate how pavement maintenance systems are implemented. However, funding is tied to record keeping, and since GA airports rely on both state and federal funds for work needed at their facilities, airports have to work with both the state and the FAA to make sure adequate funding is set aside for their projects. It requires not only the cooperation of the airport managers and state and federal planners and engineers, but also potentially the airport owner, who is often the local government (at either the city or county level). The owner may be represented by an Airport Board, a City Council, or a County Commissioner's Court. These panels are responsible for committing funding (from taxes, bonds, etc.). The involvement of these groups is based on the system the state has in place for planning and scheduling work at GA airports.

Therefore, airport managers are responsible for knowing a wide array of information, from facilities maintenance both vertically and horizontally, to business development, local politics, and budget planning. Given the variety of roles the airport manager has to fill, and the complexity of the funding, how the states manage their systems has an impact on the maintenance activities performed.

1.3 Purpose of the Study

Understandably, keeping personnel up to date is difficult; as pavement technologies are advancing it is difficult to expect the average maintenance worker at an airport to keep up with the complex chemistry and physics of todays multitude of modified pavements. Besides recognizing problems with the pavement itself, there are skid resistance requirements, marking systems standards and maintenance, recognizing drainage issues, and other potential problems. However, with budget constraints, it is more important than ever that pavements are well maintained and properly managed. For this reason, the goal of this paper will be to evaluate the current pavement preservation and airfield maintenance practices used at GA airports in the FAA Southwest Region: Texas, Arkansas, Louisiana, Oklahoma, and New Mexico.

1.4 Significance of the Study

By identifying the preferences of the stakeholders and the processes through which work is done, issues or inefficiencies in the system can be identified and addressed. A review of specifications and discussions with state agencies provide the framework for surveys given to airport managers. The survey includes both qualitative and quantitative questions regarding airport pavement maintenance practices. It results in the identification of practices regarded as preferred or successful, and provides an understanding of the process by which work is done. Included is a discussion on cost considerations, and the process of each state’s routine airfield pavement maintenance activities planning and implementation are documented. Analysis of the survey results exposes barriers to efficient maintenance practices, but also yields implications for future strategies that can be considered for increasing the ability of airports to get more routine maintenance approved.

CHAPTER 2

REVIEW OF LITERATURE AND DEVELOPMENT OF RESEARCH QUESTIONS

Airport pavement is different from road and highway pavement. The loads carried by the asphalt and concrete on airfields are much heavier than those endured on roadways, and therefore must be engineered to higher specifications. This pavement quality is essential, and there could be tens or hundreds of mix designs on one airfield, which contributes to making airports especially challenging to evaluate. Besides the pavement itself, the ground around the pavement has to be exact. Along with traffic loading, drainage is one of the biggest contributors to pavement deterioration (Hare, Pur, & Dempsey, 1990). There are many ways to mitigate damage, and requiring high standards for materials and construction is one of the ways the FAA attempts to keep planes embarking and debarking safely. The FAA is responsible for enforcing the aviation regulations here in the United States, and they are increasingly working with the International Civil Aviation Organization (ICAO) to bring the standards for other countries more in-line with those here. These standards include pavement quality as well as requirements for maintenance and safety, such as skid resistance levels of runways and high-speed taxiways, markings systems for guidance, and types of surface treatments that can be applied.

2.1 Standards and Regulations

The regulating body for aviation in the United States is the FAA. They create and publish the rules, standards, and specifications that govern public and private airfields of a particular designation, which is determined based on the Code of Federal Regulations (CFR) 14 Part 139. These standards address every aspect of air travel, from mix design of the asphalt to tower rules and behaviors, landscaping requirements to the wires that can be used in the airfield lights, the firefighting operations to weather stations, and almost every other aspect of air travel that can be built, constructed, or dug out. Because this project deals with the maintenance of airfields, the primary FAA Advisory Circulars (AC) used for reference will be:

- AC 150/5380-7A – Airport Pavement Management Program
- AC 150/5380-6B – Guidelines and Procedures for Maintenance of Airport Pavements (FAA, 2007)
- AC 150/5320-6E – Airport Pavement Design and Evaluation (FAA, 2009)
- AC 150/5320-12C – Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces (FAA, 1997)
- AC 150/5320-17 – Airfield Pavement Surface Evaluation and Rating Manuals (FAA, 2004)
- AC 150/5300-13A – Airport Design (FAA, 2012)

AC 150/5300-13A is the overarching airport design manual. As stated in the manual, compliance with the regulations and standards are not mandatory, unless the airport has or wishes to obtain it's Part 139 Certification (FAA, 2012, p. i). Per CFR 14 Part 139, the FAA requires all airports which:

- Serve scheduled and unscheduled air carrier aircraft with more than 30 seats;
- Serve scheduled air carrier operations in aircraft with more than 9 seats but less than 31 seats; and

- The FAA Administrator requires to have a certificate. (FAA, 2013, Part 139 Cert)

Applying these criteria, there are currently 30 Part 139 certificated airports in Texas (as of February 6, 2015) (FAA, 2015, Table of 139 Certs). It is precisely because GA airports may not fit this designation that they may be overlooked. Furthermore, airports wishing to obtain their Part 139 certification do abide by these regulations.

Beyond the requirements, GA airports look to the FAA regulations for guidance in managing their own pavements. This is particularly true if an airport is involved in a project where federal funding is involved, as these standards must be followed per the grant award. Therefore, this paper assumes that it is in the best interest of all airports to adhere to these standards and regulations as closely as possible, no matter the size. When planning routine maintenance, issues such as pavement quality, treatment options, and how it all fits into an effective pavement maintenance plan need to be considered.

2.2 Pavement Quality

There are two types of pavements on airfields: flexible and rigid. Flexible pavements are asphaltic in nature, whereas rigid pavements are concrete, generally containing Portland Cement. Due to the nature of maintenance on airfields, more emphasis will be placed on flexible pavements for this project, though rigid pavements are becoming more prevalent. The primary reason to do this is that flexible pavement (asphalt) is far more common on airfields, especially GA airports, as it is usually cheaper than concrete. Concrete will be addressed however, as some GA airports are converted military bases with a good amount or all concrete pavements, and other facilities have concrete aprons. There are two types of concrete pavement, jointed and continuously reinforced, used at airports, and similar mix designs are used for both. However, concrete requires far less maintenance over it's life-cycle (when properly installed at initial construction) than asphalt does. Many of the problems associated with concrete pavements are caused by insufficient sub-base and subgrade. Improper support will cause concrete pavements to buckle, as they are rigid, and thus many of the issues with concrete are not preventable with surface treatments or practices typical of asphalt pavement maintenance (Packard, 1995). However, similar factors cause pavement deterioration. It is important to appreciate the difference between distresses that can be treated with routine pavement maintenance and those that cannot, and so an understanding of the pavement itself is necessary.

One of the most important ways to prevent pavement distress is by installing pavement that is designed to handle the anticipated loads and the known environmental factors. These factors are addressed during the pavement design for both asphaltic concrete (asphalt) and Portland Cement Concrete (PCC) pavements. One of the new design methods currently in use for asphalt at airports is the Superpave (*Su*perior *Per*forming Asphalt *Pave*ments) Mix Design. The method involves careful selection of the asphalt binder and aggregates based on climate conditions, followed by the evaluation of at least three trial blends before selection of the mix design for the particular project (Asphalt Institute, 2001). Due to the prevalence of this new method, maintenance methods may also need to be adjusted. The Superpave system addresses both the load and environmental factors for asphalt present in airfield settings.

Airport pavements have to be able to handle heavy loads. As noted by the FAA in Advisory Circular No. 150/5320-6E, *Airport pavement design and evaluation*, (2009):

"In 1958, the FAA adopted a policy of limiting maximum Federal participation in airport pavements to a pavement section designed to serve a 350,000-pound (158,757 kg) airplane with a DC-8-50 series landing gear configuration. The intent of the policy was to ensure that future airplanes were equipped with landing gears that would not stress pavements more than the referenced 350,000-pound (158,757 kg) airplane." (p. viii)

Planes have gotten larger, and engineers worked around the FAA's policy for years by adding and reconfiguring landing gear to disperse the weight. Recent advancements in modern asphalt technology are allowing engineers to design stronger pavements, and specifications are becoming more complex and can require modifiers. The Superpave specifications have performance measures for asphalt which require certain stiffness Some examples of asphalt modifiers include:

- Rubber (Natural and synthetic latexes, reclaimed tire rubber, etc.);
- Plastic (polyethylene, polypropylene, etc.);
- Polymer (Sasobit, Leadcap, etc.);
- Fiber (Natural and Synthetic); and
- Others (fillers, extenders, antioxidants, oxidants, antistripping agents, hydrocarbon, and waste materials) (PavementInteractive.Org, 2010)

These modifiers all serve different purposes, but the main goal is to improve the asphalt performance without causing unnecessary or additional environmental damage, beyond the problems already caused by the paving process. Additionally, modifiers may be added to achieve:

- Lower stiffness (viscosity) during construction;

- Higher stiffness at high service temperatures to reduce rutting and shoving;
- Lower stiffness and facilitate "faster relaxation properties at low service temperatures" (PavementInteractive.Org, 2010, p. "Asphalt Modifiers"); and/or
- Increased adhesion between binder and aggregate (PavementInteractive.Org, 2010).

Superpave accomplishes addressing these issues by creating performance-based requirements in three areas: the asphalt binder specification, mixture design, and analysis system, sometimes with the use of computer software (Asphalt Institute, 2001). Loads that are too heavy for a designed pavement will cause damage such as rutting, which is difficult to prevent or repair using only surface treatments.

Besides load, the other major impacts on airport pavements are the environmental factors. Weather is a huge contributing factor to pavement deterioration, thus the Superpave system addresses the changes in asphalt mix design in relation to the climate of the area, and makes provisions to mitigate damages. Rain introduces moisture to pavements, which will cause them to break down, especially the more extreme the freeze-thaw cycle of the pavement. Because asphalt is a viscous liquid, it is susceptible to climatic changes, and freezing will have an effect on the structure. Superpave is based on the use of Performance Grade (PG) asphalt materials, as determined by the selection and testing of the mix designs. PG asphalt binders have been modified in some way to conform to a certain temperature tolerance, either on the low or the high end. While asphalt can be modified to accommodate any temperature, the most common are given below in Table 1. PG binders are distinguished by a set of two numbers joined with a dash (i.e. 58-28, 64-22, 76-40, etc) given in degrees Celsius, and reflect the high and low temperatures the pavement is designed to withstand. Thus, a PG binder with the designation 64-22 is designed for temperatures up to 64° C (~147° F) on the high end, and down to -22° C (~ -7.5° F) on the low end, sustained for one week. Thus, a PG binder with this designation would be optimal for climates where the temperature does not drop and stay below -22° C.

Table 1. Performance Grade Binders

(adapted from PavementInteractive.Org, 2008, "Superpave Performance Grading")

Low Temperature, °C \ High Temperature, °C	52	58	64	70	76
-16	52-16	58-16	64-16	70-16	76-16
-22	52-22	58-22	64-22	70-22	76-22
-28	52-28	58-28	64-28	70-28	76-28
-34	52-34	58-34	64-34	70-34	76-34
-40	52-40	58-40	64-40	70-40	76-40

= Crude Oil

= High Quality Crude Oil

= Modifier Required

While the next section covers pavement maintenance, it should be noted that there are several important reasons to mention Superpave and mix design when discussing pavement quality as it pertains to and moves to the topic of maintenance. First, traditional treatment methods are designed for traditional pavements. With advancement in pavement technology, there needs to be an equivalent advance in pavement treatment technology. It follows the same products used on traditional asphalt may not work on modified asphalt, or they may not work in the same way. For airports with old pavement who are simply trying to maintain what they have and are unable to build new, it is critical to know what treatments and other maintenance activities will work with their particular pavement. Second, all new airport construction using federal funding must comply with Superpave, therefore requiring airports which may not have previously had experience maintaining modified asphalt to adapt their maintenance strategies to the new pavement. Third, Superpave is a performance-based specification, and thus the modified asphalt is expected to maintain it's characteristics for a length of time, including throughout maintenance activities. It is important to know the type of modification, age of the asphalt, and maintenance activities performed when assessing the distresses, as well as relevant climate history, so that the best evaluation of the pavement condition can be made. For example, if a pavement appears to be in bad condition, but it is only several years old, any issues may be due to the mix design of the pavement. However, if the pavement is in bad condition but is 20 years old, then perhaps the mix design was perfect, the pavement has just reached the end of it's operational life. It is the maintenance processes and activities that occur on airfield pavements from the time it is built until the time it needs to be rebuilt that can shorten or lengthen the pavement life.

