C CAPACITY ANALYSIS

INTRODUCTION. The capacity of an airfield is primarily a function of the major aircraft operating surfaces that compose the facility and the configuration of those surfaces (runways and taxiways). However, it is also related to, and considered in conjunction with, wind coverage, airspace utilization, and the availability and type of navigational aids. Capacity refers to the number of aircraft operations that a facility can accommodate on either an hourly or yearly basis, not to the size or weight of the aircraft.

Airfield Capacity Methodology

The evaluation method used to determine the capability of the airside facilities to accommodate aviation operational demand is described in the following narrative. Evaluation of this capability is expressed in terms of potential excesses and deficiencies in capacity. The methodology used for the measurement of airfield capacity in this study is described in Federal Aviation Administration (FAA) Advisory Circular 150/5060-5, *Airport Capacity and Delay*. From this methodology, airfield capacity is defined in the following terms:

- *Hourly Capacity of Runways*: The maximum number of aircraft that can be accommodated under conditions of continuous demand during a one-hour period.
- *Annual Service Volume (ASV)*: A reasonable estimate of an airport's annual capacity (i.e., level of annual aircraft operations that will result in an average annual aircraft delay of approximately one to four minutes).

The capacity of an airport's airside facilities is a function of several factors, including the layout of the airfield, local environmental conditions, specific characteristics of local aviation demand, and air traffic control requirements. The relationship of these factors and their cumulative impact on airfield capacity are examined in the following paragraphs.

Airfield Layout

The arrangement and interaction of airfield components (runways, taxiways, and ramp entrances) refers to the layout or "design" of the airfield. As previously described, Will Rogers World Airport is served by three principal runways: Runway 17R/35L, Runway 17L/35R, and Runway 13/31. The west parallel runway (Runway 17R/35L) is located west of the terminal complex, and is served by a full parallel taxiway (Taxiway A) on its east side and a partial parallel taxiway (Taxiway B) on in its west side. The east parallel runway (Runway 17L/35R) is located on the east side of the terminal complex, and is served by a full parallel taxiway on its west side (Taxiway E) and a parallel taxiway to the east (Taxiway H). The crosswind runway (Runway 13/31) is located west of the terminal complex and has a partial parallel taxiway system on its northeast side (Taxiway C).

Environmental Conditions

Climatological conditions specific to the location of an airport not only influence the layout of the airfield, but also impact the use of the runway system. Variations in the weather resulting in limited cloud ceilings and reduced visibility typically lower airfield capacity, while changes in wind direction and velocity typically dictate runway usage and also influence runway capacity.

Ceiling and Visibility. FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*, describes three categories of ceiling and visibility minimums for use in both capacity and delay calculations. Visual Flight Rules (VFR) conditions occur whenever the cloud ceiling is at least 1,000 feet above ground level and the visibility is at least three statute miles. Instrument Flight Rules (IFR) conditions occur when the reported cloud ceiling is at least 500 feet, but less than 1,000 feet, and/or visibility is at least one statute mile, but less than three statute miles. Poor Visibility and Ceiling (PVC) conditions exist whenever the cloud ceiling is less than 500 feet and/or the visibility is less than one statute mile.

Meteorological data from the National Climatic Data Center have been used to tabulate information at Will Rogers World Airport in more specific terms:

- *VFR conditions* - Ceiling equal to or greater than 1,000 feet above ground level and visibility is equal to or greater than three statute miles. These conditions occur at the Airport approximately 82.2% percent of the time annually.

- *VFR minimums to existing Category I ILS approach minimums* - Ceiling less than 1,000 feet and/or visibility less than three statue miles, but ceiling equal to or greater than 200 feet and visibility equal to or greater than ½ mile. These conditions occur at the Airport approximately 15.6% of the time annually.

- *The Airport also has very low minimum instrument approach capabilities (Category II), which allow properly equipped aircraft operated by properly trained pilots to operate when visibility conditions are as low as ¼ mile. Visibility minimums lower than ½ mile, but equal to or greater than ¼ mile, occur at the Airport approximately 1.4% of the time annually.*

Wind Coverage. Surface wind conditions have a direct effect on the operation of an airport; runways not oriented to take the fullest advantage of prevailing winds will restrict the capacity of the Airport to varying degrees. When landing and taking off, aircraft are able to properly operate on a runway as long as the wind component perpendicular to the direction of travel (defined as a crosswind) is not excessive.