2.3 Pavement Maintenance

Once the proper pavement is in place, it is in the best interest of the airport to maintain it in good condition as long as possible. Naturally, the airport wants to do this with maximum efficiency at the lowest cost. But what may be considered the most efficient maintenance is not the same for every airport. The most efficient maintenance for the best price will depend on the amount and type of traffic, type (or types) of pavement, and location-specific environmental conditions, among other things. Much of the pavement life depends on the proper installation of the pavement at construction. However, there are 3 important aspects of pavement maintenance on airfields after the pavement is placed: skid resistance, surface treatments, and pavement markings.

Skid Resistance. “Skid resistance” refers to the force that occurs as the effect of the interaction between airfield pavement and aircraft tires. It is the force which assists an aircraft in slowing down the instant the tires hit the runway, makes taxiing planes less likely to slide on turns in wet weather, and it is one of the most important safety features of airfield pavement. Skid resistance is what causes the friction between the pavement and the tires, and the friction: 1) generates heat that causes rubber from aircraft tires to be deposited on the runway when planes are landing, filling the macrotexture of the pavement; and 2) wears on the surface, smoothing stones and wearing down the microtexture of the pavement.

Macrotexture and microtexture are the two main pavement characteristics that impact skid resistance. Macrotexture is the space between the aggregate, and is effected by the amount of aggregate in the mix design. Microtexture refers to the surface of the aggregate itself, and is impacted by the type of aggregate chosen for a mix design. Per the FAA (1997), “Microtexture provides frictional properties for aircraft operating at low speeds and macrotexture provides frictional properties for aircraft operating at high speeds. Together they provide adequate frictional properties for aircraft throughout their landing/takeoff speed range” (p. 3). Figure 1 illustrates the difference.

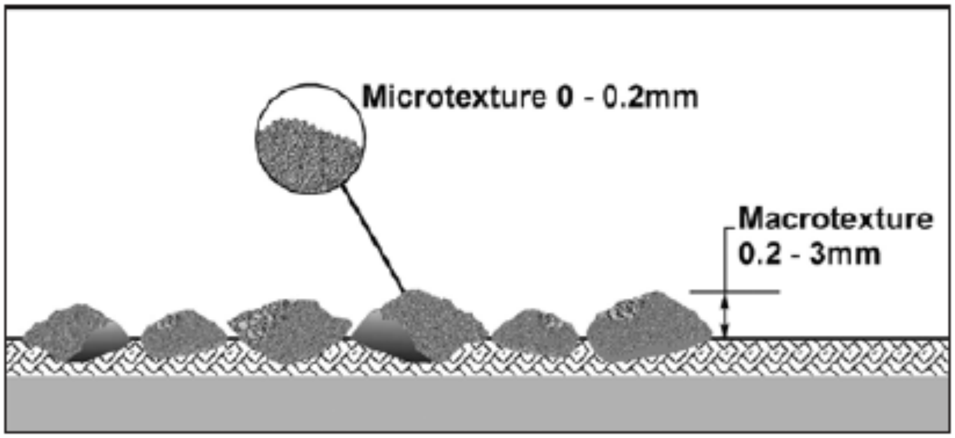

Figure 1. Runway Pavement Surface Microtexture and Macrotexture (Gransberg, 2008)

The two primary ways skid resistance is reduced are: rubber and other contaminant build-up in the macrotexture, and polishing of the aggregate by traffic (reduces microtexture). Rubber removal can be done and there are several methods by which it can be accomplished: chemical, shotblasting, waterblasting, or mechanical.

- Chemical removal includes the use of some sort of chemical to soften the rubber before it is removed, either with a hand-held power washer or some other method.
- Shotblasting (also called “shot-peening”) utilizes special equipment which fires abrasives (such as small gauge steel shot) at the surface at a high speed, and then immediately reclaims the abrasive and removed material. Shotblasting can be used to improve the microtexture of the pavement when it has been polished, not just remove rubber.
- Waterblasting involves the use of high-pressure or ultra high-pressure water shot at the pavement to remove rubber and other contaminants. Industry professionals distinguish between high-pressure and ultra high-pressure differently, but there seems to be a general consensus that high-pressure equipment goes up to an

operating pressure of around 30,000 psi, and ultra high-pressure equipment tops out around 55,000 psi. The distinction of maximum psi as the determining factor applies because the 55,000 psi machine can operate at 30,000 psi and below, but the high-pressure units cannot operate with a pressure higher than one for which it is designed. High-pressure/ultra high-pressure therefore refers to the operating capability of the equipment, not to the optimal operation level of the machine.

- Mechanical removal is basically anything that is not the other three, including "the simple use of stiff-bristle rotary brooms… sandblasting [or] sophisticated milling machines" (Gransberg, 2007, p. 38). It can be used in conjunction with chemical removal, as when a softening chemical is used and the surface is then broomed with a steel and polypropylene bristle combination to remove the softened rubber.
- It is worth noting here that all runways are required to be grooved, regardless of pavement type. The FAA (1997) provides the specifications for this. This is to assist in the faster dispersion of water from the pavement surface during inclement weather conditions.

As the FAA accepts the use of all of these methods, it is anticipated that all methods may be encountered during data gathering and analysis. It is also entirely likely that due to the traffic frequency and low load volume at GA airports, no rubber removal is performed. The frequency with which runway rubber removal should occur depends on the type of the aircraft and the amount of traffic, and is determined using continuous friction measuring equipment (CFME), or friction testers. The FAA recommends the following schedules for airports accepting jet traffic:

Table 2. Friction Survey Frequency (FAA, 1997)

Number of Daily Minimum Turbojet Aircraft Landings Per Runway End	Minimum Friction Survey Frequency
Less than 15	1 year
16 to 30	6 months
31 to 90	3 months
91 to 150	1 month
151 to 210	2 weeks
Greater than 210	1 week

Table 3. Rubber Deposit Removal Frequency (FAA, 1997)

Number of Daily Turbojet Aircraft Landing Per Runway End	Suggested Rubber Deposit Removal Frequency
Less than 15	2 years
16 to 30	1 year
31 to 90	6 months
91 to 150	4 months
151 to 210	3 months
Greater than 210	2 months

There are several levels at which friction levels are differentiated: new design/construction, maintenance planning, and minimum. On a scale of 0 to 1, a score closer to 1 indicates high friction, whereas a score closer to 0 indicates low friction. Tests are conducted at two different speeds (40 mph and 60mph) to get the most accurate readings. Because of the difference in the measurement equipment, the new design/construction levels vary from 0.69 to 0.82 at 40 mph, to 0.63 to 0.74 at 60 mph; the maintenance planning varies from 0.52 to 0.60 at 40 mph, and 0.36 to 0.54 at 60 mph; and the minimum friction at which aircraft are still allowed to operate on the pavement varies from 0.42 to 0.50 at 40 mph, and from .24 to .42 at 60 mph. Specific standards for each piece of approved equipment is located in FAA AC 150/5320-12c. Additionally, when improperly performed, runway rubber removal can damage airfield pavement, creating a safety concern.

Runway skid resistance is an important safety issue on an airfield. However, high-speed taxiways must also maintain high skid resistance, and it is in the best interest of the airport to periodically check other high-use pavements, such as gate areas, as well. Aggregate can become polished over time, creating unsafe pavements in wet conditions. In this case, pavement may have to be retextured using a shotblaster or some other surface abrasion technique. This restores microtexture, but can also remove the top 1/8" of the pavement, so the pavement must be able to withstand the treatment. While removing rubber and other contaminants from airfield pavements and retexturing are ways to increase friction, another method is the use of surface treatments.

Surface Treatments. Surface treatments can be used for multiple purposes on an airfield. A surface treatment is some material or combination of materials applied to the surface of a pavement which is designed to improve the quality of the pavement surface. Fog seals, slurry seals, coal-tar sealers, rejuvenators, chip-seals, microsurfacing, etc., are all surface treatments. Surface treatments do not add structural life to the pavement, but may add operational life by extending the life of the pavement. For example, a hot mix asphalt pavement in a dry area may be designed for a 25-year life, but if properly maintained and treated so as to keep the maximum amount of moisture out and reduce the effects of ultraviolet light and other stressors, could last for 35 years or longer.

There are multiple types of surface treatments, but they are all meant to extend the life of airfield pavement. Currently, the FAA has specifications out for seal coats and bituminous surface treatments, emulsified asphalt slurry seal, slurry seal treatments, and bituminous pavement rejuvenators, as well as material specifications for joint sealant, crack filler, concrete, and epoxy grouts and concretes (FAA, 2007; FAA, 2011). Prior to the Superpave specifications being fully implemented, as mentioned previously, specifications dealt only with material properties, not performance. Now, specifications are written with multi-year testing requirements for material approval. This will ultimately result in higher quality surface treatments being adopted and lower quality options being phased out.

The last aspect of pavement surface maintenance pertains to the marking system applied to it, which is used by pilots from all over the world to safely navigate airfields known and unknown to them, so they must be clear, precise, and correct.

Markings. The markings systems used on airfields are quickly becoming standardized around the world, as the International Civil Aviation Organization (ICAO) and the FAA work and move more closely together in this area. English is considered the language of aviation; However, as global travel increases, and more pilots from more countries are flying into the United States, and even as American pilots are flying to new countries, it is imperative that they do not have to rely solely on language and are able to navigate an airfield using the markings on the pavement. While this is mostly a safety concern, markings can be damaging to the pavement as well and must be maintained.

Pavement marking materials can cause pavement damage. These materials include paints that are waterborne, solvent-based, epoxy, methacrylate, or preformed thermoplastic. Regular thermoplastic materials are not allowed due their predisposition to break and become Foreign Object Debris (FOD), a huge safety concern on airfields. Marking materials do not expand and contract at the same rates as the pavement, which in addition to cracking the markings, can cause pavement stress and cracking. Figure 2 below illustrates a close up of pavement damage caused by markings.

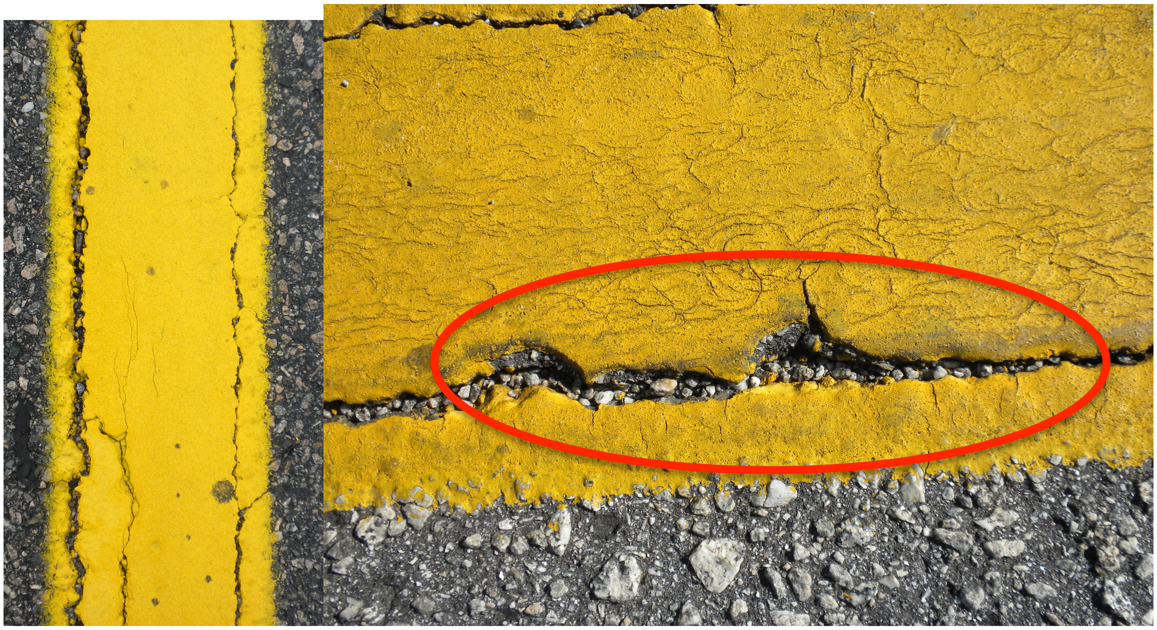

Figure 2. Pavement Damage Caused by Marking Materials

In the case of Figure 2 above, the marking material is waterborne paint. It has been applied in too many layers (the previous paint was not removed prior to new application), and is causing fractures in the pavement (visible inside circle). This opens it up and exposes the pavement to water and other contaminants, which could eventually contribute to or cause pavement failure. These situations are easily avoided with a good pavement maintenance plan.

Marking replacement is determined by the retroreflectivity of the glass media in the markings ("glass beads"), the color of the markings, and the condition of the markings. Airfields that allow night-time operations should have reflective media in their markings, glass beads are required in epoxy and methacrylate paints, as well as in the preformed thermoplastic (FAA, 2010). Waterborne and solvent-based markings are not required to have them, though they are recommended to "increase conspicuity of the markings" (FAA, 2011, p. 378-379). The second aspect of marking visibility is the color itself. The FAA has very stringent guidelines on the precise hues of white, yellow, red, green, pink, and other colored paints that appear on airfields, so much so that a colorimeter may be used to verify that a paint meets the specification. The tolerances for the different colors are found in FAA AC 150/5340-1k. Lastly, the condition of the markings is important. If the markings are so faded or chipped that they are not visible, or are confusing, then they could cause an incursion and are a safety concern. All of these issues can be mitigated with an effective pavement management plan and system.

2.4 Pavement Management Plans and Systems

To develop a Pavement Management Program, two separate but intertwined concepts are needed: the plan and the system. The pavement management plan is the concepts, schedule, and activities projected to be needed, usually for 20 years into the future (these plans are developed, but are speculative and based on past history and just because an activity is predicted, it may not be needed or performed). Pavement management systems are the methods and processes used to accomplish various elements of the plan. Pavement management systems can be complicated, taking many different forms and requiring differing levels of knowledge. Often, they are developed from empirical research, turned into models, and incorporated into computer programs. In general, according to the FAA (2010b), an airport pavement management system should include the following:

- A systematic means for collecting and storing information;
- An objective and repeatable system for evaluating pavement condition;
- Procedures for predicting future pavement condition;
- Procedures for modeling pavement performance (both past and future condition);
- Procedures for determining the consequence on pavement condition and life-cycle costing for a given M&R budget;
- Procedures for determining budget requirements to meet management objectives, such as maintaining a minimum condition; and
- Procedures for formulating and prioritizing M&R projects. A project normally consists of multiple pavement sections and may include different M&R actions for different sections. (p. 4-5)

Many of the attempts at researching pavement maintenance systems focus on one aspect of a model, rather than attempting to present a maintenance plan. These models for assessing pavement maintenance activity and creating long-term maintenance plans rely heavily on software and involved mathematical estimations, and pertain mostly to highways and other roadways (Lytton, 1987; Ferreira, Picado-Santos, Wu, & Flintsch, 2011). Complex algorithms are used to estimate parameters, determine relationships, and make predictions for future pavement condition. The performance models into which these equations have been built can be used to estimate pavement deterioration, potential treatments, and measure the effects of treatments on pavement, but can be limited in scope.

Wang, Zhang, and Machemehl (2003) used user disturbance costs (budgeted) and maintenance and rehabilitation (M&R) effectiveness as optimization objectives in their study. Using Texas Department of Transportation's (TxDOT) Pavement Maintenance Information System (PMIS) database, they developed a model for assisting in determining network-level project selection, or which roads might benefit the most from M&R. They then applied their model to ten sections of roadway and found that a minimum budget of $200,000 per year is required in order to satisfy M&R effectiveness and annual budget constraints. They also determine that it is more costly to repeatedly use less expensive M&R methods when budgets are tight, as problems often recur more quickly than if they had been "fixed for good." This illustrates the need for a plan which can be budgeted out over years, rather then one-shot repairs which may seem more attractive due to cost.

Chu and Cohen (2008) discuss incorporating maintenance effectiveness into dynamic infrastructure performance models. Their experiment examined rutting and slope variance in asphaltic pavement. They determined that not only did the overlay improve the pavement, but it improved the response of the original pavement to traffic. The model they develop is applicable only to rutting and slope variance, however, and so is not applicable to other treatments in its current form. However, it does provide evidence for the benefits of treating pavement to extend its life.

Perhaps the best known pavement management system software that exists for airports are the FAA's MicroPAVER and PAVEAIR. Originally a software program designed for use by the U.S. Army Corps of Engineers, it was developed for use on personal computers as MicroPAVER, and as a web-based application to meet FAA AC/150-5380-7a, "Airport Pavement Management Program." These programs require many inputs, and GA airports may not have the personnel or the resources to maintain a database such as is required by these programs. It is for this reason this research is being attempted.

It is theorized that the current approach to pavement maintenance at GA airports across Texas is a reactive approach, with problems being addressed as they arise. This is in contrast to a proactive approach, which seeks to prevent issues before they arise. This will be assessed while attempting to reach the goals of this research.

2.5 Delimitations and Research Questions

This research focuses solely on GA airports; Commercial, Cargo, and Heliports will be excluded. Since there are thousands of GA airports in the country, for the sake of time and scope, this project will focus only on those included on the NPIAS. Additionally, this scope will be further restricted to those GA airports in the FAA Southwest Region: Texas, Louisiana, Arkansas, Oklahoma, and New Mexico. Since the primary focus of this project is the performance of routine maintenance at these particular airports, the first question is:

Q1: What maintenance practices are currently being performed at GA airports in the FAA Southwest Region?

It is anticipated that the current approach to pavement maintenance is reactive, and not proactive in nature. This can be confirmed while answering the second research question:

Q2: What is the process for having routine maintenance performed (funded, planned, and scheduled) at GA airports in the FAA Southwest Region?

Lastly, given the variety of complex roles an airport manager must fill:

> Q3: What are the barriers to implementation of an efficient, FAA compliant pavement management plan at the local level?

2.6 Assumptions

Based on information obtained in the literature review, all airports should strive to use practices and materials that meet federal specifications. The person with the title "Airport Manager" should be knowledgeable of the pavements on the airfield, as well as the maintenance practices used to maintain them. Or, depending on their tenure, they may need to refer to someone else. Someone at the airport should be informed as to the current status of the pavement and the management systems in place.

2.7 Anticipated Limitations

Knowledge of pavement treatments is expected to be an inhibitor. The vast array of pavements and treatments mean that some contacts may be unaware of or unfamiliar with some methods and materials. Additionally, the ability to disclose certain information may be an issue, particularly as it relates to national security concerns.

Chapter Three discusses the methodology, including the survey, subjects, and procedures used to collect data. Chapter Four presents the results and discussion from the surveys and interviews, including the system of each state in the FAA Southwest Region. Chapter Five lays out the major conclusions, limitations, and ideas for future research.

CHAPTER 3

METHODOLOGY

The Literature Review provided an in depth overview of the considerations airport managers, state agencies, and the FAA have to keep in mind in regards to pavement. Pavement quality is directly related to pavement maintenance, and maintenance is dictated by the airport designation and funding sources for work. In order to understand the complex system that is the current state of pavement maintenance in the states in the selected region, a multipronged approach was taken involving informal interviews with state officials, specification review, survey of GA airport managers, and informal interviews with several engineering firms directly involved in maintenance at airports.

In order to narrow down the information gathered from the Literature Review, and standardize the survey for all states, each state agency responsible was contacted and asked about the specifications used on the airfields at GA airports in their state. This resulted in a list of common maintenance treatments used in each state. Additionally, as each agency responded to the questions about routine maintenance treatments, they also discussed funding opportunities and systems. These results will be discussed in the next chapter. However, their comments greatly informed the development of the survey.

A survey was developed and distributed to GA airport manager's in the FAA Southwest Region that covered routine maintenance and planning. Based on the replies, further interviews were conducted and broader issues were explored.

One of the first questions that arose during survey planning (prior to distribution) was in regard to the specifications used on GA airports. For consistency purposes, it was necessary to ensure that each survey, no matter what state it was from, dealt with the same maintenance treatments. For each of the states, the following organizations were contacted for preliminary interviews regarding specifications:

- Texas Department of Transportation, Aviation Division
- Arkansas Department of Aeronautics
- New Mexico Department of Transportation, Aviation Division
- Oklahoma Aeronautics Commission
- Louisiana Department of Transportation and Development, Aviation Section

They were asked about the specifications used on their GA airports. The unanimous response was that if an airport was included in the NPIAS, and received federal money for AIP projects, then FAA specifications were always used on the airfield. This confirmed that all airports should have the same FAA approved treatments in place. The survey was developed based on the assumption that although contractor's may vary from airport to airport, the materials for all the treatments at least met the same standards.

In the process of conducting these preliminary interviews, it was discovered that two states, Oklahoma and New Mexico, have stringent state-managed pavement systems in place for their airports. This will be discussed in Chapter Four, but it should be noted that for this reason, the airport managers from these states were not included in the survey subjects.

3.1 Subjects

The population was Reliever and General Aviation Airports in the states of Texas, Louisiana, and Arkansas identified in the "General Aviation Airports: A National Asset" report. These airports are those designated as critical to the nation's transportation infrastructure, and included on the NPIAS. The Excel file "2012AssetReportAppB.xlsx" containing the newly reclassified GA airports was downloaded from the FAA website. This file contains the state, city, airport name, and airport identifier, as well as identifying the service level (General Aviation, Commercial Service, Reliever, etc.), new classification, and whether it was publicly or privately owned, for every GA airport identified. Once downloaded, the owner, primary contact and phone number were located for each airport on AirNav.com. Additionally, the number of operational runways, runway types, and most recently reported average movements per day were recorded. After the initial reclassifications came out in 2012, those airports unable to be classified were revisited and changes were released in early 2014. The spreadsheet was updated with the most recent classifications for those originally identified as "Not Classified." The result was a spreadsheet identifying 302 Reliever or GA airports in Arkansas, Texas, and Louisiana in the NPIAS, including basic information, and a primary contact.

3.2 Survey

A survey instrument consisting of both quantitative and qualitative questions was developed for the initial gathering of data. A copy of the survey is included as Appendix A. It was determined that for the best response rate, the surveys would be conducted via telephone. When the airport was contacted, a request was made to speak with the person who could best answer questions about the airport pavement maintenance. Once the best respondent was identified, they were informed of the intent of the survey and given a general overview of the types of questions to be asked. Basic information such as the airport name, contact, title, and time in position was collected and confirmed. Respondents were asked specifically if the airport had a pavement maintenance plan in place, and if so, what form it took and who was responsible for maintaining it, as well as who made pavement maintenance decisions.

The respondents were then informed in more detail about the intent of the research. Specifically, they were told about the development of tools available to enable those responsible for the pavement at GA airports to better manage their pavement between major projects. Respondents were then asked what types of information they would like to see included in any developed tools. When discussing the pavement maintenance activity database, they were asked for types of information they would be interested in accessing, and what types of queries they might be interested in running if they had access to a database. A sample query pertaining to the average life of a particular surface treatment in a certain type of climate with a particular amount of traffic was provided for clarification. These questions were open-ended, as shown in Table 4. After the questions regarding the tools (Questions 4a, 4b, and 5, in Table 4), respondents were asked about specific routine maintenance treatments. They were asked to give their opinion on specific treatments using a Likert-type scale of 1 to 7, with 1 being "Not Effective at All" and 7 being "Extremely Effective", and defining "effective" as treating the problem it was intended to treat in a satisfactory manner.

Table 4. Open-Ended Survey Questions

Open-Ended Questions
1. Does your airport currently have a scheduled pavement management program in place?
2. If it is software, which program? Who is responsible for maintaining it?
3. Who makes the pavement management decisions?
4a. What type of information would you want to be included?
4b. What information do you feel you lack now?
5. If you had access to an online database of pavement maintenance activities, what types of information would you be interested in accessing? What types of queries would you run?
6. Is there anything else you would like to mention about your pavement surface maintenance? (end of survey)

Specific treatments included are shown in Table 5. An option for “other” to provide for new or experimental treatments was given. Using the same scale, respondents were asked about their markings, any re-texturing methods, and rubber/contaminant removal. These material and method questions are shown in Table 6. It should be noted that the surface treatments used were chosen because they are the most common and already approved treatments, as per the interviews with state agencies.