The determination of the appropriate crosswind component is dependent upon the Airport Reference Code (ARC) for the type of aircraft that use the Airport on a regular basis. The ARC is set by the approach speed and wingspan of the "Design Aircraft" (the most critical aircraft in consideration of wingspan and approach speed that will regularly use a runway). As presented in the previous chapter, the most critical aircraft associated with the parallel runways (in regard to wingspan) is the B-757, which has an ARC classification of C-IV. However, several other commercial passenger, air cargo, and business jet aircraft could utilize these runways that have faster approach speeds (i.e., category "D"). Examples of category "D" approach speed aircraft include the Gulfstream II and IV). This group of aircraft indicates that D-IV is the appropriate ARC classification for the parallel runways at Will Rogers World Airport. However, it should be noted that Runways 17R/35L, 17L/35R, and 13/31 have been designed and constructed to ARC D-V criteria in the past, and it is expected that this designation will continue in the future.

Runway 18/36 has historically been used by ANG C-130 aircraft for training, and has been designed to ARC C-IV criteria. With the recent ANG mission change and the subsequent re-assignment of C-130 aircraft, it is doubtful that this runway will remain operational. However, should a decision be made to keep the runway functional, ARC C-IV is the appropriate designation.

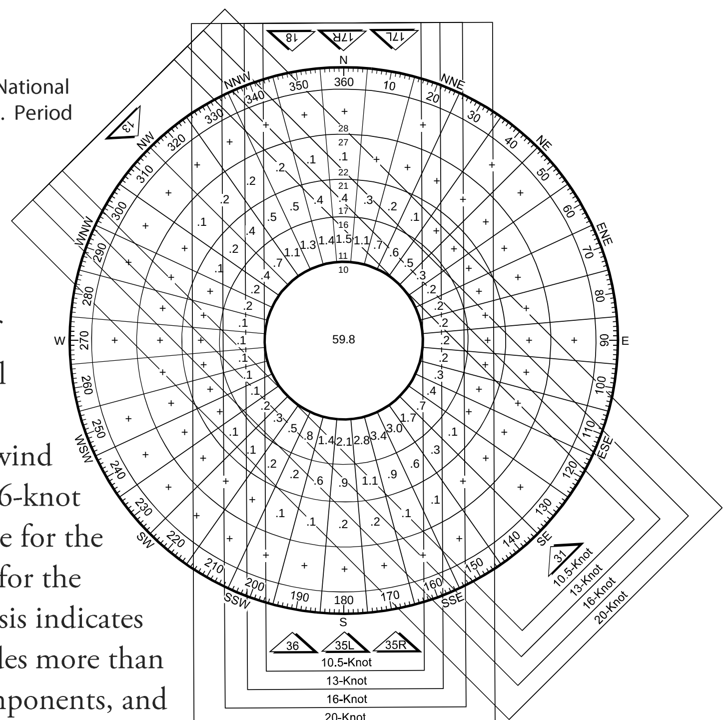
Another consideration is the fact that many aircraft operating at the Airport fit into the smaller ARC categories (A-I, B-I, B-II, C-I, and C-II). According to FAA AC 150/5300-13, *Airport Design*, for ARC A-I and B-I airports, a crosswind component of 10.5 knots is considered maximum. For

ARC A-II and B-II airports, a crosswind component of 13 knots is considered maximum. For ARC C-I through D-III airports, a crosswind component of 16 knots is considered maximum. Finally, for ARC A-IV through D-VI airports, a crosswind component of 20 knots is considered maximum. Because Will Rogers World Airport is utilized regularly by all sizes and types of aircraft, with various ARC categories, the wind coverage analysis will consider all four crosswind components.

To determine wind velocity and direction at Will Rogers World Airport, wind data were obtained and an all weather wind rose was constructed, which is presented in the following illustration, entitled *ALL WEATHER WIND ROSE*. The wind data to construct the wind rose were obtained from the National Climatic Data Center for the period January 1997 through December 2006 from a weather station located at the Airport.

Figure C1 **ALL WEATHER WIND ROSE**

Source: National Oceanic and Atmospheric Administration, National Climatic Data Center. Station 72353, Oklahoma City, Oklahoma. Period of Record: 1997-2006.

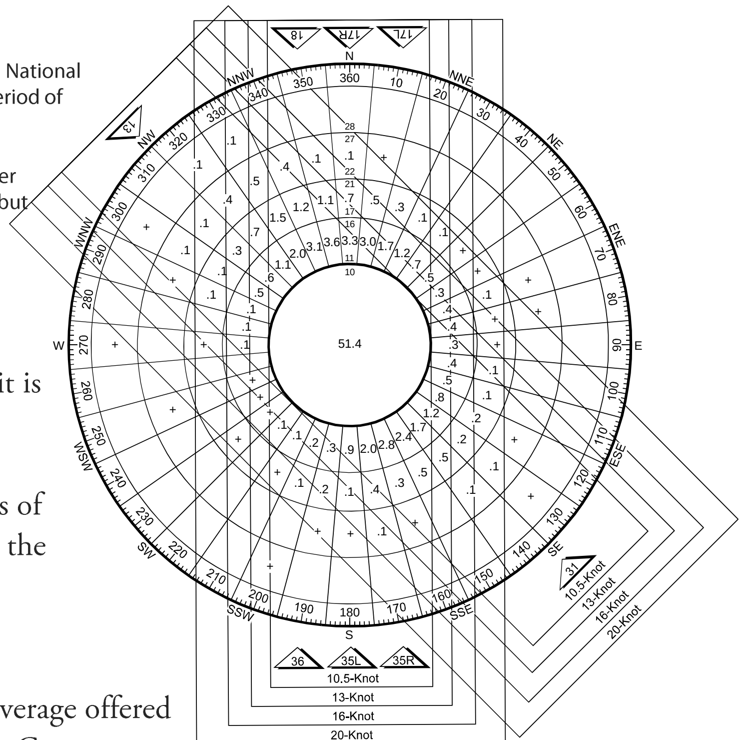


The desirable wind coverage for an airport is 95%. This means that the runway should be oriented so that the maximum crosswind component is not exceeded more than 5% of the time. Based on the wind analysis for Will Rogers World Airport, the runways provide 99.94% wind coverage for the 20-knot crosswind component, 99.79% wind coverage for the 16-knot crosswind component, 99.29% wind coverage for the 13-knot crosswind component, and 98.12% for the 10.5-knot crosswind component. This analysis indicates that the existing runway configuration provides more than adequate wind coverage for all crosswind components, and that no additional runways are required to provide additional wind coverage. As stated previously, the Airport currently has four Category I ILS (decision height of 200 feet, visibility minimums of ½ mile) instrument approach procedures; along with a Category II ILS (decision height of 100 feet, visibility minimums of ¼ mile) approach procedure serving Runway 35R. In an effort to analyze the effectiveness of these approaches, the following Instrument Flight Rules (IFR) wind rose has been constructed and is presented in the following figure entitled *IFR WIND ROSE*. Again, wind data from the National Climatic Data Center have been used in the construction of the IFR wind rose.

Figure C2 **IFR[1] WIND ROSE**

Source: National Oceanic and Atmospheric Administration National Climatic Data. Station 72353, Oklahoma City, Oklahoma. Period of Record: 1997-2006.

Note: [1] Ceiling of less than 1,000 feet, but equal to or greater than 200 feet and/or visibility less than three statute miles, but equal to or greater than ½ statute mile.



While the following table illustrates information provided for the Category I precision instrument approach condition, it is recognized that all the approaches play an important role in accommodating IFR conditions. Basically, from an effectiveness of the location of the instrument approaches, the existing runway orientation is adequate in accommodating all the approaches.

The following table quantifies the wind coverage offered by each runway end in consideration of the Category I precision approach minimums (ceiling less than 1,000 feet and/or visibility less than three statute miles, but ceiling equal to or greater than 200 feet and visibility equal to or greater than ½ statute mile).

Table C1 **IFR WIND COVERAGE SUMMARY**

Runway Designation	Wind Coverage Provided Under IFR Conditions[1] 20-Knot Crosswind	16-Knot Crosswind	13-Knot Crosswind	10.5-Knot Crosswind
Runway 17R/L	51.00%	50.48%	48.72%	46.23%
Runway 35R/L	74.34%	73.61%	71.37%	68.20%
Runway 13	60.76%	60.20%	57.95%	55.16%
Runway 31	69.94%	69.06%	65.36%	59.51%
Combined	99.91%	99.82%	99.38%	98.16%

Source: BARNARD DUNKELBERG & COMPANY utilizing the FAA Airport Design Software supplied with AC 150/5300-13, *Airport Design*. [1] Ceiling of less than 1,000 feet, but equal to or greater than 200 feet and/or visibility less than three statute miles, but equal to or greater than ½ statute mile. 5-knot tailwind to maximum headwind.

From this IFR wind coverage summary, it can be determined that the runways' existing instrument approach capabilities provide excellent wind coverage during IFR conditions.