Table 5. Surface Treatments Specifically Included on Survey for Likert-type Ranking

Surface Treatments on Survey (Likert-type scale ranking)	
Slurry Seal	Microsurfacing
Fog Seal	Cape Seal
Seal Coat (other)	Coal Tar
Crack Seal	Other
Crack Seal/Seal Coat combo	

Table 6. Material and Method Questions with "Affirmative" Follow-Up Ranking

Material and Method Questions
7. What type of markings does the airport have? Is there reflective media in the paint?
8. Have you ever had to re-texture some part of the pavement?
9. Has your airport ever performed rubber removal or contaminant removal?
10. Is there concrete on the airfield?
10a. How often is joint sealant replaced?
10b. What other concrete surface maintenance practices have been utilized?

Most GA airports have asphalt pavements, but may have some concrete somewhere. Respondents were asked if there was concrete on the airfield, and if so, how often joint sealant was replaced. They were then asked if any maintenance had been done and if so, what kind, and asked to rate it on the same Likert-type scale used for other treatments (Table 5). Lastly, at the end of the survey, respondents were asked if there was anything else they thought should be taken into consideration or wanted to mention (Table 5, Question 6).

3.3 Procedure

Once the survey was approved, the initial goal was to contact each of the 302 airports. At the outset, airports were contacted in alphabetical order sorted by state. However as the time allotted for the survey period progressed, it became apparent that at many of the smaller airports, there may not be anyone on site to immediately answer questions or hear and reply to messages, and so it was decided to re-sort the list (from alphabetical by state) by the new classifications and average number of landings. This created blocks of airports in each of the new categories (Basic, Local, Regional, and National) organized by average amount of annual traffic. Once these groups had been developed, airports were selected at random from the classifications for sampling. This allowed for guaranteed representation from all categories of GA airports.

The airport was contacted, and if a contact agreed to answer the survey questions, the survey was given immediately over the phone. Respondents were not informed that their results would be confidential, although since it was requested by multiple people, the attempt has been made to keep all answers confidential. Respondents were instructed to answer the questions to the best of their ability, and to ask clarifying questions if they needed to, particularly regarding the open-ended questions about tool development. Once the survey progressed to the Likert Scale-type questions, respondents were asked to first confirm if they had a specific treatment on their airfield, and if so, to rate it on a scale of 1 to 7 for effectiveness. Effectiveness was verbally defined to them as doing the job it was intended to do, or treating the issue it was intended to treat. Once all of those questions had been addressed, and any further considerations requested, respondents were asked if they had any questions or concerns, or desired any contact information for later follow up.

During the course of the surveys, multiple people suggested contacting their engineering firm(s). Many gave the name, firm, and a contact phone number. There were two companies used more than any other, and so phone calls were made to those companies and short, general telephone interviews were conducted. At each firm, it was requested to speak with an engineer who worked with GA airports. Interviewees were asked about their general experiences with pavement maintenance planning at GA airports, if they had noticed any trends or had any regular experiences. They were then asked about long-term planning options available to GA airports, and about recommendations for regular maintenance. Additionally, since there seemed to be an issue with record keeping, a third firm specializing in implementing controls systems was contacted and asked very generally about other pavement maintenance systems in the country. This conversation also involved a brief discussion of PAVEAIR as a potential pavement management tool, though it was the opinion of the firm that per their experience, it would be run most effectively from the state or agency level.

CHAPTER 4

RESULTS AND DISCUSSION

Of the 302 airports deemed eligible for survey, contact was made with 124 airports, and 58 responses were obtained, a 46.7% response rate for contacted airports. Additionally, two of the respondents were County Airport Managers, so a total of 60 airports were represented. The most common respondent to the survey was the Airport Manager. At GA airports, the Airport Manager is generally in charge of monitoring their pavement on a regular basis, applying for funding for projects, and spearheading economic development.

The person with the title of Airport Manager has a complicated role to navigate, one of which is to ensure the continued safety of their airfield, including being involved in planning the work that must take place. This requires a certain knowledge about pavement planning, one that not many GA airport managers have in depth. One of the initial objectives of this project involved determining what types of tools those making pavement planning decisions would be interested in having to assist them with managing their pavement more efficiently. This lead to interest in the planning systems for each of the states. After the routine maintenance findings are discussed, the general findings of the survey and interviews are presented, followed by a detailed assessment of each state's role in planning and funding work at their GA airports. The implications of the various systems directly impact the timing and quantity of work done, in turn influencing the life of the pavement.

4.1 General Findings

Of the total number of General Aviation airports in the FAA Southwest Region, almost two-thirds are in Texas (41%) and Oklahoma (22%). The other 37% are split among the other three states. Figure 3 represents the total percentage of total GA airports per state in the FAA SW Region.

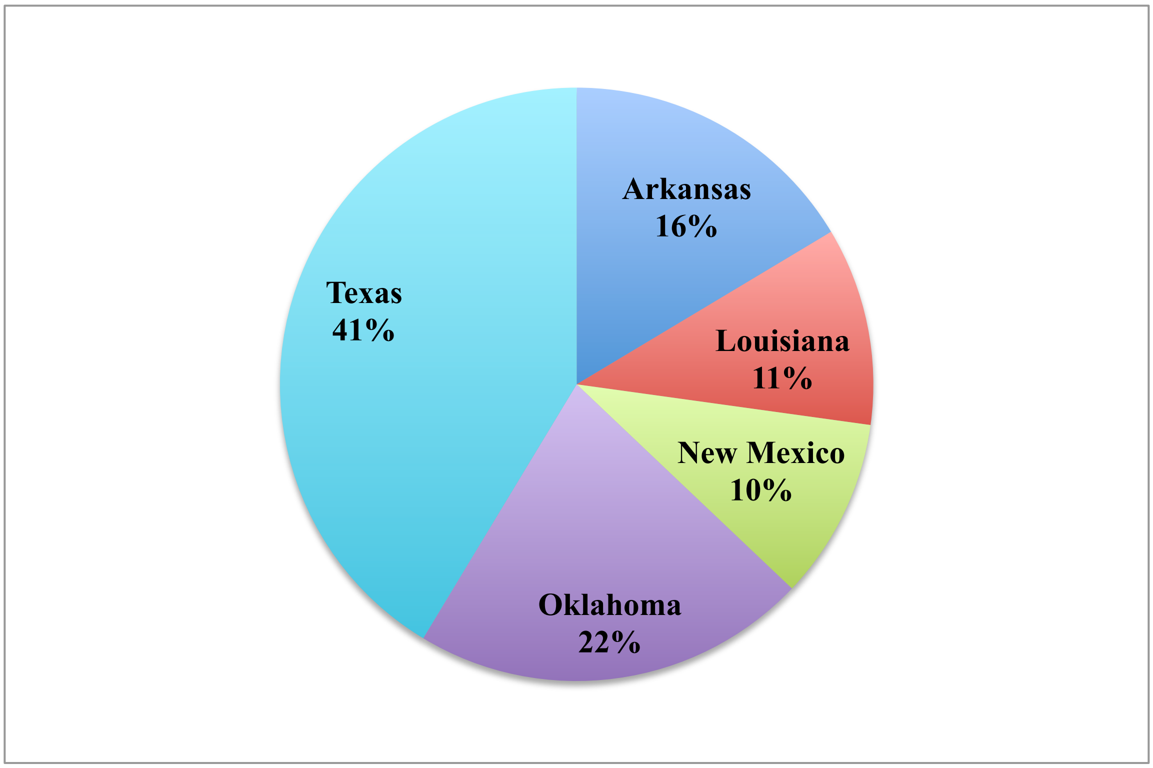

Figure 3. Percentage Total of General Aviation Airports in the FAA Southwest Region

The predominant surface type is asphalt, comprising 78% of the runways at GA airports in the FAA Southwest Region. Concrete was second with 13%. Turf and dirt, gravel, and "combination" materials were also represented (Figure 4). This accounts for a total of 445 airports, and 640 runways. When comparing the total airport representation to the total runway representation, the numbers are very similar. While Texas accounts for 41% of the airports, for example, they account for 44% of the runways.

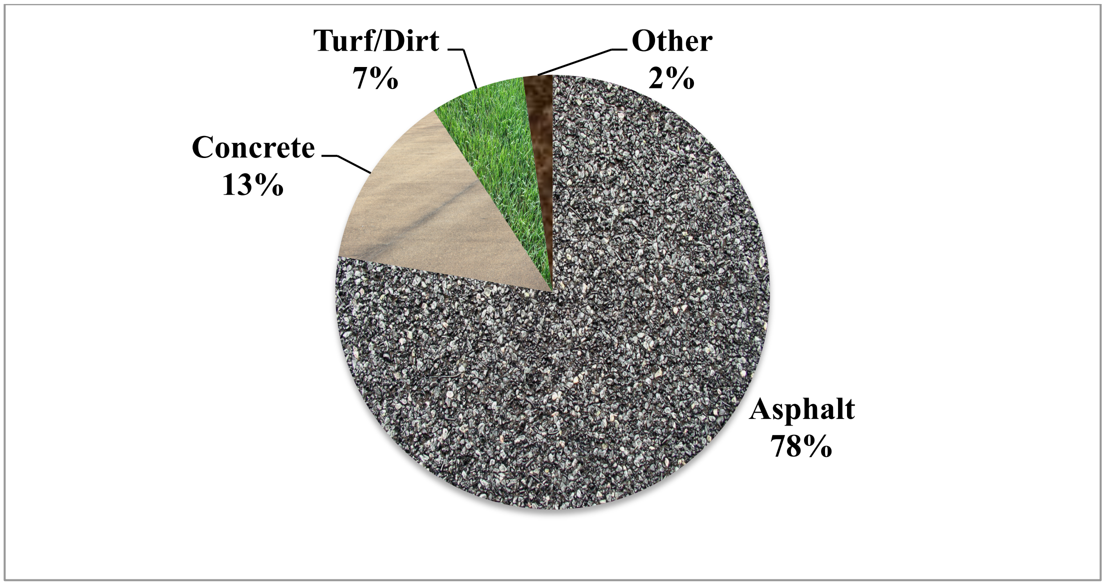

Figure 4. Surface Types of Runways at General Aviation Airports in the FAA Southwest Region

Table 7. Total Runways by Type per State at NPIAS GA Airports

	Arkansas	Louisiana	New Mexico	Oklahoma	Texas
Total Airports	73	48	44	96	181
Total Runways	90	60	79	129	282
Asphalt	78	49	67	85	218
Concrete	11	9	1	30	33
Turf/Dirt	1	1	7	11	25
Other	0	1	4	3	6

Having a pavement maintenance plan in place at a General Airport is heavily dependent on the state system in which the airport operates. That said, however, the idea of what an airport pavement maintenance or management program *is* varies widely. For some GA airports, when asked if there was a pavement maintenance or management program in place, the answer was "yes." But when asked what form that took, their responses indicated that their understanding of what constituted such a system varied substantially. Some people actually had a system in place, others thought that the system the state had in place constituted a plan, and still others thought that the bare minimum that is required by the FAA (consisting of monthly and annual inspections) was a planning system. This was reinforced speaking to representatives of several state agencies, who made remarks such as "The link is broken. [Routine maintenance grant] money means 'maintenance planning'", and, "AIP worksheets are meant to help plan, but sponsors don't know where to start. Education is a barrier."

Table 8 breaks down the ownership, and thus financial responsibility, of the GA airports in the FAA Southwest Region. Most are owned and operated by the City or County in which it is located. The privately owned airports included here are all in Texas and are all public-use, they are simply owned and maintained by a private company. Additionally, all three are located in the Houston, Texas area, a major hub for business, which includes an ocean port and two primary commercial airports. Those airports in the "other" ownership category include airports officially owned by universities, public works departments, the National Guard, Native American tribes, and by joint districts, such as combined utility districts.

Table 8. Ownership Breakdown by State

Owner	**Arkansas**	**Louisiana**	**New Mexico**	**Oklahoma**	**Texas**
City/Town	59	21	29	88	114
County/Parish	10	15	7	0	53
City/County (Parish)	0	1	0	0	9
State/Government	2	1	3	5	0
Airport Authority	2	7	0	1	1
Private	0	0	0	0	3
Other	0	3	5	2	1

Respondents came from different backgrounds, and were hired for various reasons. Mostly, they had the title "Airport Manager," although that was not always the case. For smaller airports, depending on who owned the airport(s), the City Manager was also the Airport Manager. When this was the case, it was generally stated that only about 10% of the Manager's time was spent on the airport. If an Airport Manager is spending 10% of their time on the airport, that means even less time is being spent thinking about the pavement. Other managers had backgrounds in aviation, or in pavement. Many had backgrounds in business. Some had been with the airport in some capacity for decades, and were "just next in line" to be Airport Manager. Two were County Airport Managers responsible for more than one airport. Thus, there was a difference in airports who were being proactive and hiring managers to take care of and promote the airport, and those who had managers that just slipped into the position.

Education is a barrier for both sponsors who lack pavement knowledge and the Airport Boards, City Councils, and County Commissioner's Courts who approve funding. Pavement is technical, people are not. Once placed, pavement begins to deteriorate, and certain factors will influence the rate at which that occurs. The dynamic element that can impact that deterioration is people. Many airport managers expressed frustration at having to debate with their Airport Board, City Council, or County Commissioners or Judge, over preventative maintenance. People get elected to those positions, and they may or may not be aware of the benefits and cost-savings preventative pavement maintenance can provide to an airfield. Several respondents indicated that the cycling of "approvers" (via elections) had been a source of frustration. Figure 5 illustrates the breakdown of ownership of public use airports. Again, ownership is critical because "owners" are usually responsible for approving and allocating funding for airports.

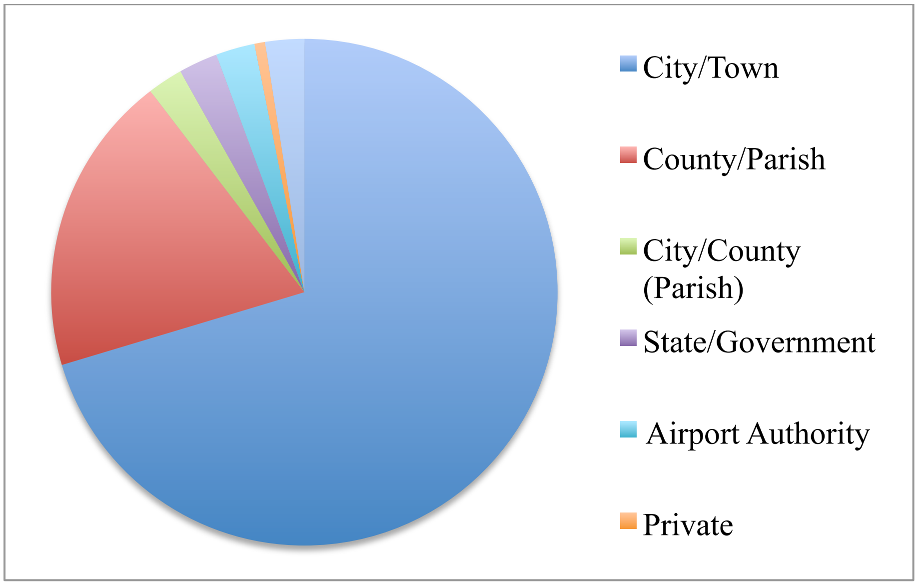

Figure 5. Owners of General Aviation Airports (Responsible for Funding)

This is also an issue for Airport Managers who are also City Managers, County Judges, or other elected position. The project planning process can take several years, and if the people who are pushing for improvements leave, there is no guarantee the next person is going to push for the same work, or even understand why the work was being sought in the first place. Some cities and counties got around this by putting their Street and Bridge (or Road and Bridge) Departments in charge of inspecting the airfield pavement. That way, someone with pavement knowledge was doing the inspections and could discuss short- and long-term needs at any meetings with Airport Boards, etc. However, even if it is possible to convince the necessary people that the work should be done, it still has to be paid for. The difference in proactive and reactive strategies can be traced to one key perception in how airports are viewed by the people responsible for them.

The perception of the role of the airport itself by those making funding decisions was the biggest indicator of whether or not an airport would perform preventative maintenance. One respondent, who was not an airport manager, but worked for a company that manages airports, stated it best when she said:

> There are two approaches a city [or county] can have towards their airport: they can see it like a library or a park, where once it is built, maintenance is minimal, and it is there for people to use or not, but is not typically considered a profit generator. The other way a city [or county] can view their airport is as a dynamic property, like a shopping center or other commercial development, and treat it like such. (personal communication, May 5, 2014)

It will be addressing this difference in perception that will lead to more frequent routine maintenance, and ultimately longer pavement life. The primary way this will need to be addressed is through the education of those people ultimately making funding decisions at the local level, and this will have to be addressed differently in each state.

4.2 Routine Maintenance Activities

Interviews with state aviation agencies yielded insight as to the types of maintenance activities being undertaken on airfield pavements. It was those approved maintenance treatments which the subjects were surveyed on. It is of note that many of the survey respondents, though responsible for bringing pavement issues up for correction and applying for funding, are unaware of what basic pavement maintenance activities consist of. Please keep in mind what is reported on here are the answers given by survey respondents, and not based on physical evaluations of the airfields by the author. This is all self-reported data. Of the 58 respondents, 50% (n=29) knew what most of the treatments were and could answer most or all of the questions. Another 19% knew a little about the treatments, and could answer a few questions. Some people (n=5) knew about treatments, at least somewhat, but could not answer the survey questions because they were new to the airport and didn't know the airports history. That left 22% of people surveyed who were unfamiliar with routine pavement maintenance treatments and could not answer most of the survey questions. Table 8 gives the breakdown.

Table 9. Treatment Knowledge of Survey Respondents

Treatment Knowledge	**Number**	**% of Total**
Did not know, could not answer questions	13	22%
Knew a little, could not answer questions	5	9%
Knew a little, could answer a few questions	11	19%
Knew about treatments, could answer questions	28	48%
Street Superintendent, knew and answered	1	2%

Given the seemingly large portion of those who reported being in charge of making pavement decisions who also don't appear to be familiar with routine maintenance activities, it stands to reason that a large gap exists in work that could be done and work that is being done.

Table 10 below shows the most common routine pavement maintenance activities and their respective average rankings by survey respondents. Crack seal is the most common, with 55% of airports reporting crack seal on their airfield pavements. It is also widely accepted as effective, with a 6.59 out of 7. Only one person reported having a cape seal, but said it had been wonderful, and they really liked the results so they gave it a 7 out of 7. Microsurfacing was also not widespread (n=4), but was popular with those who had it with 6.75 out of 7. The crack seal and seal coat combination (crack sealing then applying a seal coat) was also highly liked, in use at 29% of the airports (n=17). Slurry seal was commonly used, 41% of cases (n=24), thought it was discovered through the survey that rather than have retexturing done, airports would apply slurry seal to polished pavement to increase friction. Thus it is not being used to seal water out, but as a surface roughness tool. Whatever the use, it was highly rated, at a 6.13 out of 7.

Table 10. Rating and Number of Occurrences of Routine Maintenance Activities

Routine Maintenance Treatments			
Method	**Average Rating**	**% of Total with Method**	**Number**
Cape Seal	7	2%	1
Microsurfacing	6.75	7%	4
Crack Seal	6.59	55%	32
CS/SC Combo	6.29	29%	17
Slurry Seal	6.13	41%	24
Rejuvenator	5.63	14%	8
Coal Tar	5.6	9%	5
Fog Seal	4.75	7%	4
Seal Coat (Other)	4	5%	3

Rejuvenators were not originally included as their own category, though they were broken out after several people reported having the treatment somewhere on their airfield. Indeed, they were fairly common, occurring in 14% of the surveys (n=8), and having a decent rating of 5.63 out of 7. Coal tar based rejuvenators were the ones used, and in various places. Some small airports had it on their runways, others on their fueling area because the coal tar helps seal out things like fuel and hydraulic oil. Fueling stations and aprons were the two most likely places on an airfield to have just plan coal tar as well (n=5), though it was considered fairly effective for that purpose, earning 5.6 out of 7.

Fog seals were known in only 5% of the responses (n=4), and rated poorly with 4.75 out of 7.

When it came to markings, many of those answering survey questions did not know what type of markings were on their airfield. Most could answer that yes, there was reflective media in their paint, but that was it. Of those who did know (n=17, or 29%), oil was preferred as it lasted two to three times longer than waterborne, according to the survey.

Table 11. Marking Type and Rating

Markings		
Type	**Average Rating**	**Number**
Oil	6.43	7
Water	5.71	10

Four people reported doing something to explicitly retexture some part of their pavement. Each of the four was different, one used slurry as a retexturing method, another used a grinder, someone else employed waterblasting, and the fourth person reported doing an overlay. Waterblasting was the lowest ranked, with just a 1 out of 7 for retexturing. All others treatments were given a 6 out of 7.

However, when discussing rubber and contaminant removal, waterblasting received a 7 out of 7 from the one airport who reported having it used on their airfield. The only other contaminant removal methods reported pertained specifically to areas where there had been fuel spills, and involved the removal of some or all of the pavement surface course, either by grinding (n=2, 5.5 out of 7) or removing and replacing (n=1, 7 out of 7).

Lastly, when it came to concrete on the airfields, many GA airports expressed the desire to have it, though only a small number did. Some had concrete runways, others had concrete aprons or parking areas. Of those who had PCC on their airfield, they reported replacing the joint sealant on average once every 10 years. Additionally, Table 12 lists the maintenance methods and rating of those who were knowledgeable of their concrete.

Table 12. Concrete Maintenance Activities Rating and Number

Concrete		
Method	**Rating**	**No.**
Joint Repair	7	1
Crack Seal	7	1
Spall Repair	6	4
Patching	6.5	2

As mentioned previously, it was the state's systems that seemed to have the greatest impact on the work being done. Since each state can manage their aviation systems as they would like, there are some similarities but also some big differences in how pavement maintenance is approached by all the involved parties.

4.3 State Specific Findings

The role and responsibilities of the Airport Manager at General Aviation airports in the FAA Southwest Region depended heavily on the role of the state in assisting their GA facilities. The more involved the state is, the more routine maintenance is a priority. The systems in the five states in the FAA SW Region varied greatly, and included one block grant state (Texas), two states with a broad but involved central planning core (Arkansas and Louisiana), and two states with state-managed pavement management programs in place (Oklahoma and New Mexico). The way the system operates also dictates how funding is obtained and thus what work is done.

4.3.1 Texas

Texas as a state has more General Aviation airports than any other state except Alaska. A study by TxDOT (TxDOT, 2011) indicates that the GA system in Texas is economically critical, providing for more than 56,000 jobs and $3.1 billion in payroll, as well as $14.6 billion in total economic output for the year 2010. This included the 292 airports in the Texas Airports System Plan (TASP), 184 of which are in the NPIAS. Texas has 41% of the GA airports in the FAA SW Region, as well as 44% of the total operational runways. The most common other surface types besides asphalt, concrete, turf and dirt, are combination asphalt and concrete, including HMA overlays and portions of pavement being switched to the other material when replacement is needed.

Texas is a block grant state, where the FAA provides a certain amount of money to the Texas Department of Transportation (TxDOT) Aviation Division each year for non primary airport developments, and it is up to them to determine how to allocate it to the different airports. For Fiscal Year 2014, TxDOT received 3 block grants totaling $56,514,593.00 towards non primary Reliever and GA airports. While Reliever airports are eligible for money outside of the state block program, it depends on the classification of the airport and it's role in the greater National Airport System. While $56.5 million seems like a lot, if the state was to attempt to allocate it evenly among the 292 airports in the TASP, it would only provide about $193,543 to each airport. Since airport projects often and easily range up into the millions, Texas has to be extremely selective in where it spends the money, and obtaining funding for projects can take 3-5 years on average.

Texas has a priority ranking system for airports. Airport pavement projects are considered on the impact of their importance to the state and national system as determined by amount and type of traffic, as well as the deterioration status of the pavement. If an airport is included in the NPIAS, then it should have an AIP plan. During the course of interviewing people in Texas, it was revealed that up until several years ago, Airport Managers in Texas had annual meetings with TxDOT Aviation officials to discuss and update their AIP plans. It was during these annual meetings that advisers discussed routine maintenance needs, funding options, and made arrangements to request money from governing boards. At some point, these annual reviews quit occurring. Through conversations during the research process, it was discovered that about the time the meetings stopped, there was a large shift in senior management at TxDOT. A panel of three outside advisers, who had been appointed to figure out how to best restructure TxDOT, "recommended that the agency change its senior management to create a more business-like and entrepreneurial culture" (Lindenberger, 2011). These changes did occur, and with it, so did the culture of the agency. The person who had scheduled the meetings to go over AIP plans changed, and there was a new emphasis on economic development.