Characteristics of Demand

There are certain site-specific characteristics related to the aircraft fleet makeup and aviation uses that impact the capacity of the airfield. These characteristics include aircraft mix, runway use, percent arrivals, touch-and-go operations, exit taxiways, and air traffic control rules.

Aircraft Mix. The capacity of a runway system is dependent upon the type and size of the aircraft that use the facility. FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*, categorized aircraft into four classes based on maximum certificated takeoff weight. This differs from the Airport Reference Code (ARC) defined previously, which classifies aircraft based on aircraft approach speed. For aircraft mix, aircraft Classes A and B consist of small single engine and twin-engine aircraft (both prop and jet), weighing 12,500 pounds or less, which are representative of the general aviation fleet. Classes C and D aircraft are larger jet and propeller aircraft typical of the business jet fleet, the airline fleet, and the military fleet. The majority of aircraft operations at Will Rogers World Airport are classified as Class C (aircraft weighing between 12,500 and 300,000 pounds), with a few operations by Class D aircraft (over 300,000 pounds).

According to AC 150/5060-5, aircraft mix is defined as the relative percentage of operations conducted by each of these four classes of aircraft. The aircraft mix for Will Rogers World Airport is depicted in the following table entitled *AIRCRAFT CLASS MIX FORECAST, 2006-2026*.

Table C2 **AIRCRAFT CLASS MIX FORECAST, 2006-2026**

	VFR Conditions			IFR Conditions		
Year	**Class A & B**	**Class C**	**Class D**	**Class A & B**	**Class C**	**Class D**
2006[1]	17.2%	81.6%	1.2%	12%	88%	<1%
2011	17.5%	81.5%	1.0%	12%	88%	<1%
2016	18.0%	81.0%	1.0%	13%	87%	<1%
2021	18.5%	80.5%	1.0%	14%	86%	<1%
2026	18.5%	80.5%	1.0%	15%	85%	<1%

Source: BARNARD DUNKELBERG & COMPANY.
Class A - Small Single Engine, < 12,500 pounds
Class B - Small Twin Engine, < 12,500 pounds
Class C - 12,500-300,000 pounds
Class D - > 300,000 pounds
[1] Actual.

Runway Use. Runway use is defined by the number, location, and orientation of the active runway(s) and relates to the distribution and frequency of aircraft operations to those facilities. It is estimated that landings and takeoffs occur on Runway 13 approximately 2.5% of the time, Runway 31 approximately 5.0% of the time, Runway 17L approximately 19.1% of the time, Runway 17R approximately 40.1% of the time, Runway 35L approximately 22.1% of the time, and Runway 35R approximately 11.2% of the time. Landings and takeoffs occurred on Runway 18, but are not sufficient to be a statistically meaningful number.

Percent Arrivals. Runway capacity is also significantly influenced by the percentage of all operations that are arrivals. Because aircraft on final approach are typically given absolute priority over departures, higher percentages of arrivals during peak periods of operations reduce the Annual Service Volume. The operations mix occurring on the runway system at Will Rogers World Airport reflects a general balance of arrivals to departures. Therefore, it was assumed in the capacity calculations that arrivals equal departures during the peak period.

Touch-and-Go Operations. A touch-and-go operation refers to an aircraft maneuver in which the aircraft performs a normal landing touchdown followed by an immediate takeoff without stopping or taxiing clear of the runway. These operations by civilian and military operators are normally associated with training and are included in local operations figures. Touch-and-go operations comprised approximately 10% of all operations at the Airport in 2006, which are fairly standard numbers for a commercial service airport of this size. By the end of the 20-year planning period, local operations are forecast to decrease slightly, to approximately 9% of the total aircraft operations at the Airport.

Exit Taxiways. The capacity of a runway is greatly influenced by the ability of an aircraft to exit the runway as quickly and safely as possible. Therefore, the quantity and design of the exit taxiways can directly influence aircraft runway occupancy time and the capacity of the runway system.

Due to the location of the existing exit taxiways serving the runway system at the Airport, the number of available exit taxiways for use in the capacity calculation is adequate. Based upon the mix index of aircraft operating at the Airport under VFR conditions, the capacity analysis, as described in the FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*, gives credit to only those runway exit taxiways located between 5,000 and 7,000 feet from the landing threshold. Therefore, several of the runways received exit factors lower than the maximum. From a capacity standpoint, it appears that the runway system might benefit from additional exit taxiways. The future location of all taxiway improvements will be evaluated in conjunction with the formulation of airside development alternatives.

Air Traffic Control Rules. The FAA specifies separation criteria and operational procedures for aircraft in the vicinity of an airport contingent upon aircraft size, availability of radar, sequencing of operations, and noise abatement procedures (both advisory and/or regulatory) that may be in effect at that airport. The impact of air traffic control on runway capacity is most influenced by aircraft separation requirements dictated by the mix of aircraft using that airport. Presently, there are no special air traffic control rules in effect at Will Rogers World Airport that significantly impact operational capacity.

Airfield Capacity Analysis

As previously described, the determination of capacity for Will Rogers World Airport uses the methodology described in the FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*. Several assumptions are incorporated in these capacity calculations: arrivals equal departures, the percent of touch-and-go operations is between 0-50% of total operations, there is a full-length parallel taxiway with ample exits and no taxiway crossing problems, there are no airspace limitations, the Airport has at least one runway equipped with an ILS and the necessary air traffic control facilities to carry out operations in a radar environment, IFR weather conditions occur roughly 10% of the time, and approximately 80% of the time the Airport is operated with the runway use configuration that produces the greatest hourly capacity.

Applying information generated from the preceding analyses, capacity and demand are formulated in terms of the following results:

- **Hourly Capacity of Runways (VFR and IFR)**
- **Annual Service Volume (ASV)**

Hourly Runway Capacity

Calculations of hourly capacity begin with an evaluation of each possible runway use configuration at the Airport. With consideration of the Airport's aircraft mix index, annual percentage of touch-and-go operations, and taxiway exit rating, an hourly capacity was calculated. In its normal operating configurations, the Airport's VFR hourly capacity is potentially as high as 111 operations and the IFR hourly capacity is potentially as high as around 98 operations per hour.

Annual Service Volume

After determining the hourly capacity for each potential runway use configuration, a weighted hourly capacity of the entire airport can be calculated. The weighted hourly capacity takes into consideration not only the aircraft mix index, but also the percent utilization of each possible runway use configuration. The weighted hourly capacity for Will Rogers World Airport for 2006 was determined to be approximately 91 operations per hour. This weighted hourly capacity can then be used in calculation the ASV for the Airport. The ASV is calculated using the following formula:

$$ASV = C_W \times D \times H$$

C_W Weighted hourly capacity
D Ratio of annual demand to average daily demand
H Ratio of average daily demand to average peak hour demand

With the existing runway configuration, and in consideration of existing utilization patterns, Will Rogers World Airport has been determined to have a daily ratio (D) of 318 and an hourly ratio (H) of ten and, thus, an ASV of approximately 289,494.

Conditions involved in the determination of the weighted hourly capacity and the daily demand are not forecast to change significantly at Will Rogers World Airport in the future, and those numbers will remain fairly constant through the planning period. The hourly ratio, as specified in the formula, is the inverse of the daily operations that occur during the peak period. In other words, as operations increase, the peak periods tend to spread out, increasing the hourly ratio.

As the hourly ratio increases, the ASV will increase. Thus, as presented in the following table, entitled *AIRFIELD CAPACITY FORECAST SUMMARY, 2006-2026*, even without runway improvements, the ASV at the Airport will increase to approximately 290,580 operations by 2026.

In summary, it can be determined from the analysis that the existing airfield at Will Rogers World Airport has adequate capacity to accommodate forecasted traffic throughout the planning period. However, because of increased demand from landside development and other factors, additional improvements (e.g., taxiway improvements, a future parallel runway, etc.) should be examined and programmed to maintain an efficient and safe aviation operational environment.

Table C3 **AIRFIELD CAPACITY FORECAST SUMMARY, 2006-2026**

Year	Annual Operations	Design Hour Operations	Annual Service Volume (ASV)
2006	108,318	34	289,494
2011	109,239	34	289,409
2016	116,482	37	289,582
2021	124,200	39	290,394
2026	132,688	42	290,580

Source: BARNARD DUNKELBERG & COMPANY utilizing FAA AC 150/5060-5, *Airport Capacity and Delay*.

Ground Access Capacity

The capacity of a ground access system is a function of the maximum number of vehicles accommodated by a particular facility. At Will Rogers World Airport, this relates primarily to the roadway system capacity, which is the number of vehicles that can use a certain roadway section in a given time period.