The engineers in TxDOT Aviation (there were 11 at the time of this research) had to change the way they planned and worked with airports. Now, they are not only evaluating and planning, but they are also the agency responsible for administering the grants to GA airports, setting the job priorities, and working with commercial and other primary airports to secure funding for major projects. Despite the complex array of activities they oversee, the overall funding structure is fairly simple. Navigating it is more difficult.

TxDOT Aviation offers several types of grants for GA airports. The 90/10 or 80/20 grant for AIP projects. That is, airports must provide 10-20% of the funds and the other 80-90% will come from the state block grant program. The other grant is the Routine Airport Maintenance Program (RAMP) grant. The RAMP grant allows for up to $50,000 annually in matching funds from the state for money the owner wants to invest in routine maintenance activities. There is a specific list of items which are eligible, though generally, if it can be considered routine maintenance of the facilities, it is covered.

TxDOT has a complex role in the TASP, if only because they literally do a little bit of everything. They work with airports to create a master plan, develop and maintain the AIP plans, and attempt to act as regular consultant. In the case of GA airports, TxDOT acknowledges that they act as the “engineering arm” for many of the sponsors. Whenever there is an issue, the Airport Manager calls TxDOT Aviation, who will send someone out to inspect the problem. If one is found, potential solutions are considered, and TxDOT goes back and sees how those solutions may fit into the AIP plan. If it is eligible for inclusion in the AIP, then every attempt is made to include it, since the owners get more funding help for those projects. Otherwise, it may be worked into a RAMP grant. Additionally, they can assist with obtaining emergency grants. Though not pavement related, one airport with a substantial amount of business traffic had an incident with a deer on the runway, and working with TxDOT, had an emergency federal loan for a wildlife barrier within 90 days. Several others mentioned things like lightning strikes and fuel spills that TxDOT had assisted in correcting.

After a problem and solution are identified, they must be funded. If it cannot be worked into the next round of AIP work, then a RAMP grant or other owner funding must be approved. The airport works with TxDOT engineers to get an estimate for the cost of the work. Then, the airport sponsor must present their case to the Airport Board, City Council, or County Commissioner's Court to get the funding approved. If they sponsor can get the funding approved, then they must contract with an engineering firm to get a formal bid package put together. An Invitation to Bid is issued, along with the specifications, and generally, unless otherwise specified, the lowest bidder meeting the minimum requirements is awarded. However, recently there has been a shift towards accepting bids on more value-driven alternatives, such as concrete instead of asphalt.

TxDOT would benefit from the utilization of a tool, such as a pavement database like MicroPAVER or PAVEAIR, hosted and supported centrally by the agency. This would provide a standard reporting system for pavement issues, as there is currently no standard reporting system for PCI at GA airports in Texas. TxDOT has a portion of their budget allocated to sending an engineer out to perform assessments of the GA airports around the state, but it is not a formal program, or fully funded, and so the full database of PCI information is incomplete, taking years to collect. On average, TxDOT is getting out to inspect airport pavements once every 3-5 years, sometimes longer than that. Airport sponsors keep an eye on their pavement, sometimes with the help of pilots, and other times with assistance from their city Streets or Public Works Department.

Additionally, when it comes to collecting data on RAMP grants and activities, the record keeping is minimal and general. While attempting to assess RAMP activities done with grant money, the authors found that specific information is not kept by TxDOT. In order to find that information, the contract documents from the individual jobs would have to have been located. But with so many grants combined with random odds that the activities would be pavement related (as opposed to facility or navaids), there was not enough time in this project to go through hundreds of contract documents to identify those which included pavement activities.

On the positive side, TxDOT's intense involvement means that they are very aware of the needs of their airport managers. They develop a relationship with their airport managers that enables them to work together to try and get things done in a timely manner. Those surveyed had nothing but positive things to say about working with TxDOT Aviation employees. If the agency were to implement a new system where they assisted their GA airports with getting information into a standard system, they could easily facilitate the transition. This is due to the high reliance of airports on engineering firms. Some owners contract engineers for set periods of time, others use a firm on a case by case basis. Some airports have had the same engineer for decades, simply because the engineer lives in the community in which the airport is located. These relationships can be good, because one person or firm can be intimately familiar with the history of the airport and know what maintenance issues are recurring. However, if the engineer is happy just giving the airport the cheapest pavement treatments for short term budget benefits, they could be doing the airport a disservice in the long term.

The relationships that exist among TxDOT Aviation employees, airport managers, and the engineering firms that support them are a place to implement improvement. Engineers know that GA airports do not have a lot of money, and rarely try to sell them on things like life-cycle cost analysis unless required. There is not generally a proactive approach to pavement, though that seems to be less an issue of interest than of money. Right now, most Airport Managers in Texas do not feel it is their job to be pavement engineers, because that is the way they have come up in the existing system. In differentiating a good airport manager from a bad airport manager, it seemed that the good ones wanted to improve, to have more of a role in making those decisions. This would require educating them, empowering and enabling them to participate on that level. Providing a standard information reporting system that was managed by TxDOT could provide everybody the data they want and give Airport Managers a heightened sense of responsibility and ownership of their airport pavements.

One thing that was repeated by proponents of pavement planning systems at airports was "Every airport needs a champion!" The state can only do so much, they usually only get to see the airfields after they have been called out for a problem. Once an issue has been identified, it is up to the Airport Manager (who is generally the sponsor) to obtain funding. This can take the form of a presentation or a proposal to their approval committee, submission of a form, or information from an engineering firm. Regardless, obtaining funding is usually a highly political affair. Many of the little cities, municipalities, and counties have a low tax base and high need for money. That money can be allocated to a lot of things: better roads, new traffic lights, new parks, memorials, water treatment, energy, any number of things a city or county may need to pay for.

Convincing a majority of people to vote for thousands of dollars for something not considered "critical" is difficult. This is why elected Airport Managers may not be effective. Rarely do City Managers and County Judges campaign on improving the airport. If they themselves do not understand the need, it is difficult to convince others to spend the money on it. The sponsors must understand the importance of pavement planning, have the longevity and diplomacy to work with opposing forces to get projects accomplished. A central database, compatible with MicroPAVER, hosted by TxDOT and regularly populated with information from engineering firms and Airport Managers would provide the data TxDOT needs to manage the airport pavements across the state.

4.3.2 Louisiana

Louisiana General Aviation airports are overseen by the Louisiana Department of Transportation and Development (LA DOTD). Aviation is in the Multimodal division of the agency. Of their 62 public use GA airports, Louisiana has 48 airports on the NPIAS, representing 11% of the GA airports in the FAA SW Region, and 9% of the runways, with 60. On the surface, 49 of those runways are asphalt, nine are concrete, one is turf/dirt, and the other is an asphalt/concrete combination with an asphalt friction course on top. Of note, Louisiana also has the most average daily movements (adm) per airport at 80.65, with a high of 288 adm and a low of 12.27 adm. Since traffic loading is so stressful on pavements, it is necessary for the state to take a proactive approach to their airfield pavements.

There are 69 airports in the Louisiana Airport System Plan (LASP). Two-thirds (36 of 48) are owned by the city or county (parish) in which it is located. Louisiana has the highest number of airports owned and operated by an airport authority, with seven. Louisiana is also the only state in the FAA SW Region that has special pavement specifications for non-federally funded airports, referred to as "State Standards" (LA DOTD, 2014). These standards were developed from previous FAA General Aviation Airport Standards for airport development. It specifically notes that these standards are for "State-only airports where FAA design guidelines do not apply" (LA DOTD, 2014, p. 31).

Money is available in Non-Primary Entitlement (NPE) grants and loans. State apportionments are available to cover up to 100% of state sponsored work and 10% of federally sponsored work. In FY 2014, Louisiana received 22 grants for their GA airports totaling $8,666,934.00. In addition to this money, the state sets aside $30 million annually for airports. Primary airports (of which there are 7) are eligible to apply for $20 million of this money, the 62 GA airports can apply for the other $10 million. LA DOTD operates the General Aviation and Reliever Airport Grant Program, which provides reimbursement for GA and Reliever maintenance activities up to 50% of $300,000 per fiscal year out of NPE funds. Airports are eligible to "bank" this money for up to 4 years, allowing them to plan a larger project knowing they have $600,000 to use. They also offer the 90/10 AIP grant and an 80/20 grant, which requires the sponsor to provide up to 20% of the funding. With an 80/20 grant, the state will match up to 10% of the required amount, meaning that airport sponsors could only be responsible for 10%. For a given project, the FAA determines what portion of the project is eligible for federal funding with AIP money.

The FAA uses the 5-year CIP submitted by each airport annually to plan and prioritize projects. LA DOTD uses the CIP as a grant application process, scoring requests themselves to assist in setting the state program. As opposed to states like Texas, Louisiana allows all of their public use airports to apply for grant money from the state for routine maintenance. This includes primary and commercial airports and non-NPIAS airports. When it comes to scheduling work, LA DOTD uses a scoring system in their Airport Construction and Development Priority Program. Sponsors submit their requests, and each project is scored. The work is then budgeted and scheduled for the year in the Program. According to LA DOTD, if a project receives 90% or more of it's funding in Federal dollars or other out of state money, that project is given priority in the program, even if it had none before. The scoring system considers:

- Project type
- Facility usage
- Sponsor compliance
- Special considerations

Project types include (in order of importance): safety; airside preservation; airside improvements; and landside improvements. Facility usage includes (in order of importance): based aircraft; enplanements; and reliever airports. Sponsor compliance is comprised of (in order of importance): height zoning; land use; and sponsor responsibility. Other special considerations include: special programs; economic development potential; commerce service; local funding, and GA Entitlement Loan Program.

LA DOTD requires monthly inspections of their airport pavements. Additionally, once per year, a LA DOTD engineer will go out and perform the 5010 annual pavement inspection. Airports may contract with a consultant or retain one when needed. LA DOTD works closely with their Airport managers on their 5-year CIP, since it sets the priority for scheduling work and allows for planning at least 5 years out. The largest concern of airport managers was the new classifications for GA airports and how that was going to impact the project prioritization process. Survey respondents felt that the state should be able to set the designation of the airports, since the state was more familiar with the role that airports played locally.

Louisiana airports seem to be proactive in applying surface treatments. For example, coal tar rejuvenators are popular in the state. This is due to high UV exposure and wet climatic conditions of asphalt pavements. Several airports have a regularly scheduled application of the material, to keep pavements flexible and water from intruding through the surface. This proactive approach by leadership, along with the large amounts of flexible funding, provide for a fairly stable pavement management system in the state.

While the LA DOTD is available to assist with planning and development, there is still no central repository of information maintained by the state. The state is able to play a strong supporting role, but lacks the information to make improvements based on data such as would be possible if they utilized a system like PAVEAIR. Additionally, benefits of treatments such as rejuvenators could be analyzed to see if they are actually improving the condition of the pavement or at least slowing the deterioration over time and extending the life.

In Louisiana, the Airport Manager takes a central role in the planning process. It is up to them to update the CIP every year. They must also show justification for the projects they are requesting, as well as an anticipated budget for the projects. This means they must be familiar with treatment options and costs. It is up to the sponsor to provide all paperwork, records, and documentation necessary to obtain grant funding. Sponsor relationships with DOTD are strong, everyone wants to know where they stand in prioritization, and thus funding.

4.3.3 Arkansas

The Arkansas Department of Aeronautics (ADoA) is a standalone agency of four staff members and seven commission members overseeing the 91 public use state airports, 73 of which are NPIAS GA airports, or 16% of the GA airports in the FAA SW Region. They have 14% of the runways (n=90), 78 of which are asphalt, 11 are concrete, and 1 is turf/dirt. Of those 73 airports, 69 are owned by the city or county in which they are located. Of the other four, two are owned by the state and two are owned by the airport authority that oversees them. They have the second highest average daily movements per airport at 56.42, with a high of 168 adm and a low of 5.57 adm.

Arkansas received 42 General Aviation grants last year, totaling $13,379,186.00. Additionally, 2 Reliever grants were awarded, at $1,002,959.00. ADoA gets their state funding from a Special Revenue account derived from the sales tax paid on aircraft, aviation fuel/aviation related products, parts and repairs or service. Although there are 91 public use airports, it was explicitly stated that the NPIAS airports are given priority.

Arkansas offers a variety of grant options. At the state level, there is the 90/10 match grant, where the ADoA will match the 10% for the sponsor up to $100,000. Additionally, they have the state 80/20 match grant, and state share not to exceed $300,000 per year. Although not explicitly mentioned by the agent, the ADoA newsletter for July 2013 also discusses a 50/50 match grant, with state share not to exceed $300,000 (Arkansas Department of Aeronautics, 2013). For AIP projetcs, they will match the sponsors 5% or 10%, dependent on grant type, up to $350,000. Like Louisiana, commercial airports in Arkansas are eligible to apply for grants for routine maintenance. ADoA provides up to $15 million in grant assistance annually.

The ADoA inspects every airport every year. There are approximately 30 "official" visits from the FAA per year, according to the ADoA, and so it is in their interest to keep all airports in the best shape possible. Since the state monitors the pavement, they have a hand in planning, scheduling, and funding work. They prioritize safety projects in what they refer to as their State System Plan. They also stated that they push their airports to be self-sufficient when it comes to planning, since they are familiar with the volumes and uses of their airports. For example, it was stated that there are many agricultural operations in the delta region, and the ADoA wanted to allow their airport managers to plan for whatever operations they needed. The ADoA did mention that Oklahoma had copied and adapted their system about 8 years ago, improving on it in ways that Arkansas respected.

The ADoA maintains several documents, including their State System Plan, the CIP plan, and airport layout drawings for all of their public use airports. They promote aviation safety through various programs, and sponsor several clinics. Additionally, in the push for GA self-sufficiency, the ADoA stated that they do things such as build hangars and other facilities (such as fuel stations) to help airports afford their own bills. They noted that it would probably take 10-12 years for airports to start turning profits from those endeavors, but they wanted to give them the infrastructure to at least get them going.

The airport sponsor is responsible for updating the ACIP plan on a regular basis. One survey respondent stated he sits down once a month with the airport commission and his engineers to go over his 20 year plan. Sponsors work closely with engineering firms to develop plans and keep them updated. One actually stated that engineering firms are required to be on contract in Arkansas, but that they reevaluate their firm every 5 years to make sure they are happy with the work being done.

The benefit of a program like the one the ADoA operates is that by performing pavement inspections at least once or twice per year, they keep their thumb on the conditions at each airport. However by placing the bulk of the planning responsibility on the airport, they also keep their own work load down, acting as funding support for airports. Thus, they can do more with less people. Overall, the system in Arkansas seems to be running smoothly, with airport sponsors comfortable working with their engineering firms to plan and the ADoA to schedule and fund work. It would be relatively easy to implement a central database for information, and have them input data after annual or bi-annual inspections. Additionally, since each airport is required to have an engineer, data entry requirements could be placed in the contracts for those firms to keep the airports they are responsible for updated. This would provide Arkansas with historical data for analysis and planning purposes.

4.3.4 Oklahoma

The airports in Oklahoma are assisted by the Oklahoma Aeronautics Commission (OAC), it is their job to oversee the airports in the Oklahoma Airport System Plan (OASP). Oklahoma has the second largest concentration of GA airports in the NPIAS in the FAA Southwest Region, with 96 out of their 114 total airports. On those NPIAS GA airfields, there are 129 runways, or 20% of the total in the region. These are mostly asphalt (n=85), but with a high number of concrete as well (n=30). There are 11 turf/dirt runways, 3 that are combination asphalt and concrete. They do, however, have the lowest average daily movements with 22.82 per airport, a high of 209 and a low of less than 1. Of those airports, 88 are owned by the city in which they are located, 5 are owned by the state, 1 by an airport authority, and 2 by Native American tribes.

For FY 2014, Oklahoma received 43 General Aviation grants totaling $18,682,835.00. Additionally, they received two Reliever grants totaling $4,680,077.00. Additionally, GA airports may receive funding from federal Non-Primary Entitlement (NPE) program, federal state apportionment, federal discretionary funds, and state funds. Both primary commercial service and general aviation airports must also match the funding with a percentage, ranging from 5% to 50% of federal and state funding. For non-federal (state) projects, the OAC will cover up to 95% of the total, with the remainder coming from the sponsor. In projects that qualify for ACIP, the OAC may meet 50% of the required match. Maximum cost share for supplemental ACIP projects is not to exceed 95%. Oklahoma will not match any funds for federal non-primary projects that are funded only with NPE or special allocation money.

Oklahoma has a very formal and rigorous pavement management program. The state monitors all pavement, and PCI is collected at a minimum every 2-3 years for entry into an online database. The database was created by a joint undertaking from faculty at Oklahoma University and the Colorado School of Mines, as well as professionals from Applied Research Associates, Fugro, and the OAC. The result is an online record of each public use airport in Oklahoma, including contact information, address, PCI, work history, and GIS information. For each airport, there is a color-coded PCI map, an aerial photograph overlaid with runway dimensions and runway numbers. Past PCI assessments can be viewed and a 5-year PCI forecast is generated using models and pavement curves. Though not entirely complete for every airport, the database aims to have a construction history for each section of airport pavement. Additionally, core sample results for material composition and strength will be included. The database includes access to each airport's NPIAS Needs Worksheet or Airport Development Worksheet. The database is maintained by the State of Oklahoma, and is available for public viewing at:

http://apms.aeronautics.ok.gov/index.php.

As part of the OASP, the state designates each airport aside from it's classification as General Aviation, Reliever, Commercial Service, etc. The first level of designation is based on airport role and includes Basic Utility, General Utility, and Transport. Basic Utility are the small airports designed for single engine aircraft, and precision approaches are not generally expected. General Utility airports are designed to accommodate more types of aircraft than Basic, and can handle most air-taxi and commuter aircraft with 20 seats or less and low approach business jets. Transport facilities serve large corporate or jet aircraft, such as Commercial Service. After an airport is assigned to one of these groups, a particular design standard may be applied (Basic Utility Stage I, Basic Utility Stage II, General Utility Stage I, General Utility Stage II, and Transport). The system is designed this way so that as traffic changes, airports can move from one classification to another, as forecast over 10 years.

The "functional classifications" are designed to better represent the role of the airport to the larger system; they are: Regional Business Airport; District Airport; and Community Airport. An airports functional classification will also "affect the role and the design standard for participation by the state and federal government with regard to a particular airport. It affects the capital items that are eligible for programming in the Capital Improvement Program (CIP), and it also affects the priorities used to prepare the CIP" (OAC, 2014). In other words, an airport's classification helps to denote it's priority and funding opportunities.

The OAC retain the records for each airport. It is the role of the OAC to: maintain inventories, classify airports, forecast aviation activity, conduct a public participation program, identify the capital improvements needed at each system airport, and conduct special studies. Because the state is so involved in the larger planning operations, the day to day things may get overlooked if sponsors are not mindful to include routine maintenance in their requests for work. For example, the American Society of Civil Engineers (ASCE), in their "2013 Report Card for Oklahoma's Infrastructure" (ASCE, 2012), gives Oklahoma Aviation a C+ overall. They referenced that 83 of the airports assessed in 2012 were given an average PCI rating of 66. If PCI can be expected to deteriorate at 3 points per year, then in 10 years, all of those pavements would need reconstructing. Their first recommendation in aviation is, “Increase funding for preventative maintenance in order to preserve the pavements now, in return saving many more dollars later when major repair or reconstruction will be required” (ASCE, 2012, p. 6). Oklahoma parameters for work are presented in Table 13.

Table 13. Oklahoma PCI Categories

PCI greater than 85 (Excellent)
PCI between 70 and 85 (Very Good)
PCI between 60 and 70 (Good)
PCI between 40 and 60 (Fair)
PCI less than 40 (Poor)

If the OAC can be shifted in a more proactive direction, they have the system in place to report regular pavement information. With a statewide airport pavement management system, Oklahoma has taken the first steps towards proactively managing all of their pavements. The data should be there, and analysis is allegedly leading to more in-depth understanding of pavement treatments and life-cycle costs.

It is up to the airport sponsor to work with the OAC to update their CIP annually. No activities may be included in the CIP that are not approved. Sponsors must determine the type of construction, the objective of the work, and what component of the airfield is effected. They work with engineering firms to put together estimates and bid packages. The sponsor is the chief airport administrator, in charge of putting together information in order to obtain funding to improve their airfield, but they have the support system behind them to make them successful. They handle all short and long term planning in partner with the OAC. The only other state that has a similar system in place in the FAA Southwest Region is New Mexico.

3.4.5 New Mexico

The New Mexico Department of Transportation (NM DOT), Aviation Division, is responsible for overseeing the 54 public use airports in the state, 44 of which are in the NPIAS. The 79 runways in use at these 44 NPIAS GA airports are mostly asphalt (n=67), with one concrete, seven turf/dirt, and four other surface types. The "other" types are gravel, the only state to have gravel runways on record. New Mexico GA airports average 30.6 movements per day, with a high of 189 and a low of less than one. Of those 44, 36 are owned by the city or county in which it is located, three are owned by the state, and five are owned by Native American Tribes.

NM DOT draws money from the state aviation fund, which is supported by aviation fuel sales. The fund draws 4.97% of gross fuel receipts, 0.26% of the gas tax, and 0.046% of the net receipts attributable to the gross receipts tax. Additionally, NMDOT receives federal grants. In FY 2014, NM DOT received 13 GA airport grants totaling $10,524,603.00. They also received 1 Reliever grant, totaling $143,079.00. The NM DOT participates in grants from 50/50 matching to 98/2 matching, depending on the type of project.

Airports are a big economy in New Mexico. According to a 2009 NMASP update, the aviation industry in New Mexico supporting 48,795 jobs and generating $1.3 billion in payroll. It contributes $761 million to the state's economy (New Mexico Aviation Aerospace Association [NMAAA], 2014). NM DOT recently (as of last year) undertook the implementation of a statewide airport pavement maintenance database. Working with consultants, they established an online tool called the Interactive Data

Exchange Application (IDEA). This tool contains the entire NM DOT airport system, including airport layouts, PCI scores, and work histories. All runways, taxiways, aprons, and other paved areas on the airfields were assessed and PCI was loaded into the online database. NM DOT also uses PCI, like Oklahoma, but their parameters read slightly differently. They assign:

- PCI 0 – 40: reconstruction
- PCI 41 – 70: major rehabilitation
- PCI 71 – 100: Preventive maintenance

Every year, it is the responsibility of the Airports Administrator to provide information to the consultant to update the database. This includes new or worsening distresses, work done, and any changes to PCI values. In this case, it is the consultant who is maintaining the database, but the state is responsible for the data that goes into it. Engineers at each airport will work with the Airports Administrator to ensure that all information is provided for entry into the database. It is in the state's scope of work with the consultant to update the database annually. Additionally, IDEA contains maintenance and rehabilitation work plans for 5 years out. These work plans include projected cost estimates for anticipated preventive maintenance, surface treatments, and major rehabilitations. There is also an online distress id manual with color pictures, so that sponsors have a reference tool for when they go out to inspect their airfields.

The implementation of a statewide airport pavement management system that includes projected costs will mean that money can be allocated more wisely, and that NM DOT will have a better idea of the condition of the system as a whole, rather than one airport at a time. The tables that have been compiled in the IDEA tool show the airports with the greatest pavement needs, and combined with NM DOT's own prioritization program, anticipated projects can be projected at least several years into the future, allowing for better budgeting. Also, it was stated that as a rule of thumb, all pavements are sealed every 3-5 years.

While the NM DOT did implement the statewide pavement management system, their goal was to make the airport managers more self-sufficient. They thought that if they could take the some of the technical planning out of the hands of the sponsors, they could free them up to deal with issues such as obtaining funding, dealing with day to day operations, economic development, and other jobs expected of people who manage airports. The major issues at GA airports, as stated by NM DOT, are weather, soil stabilization, and a mix of agricultural, emergency medical, and fire suppression needs.