The capacity analyses for the roadways providing access to the Airport, as well as the airport roadway system, are based on the *Highway Capacity Manual*, published by the Transportation Research Board, Special Report 209, 1994. According to this manual, it is normally preferred that roadways operate below capacity to provide reasonable flow and minimize delay to the vehicles using it. The manual defines different operating conditions, known as levels-of-service. The levels-of-service are functions of the volume and composition of the traffic and the speeds attained. Six levels-of-service have been established, designated by the letters A-F, providing for best to worst service in terms of driver satisfaction. Level-of-service A roadways are completely unimpeded in their ability to maneuver within the traffic system. A level-of-service C (stable traffic flow and minimal delays) is generally the preferred level-of-service on an urban road system. Average hourly volumes of airport service roadways of typical facilities at level-of-service C and D are summarized in the following table entitled *GROUND ACCESS FACILITY VOLUME*. The various ranges given in the table makes their use in defining roadway capacity analysis useful primarily for initial problem testing.

Table C4 **GROUND ACCESS FACILITY VOLUME**

Facility Type	**Average Hourly Volume[1] (Vehicle/Hour/Lane)[2]**
Main-access and feeder freeways (controlled access, no signalization)	1,000-1,600
Ramp to and from main-access freeways, single lane	900-1,200
Principal arterial (some cross streets, two-way traffic)	900-1,600
Main-access road (signalized intersections)	700-1,000
Service road	600-1,200

Source: Highway Capacity Manual, Transportation Research Board, Special Report 209, 1985.
[1] Highway Levels-of-Service C and D. [2] Passenger-Car Equivalents.

The breadth of the ranges given in the above table is most useful for initial testing of problems with roadway capacity. The focus of the access roadway capacity assessment is on the service provided between the terminal curb or parking area and the interchange linking the Airport with the regional transportation system. Thus, the analysis for Will Rogers World Airport is focused on Terminal Drive, which connects the terminal area with Meridian Avenue and Airport Road. The information presented in the previous table would indicate that, at a level-of-service in the C to D range, the existing airport access road (Terminal Drive) has a capacity of 900 to 1,600 vehicles per hour. The following table presents existing and forecasted peak hour passenger cars in the peak direction. These estimates are intended to be somewhat high and are based upon 100% of passengers arriving at the Airport in rental cars or private automobiles, and the average vehicle occupancy rates typically observed at airports similar to Will Rogers World Airport (one passenger per vehicle).

Table C5 **AIRPORT ACCESS DEMAND FORECAST, 2006-2026**

Year	Peak Hour Passenger Cars in Peak Direction
2006	750
2011	828
2016	914
2021	1,009
2026	1,114

Source: BARNARD DUNKELBERG & COMPANY.

As can be seen even using these high estimates, it appears that the terminal access roadway system has adequate capacity to accommodate forecasted passenger traffic through the planning period. This analysis does not consider background traffic (traffic using the roadways that is unrelated to passenger traffic), the mix of traffic (semi-trailer trucks vs. automobile), or the capacity of the existing intersections. Access roadway capacity should be analyzed periodically to determine if improvements are needed.

Other ground access issues are important, but are not specifically capacity considerations. These include:

- Improvements to S.W. 54th Street from Interstate 44 to MacArthur Boulevard have recently been completed.
- Relocation of MacArthur Boulevard to the west has recently been completed. Plans included in the Southwest Sector Plan are for the additional re-alignment south to S.W. 104th Street.
- The relocation of Portland Avenue on the east side of the Airport has been considered and is an important element of this Master Plan Update. Relocation of this major arterial would provide a substantial amount of property available for aviation development east of Taxiway H.
- Other proposed street improvements from the Southwest Sector Plan include:
    - **Improvements to S.W. 104th Street from Portland Avenue to MacArthur Boulevard.**
    - **The extension of the West Outer Loop from the current end point of the Kilpatrick Turnpike at S.W. 15th Street south and east to the intersection with**

the Airport Road Expressway extension. Ultimately, the West Outer Loop is proposed to extend south of the Airport and east to Interstate 35.

- **Extension of Airport Road from MacArthur Boulevard south and west to Council Road.**

Summary

This chapter analyzed the capacity of existing facilities at Will Rogers World Airport. Both adequate airfield and ground access facilities are critical in the ability of the Airport as a whole to serve the public efficiently. Capacity breakdowns that cause delays associated with one component will be reflected in the ability of the entire facility to function properly.

The following chapters will delineate the facility needs that will be necessary to accommodate future demand properly. That information, along with the capacity analysis, provides the basis for the evaluation of airport development alternatives, which will then evolve into the formulation of the long-term development plan for the Airport.