When an airport sponsor wants to schedule work, they must first consult their airport master plan, action plan, or airport layout plan narrative report. Elements of an airport master plan include an inventory of existing conditions, aviation forecasts, facility requirements, alternatives evaluation, facility implementation plan, financial analysis, and airport layout plan preparation. Each airport is required to contract with an engineer firm, so they have someone to work with to make sure all of the master plan elements stay up to date. Uniquely, New Mexico does not have an airport commission, all work is established by the airport manager and their engineer, and then approved by the Airports Administrator. This streamlines the process, with one agency in charge of evaluating funding and scheduling work.

CHAPTER 5

CONCLUSIONS

5.1 Conclusions

The current attitude towards routine maintenance at many General Aviation airports in the states without a state managed program is reactive in nature. For those states with an airport pavement management system in place (Oklahoma, New Mexico), there was a mixed emphasis on long-term planning and being proactive, perhaps due to the work load involved when the state maintains the APMS. Of note, New Mexico went live with their system in 2014, and have not had the opportunity to evaluate it's long-term use. In the states with no "official" program in place but with fewer airports (Arkansas, Louisiana), there was more of a structured approach to airfield pavement planning.

The most common routine maintenance treatments are reactive in nature, especially crack seal and slurry seal. These treatments are used to treat distresses which have already appeared. A proactive approach is desired. In order for a proactive approach to become the norm, the paradigm in General Aviation culture toward planning and funding has to shift, which will likely be an issue of education.

The way the current system operates, long term pavement planning is not a priority for General Aviation airports, but that seems to be slowly changing. Balancing keeping up with existing infrastructure and promoting development at the same time can be challenging, especially for airports that are managed by a City Manager, County Judge, or other elected official with multiple responsibilities. Additionally, those responsible for approving the use of funds are not always aware of the cost-benefit of performing preventative maintenance.

The biggest barriers to an effective routine maintenance plan in most instances are cost and education. It would be beneficial for each state to work to implement some sort of state managed record keeping program. This data could then be analyzed and more efficient and effective pavement maintenance plans could be developed for cost savings over time. If needed, this information could then be taken to Airport Boards, County Commissioner's, and City Council's as support for funding routine maintenance.

Lastly, some sort of open communication between airport managers, state agencies, engineers, and the FAA is needed. Airport managers work with the state, the state works with the federal government, airport managers feel as though the FAA does not provide enough money for the standards they hold airports to. Engineering firms are in it to make money, and will charge accordingly for new services or additional requirements. If the desire is for General Aviation airports to take more responsibility for their airfields, then they need to be provided the framework in which to operate and the education necessary to easily perform the tasks asked of them.

5.2 Limitations

Each airport is different. Climate, materials, traffic, and other factors all impact the deterioration of pavements over time. While some of the findings may be generalizable across different states with similar systems, that is not known for sure, and so the results of this study apply only to the airports located in the FAA Southwest Region.

Airport managers change. Events change perceptions, and money has always been a key factor. If the current situation changes, such as funding or maintenance requirements, the culture will change to accommodate it. This could be in the direction of technological advancements, new systems, or material modifications. The systems examined in this project varied across the technological spectrum, and showed how advanced methods are being used to augment people's physical knowledge of pavement deterioration with hard numbers. As more convenient technologies become more affordable, the state of pavement maintenance will adapt.

5.3 Recommendations for Future Research

Opportunities to improve each state's current system exist. Future research should examine the individual systems from multiple perspectives. For example, information flows from a communication standpoint, or potential cost to upgrade systems from a Computer Information Systems perspective. There are many areas in which technology can be adapted for assistance in aviation.

The potential to offer education programs to decision makers is also a possible avenue for future research. A comparison of routine maintenance approved prior to educational sessions (in the form of presentations, webinars, formal training, etc.) to the quantity and quality of treatments approved after would be of interest. It could examine the difference in the choices people are educated about the long-term benefits and cost-savings of routine pavement maintenance make compared to those who are not. Overall, education seems to be one of the two largest barriers to implementation of an effective system, and anything that can be done to address that will be beneficial.

APPENDIX SECTION

Appendix A: Survey for Airports

Date: ______________________

Airport Name: ____

Airport Contact/Title/Time in Position: ______________________________________

Does your airport currently have a scheduled pavement management program in place?

____

If it is FAA software, which program? Who is responsible for maintaining it?

____

Who makes the pavement management decisions? ______________________________

Part of the goal of this project is to provide the managers of General Aviation airports better tools to assist them with making pavement management decisions. The information being collected will be analyzed in the development of at least two separate tools with the intention of providing a resource for pavement managers when making maintenance and rehabilitation choices. The goal is for these tools to be a source of information in aiding-decision makers in which treatments may be the best option based on their individual criteria (i.e. schedule, budget, development plans, etc.).

What type of information would you want to be included? What information do you feel you lack now?

____

____

____

If you had access to an online database of pavement maintenance activities, what types of information would you be interested in accessing? What types of queries would you run? *(Interviewer: Give examples for clarity)*

____

____

____

Now I'd like to ask you about specific treatments that have been done at your airport.

In your experience, on a scale of 1 to 7, how effective at treating the intended problem would you say the following treatments were:

		Not Effective at All					Extremely Effective	
Slurry Seal	N/A	1	2	3	4	5	6	7
Fog Seal	N/A	1	2	3	4	5	6	7
Seal Coat (other)	N/A	1	2	3	4	5	6	7
Crack Seal	N/A	1	2	3	4	5	6	7
Crack Seal/Seal Coat Combo	N/A	1	2	3	4	5	6	7
Microsurfacing	N/A	1	2	3	4	5	6	7
Cape Seal	N/A	1	2	3	4	5	6	7
Coal Tar	N/A	1	2	3	4	5	6	7
Other ______________	N/A	1	2	3	4	5	6	7

What type of markings does the airport have? (Waterborne/Solvent-Based/Methacrylate/Preformed)

Is there reflective media? (Y/N)			Not Effective at All						Extremely effective
Type:	________________	Y/N	1	2	3	4	5	6	7
Type:	________________	Y/N	1	2	3	4	5	6	7

Have you ever had to re-texture some part of your pavement? (Shotblast/UHP Water/Grinder/Other)

			Not Effective at All						Extremely Effective
Method:	________________	N/A	1	2	3	4	5	6	7

Has your airport ever performed rubber removal or contaminant removal? (Chemical/Mechanical/Waterblast/Shotblast)

			Not Effective at All						Extremely Effective
Method:	________________	N/A	1	2	3	4	5	6	7
Method:	________________	N/A	1	2	3	4	5	6	7

Concrete (Y/N): ________________

How often is joint sealant replaced? ____________________________

What other concrete surface maintenance practices have been utilized? (Spall repair/Joint repair/Other)

			Not Effective at All						Extremely Effective
Method:	________________	N/A	1	2	3	4	5	6	7
Method:	________________	N/A	1	2	3	4	5	6	7
Method:	________________	N/A	1	2	3	4	5	6	7

Is there anything else you would like to mention about your pavement surface maintenance?

REFERENCES

American Society of Civil Engineers [ASCE]. (2012). "2013 Report Card for Oklahoma's Infrastructure." Accessed July 2014, at http://okasce.org/resources/ASCE+OK+2013+Report+Card.pdf

Asphalt Institute. (2001a). *Superpave mix design (SP-2).* (3rd ed.). Lexington, Kentucky: Asphalt Institute.

Asphalt Institute. (2001b). *Construction of hot mix asphalt pavements (MS-22)*. (2nd ed.). Lexington, Kentucky: Asphalt Institute.

Arkansas Department of Aeronautics [ADoA]. (2013). "State Airport Aid Grant Classifications." July 2013. Accessed October 2014, at http://www.fly.arkansas.gov/Home/JULY13.pdf

Chu, C., & Durango-Cohen, P. (2008). Incorporating maintenance effectiveness in the estimation of dynamic infrastructure models. *Computer-Aided Civil and Infrastructure Engineering, 23*, 174-188.

FAA. (1993). *Airport pavements – Solutions for tomorrow's aircraft*. U.S. Department of Transportation, Federal Aviation Administration, FAA Technical Center, NJ.

FAA. (1997). *Measurement, construction, and maintenance of skid resistant airport pavement surfaces*. Advisory Circular No. 150/5320-12C.

FAA. (2004). *Airfield pavement surface evaluation and rating Manuals*. Advisory Circular No.150/5320-17.

FAA. (2007). G*uidelines and procedures for maintenance of airport pavements*. Advisory Circular No. 150/5380-6B.

FAA. (2009). *Airport pavement design and evaluation*. Advisory Circular No. 150/5320-6E.

FAA. (2010a). *Standards for airport markings*. Advisory Circular No. 150/5340-1k.

FAA. (2010b). *Airport pavement management program.* Advisory Circular No. 150/5380-7A.

FAA. (2012a). *General aviation airports: A national asset.* Accessed July 9, 2013, at http://www.faa.gov/airports/planning_capacity/ga_study/

FAA. (2012b). *Airport technology research plan – For the NextGen decade*. Accessed June, 2014, at http://www.airporttech.tc.faa.gov/10YearPlan

FAA. (2012c). *Airport design*. Advisory Circular No. 150/5300-13a.

FAA. (2013). Part 139 airport certification. Accessed April 1, 2013, at: http://www.faa.gov/airports/airport_safety/part139_cert/

Ferreira, A., Picado-Santos, L., Wu, Z., & Flintsch, G. (2011). Selection of pavement performance models for use in the Portuguese PMS. *International Journal of Pavement Engineering 12*(1), 87-97.

Hare, J. A., Pur, R. A., & Dempsey, B. J. (1990). Airport pavement drainage – Synthesis Report. United States Department of Transportation Report No. DOT/FAA/RD-90/24.

Gransberg, D. (2008). *ACRP synthesis 11: Impact of airport rubber removal techniques or runways*. Washington, D.C.: Transportation Research Board.

Grothaus, J. H., Helms, T. J., Germolus, S., Beaver, D., Carlson, K., Callister, T., Kinkel, R. & Johnson, A. (2009). *ACRP report 16: Guidebook for managing small airports.* Washington, D.C.: Transportation Research Board.

Louisiana Department of Transportation Development [LA DOTD]. (2014). “Aviation Regulations in Louisiana: How do they apply to your airport?” LA DOTD Aviation Training Workshop, Alexandria, LA. September 18, 2014. Accessed October 2014, at http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Multimodal/Aviation/Public_Outreach/State%20and%20Federal%20Regulations.pdf

Lindenberger, M. (2011). “Handpicked advisers tell TxDOT commissioners to ‘change senior leadership’”. Transportation Blog, *The Dallas Morning News*, January 5, 2011. Accessed September 2014, at http://transportationblog.dallasnews.com/2011/01/ handpicked-advisers-tell-txdot.html/

Lytton, R. L. (1987). Concepts of pavement performance prediction and modeling. Submitted to the *2nd North American Conference on Managing Pavements*. Toronto, Ontario, Canada. November 2-6.

Miller, J. S., & Bellinger, W. Y. (2003). *Distress identification manual for the long-term pavement performance program.* (4th ed.). FHWA Report No.: FHWA-RD-03-031.

New Mexico Aviation Aerospace Association (NMAAA). (2014). “Stats.” Accessed August 2014, at http://www.nmaaa.net/about/stats/

Oklahoma Aeronautics Commission (OAC). (2014). “Oklahoma Airport System Plan – Executive Summary.” pp.10. Accessed July 2014, at http://www.ok.gov/OAC/documents/Oklahoma%20Airport%20System%20Plan%20Revised.pdf

Packard, R. G. (1995). *Design of concrete airport pavement.* Skokie, Illinois: Portland Cement Association.

PavementInteractive.Org (University of Washington). (2013). *Asphalt modifiers.* Retrieved from http://www.pavementinteractive.org/article/asphalt-modifiers/#refmark-1

TxDOT. (2000). *Pavement management program for General Aviation airports*. Retrieved from http://www.txdot.gov/inside-txdot/forms-publications/publications/ aviation.html

TxDOT. (2011). "Economic Impact 2011 – General Aviation in Texas." Accessed April 2014, at http://txdot.gov/inside-txdot/division/aviation/eco-impact-aviation.html

Wang, F., Zhang, Z., & Machemehl, R. (2003). *Decision making problem for managing pavement maintenance and rehabilitation projects*. Submitted to 82nd Transportation Research Board Meeting, Washington D.C., January 12-16, 2003.