GREENVILLE-SPARTANBURG INTERNATIONAL AIRPORT

2040
WINGSPAN
A VISION FOR THE FUTURE

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AIRPORT MASTER PLAN UPDATE
CHAPTER 5: FACILITY REQUIREMENTS

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5. Facility Requirements

This chapter presents the airside and landside facility requirements necessary to accommodate existing and forecast demand at Greenville-Spartanburg International Airport (GSP or the Airport) in accordance with Federal Aviation Administration (FAA) design criteria and safety standards. The facility requirements are based upon several sources, including the aviation demand forecasts presented in Chapter 3, *Forecasts;* FAA Advisory Circular (AC) 150/5300-13A, *Airport Design;* 14 Code of Federal Regulations (CFR) Part 77, *Objects Affecting Navigable Airspace,* along with other industry guidance and best practices. The findings of this chapter serve as the basis for the formulation of airport alternatives and development recommendations. The major components of this chapter are listed below:

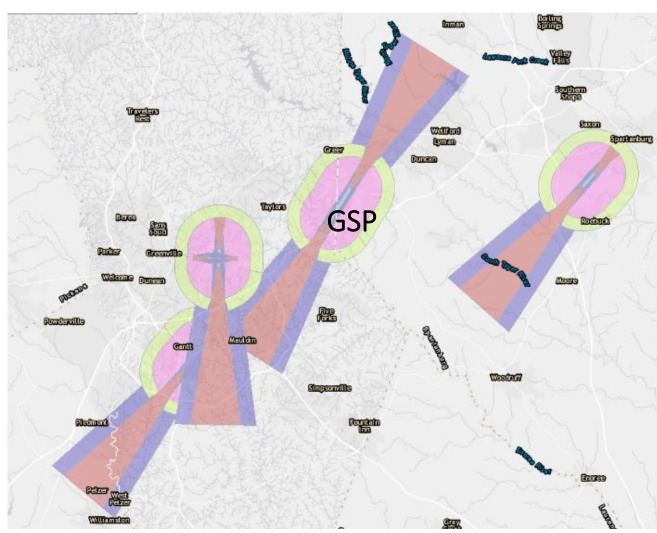
- Airport Capacity
- Airside Facility Requirements
- Passenger Terminal Facility Requirements
- Roadway Access and Parking Facility Requirements
- Air Cargo Facility Requirements
- General Aviation Facility Requirements
- Airport Support Facility Requirements
- Forecast Scenario Facility Requirements
- Facility Requirement Summary

5.1. AIRPORT CAPACITY

5.1.1. Airspace Capacity Analysis

Airspace capacity at an airport is of concern when the flight paths of nearby airports or local navigational aids (NAVAIDS) interact to adversely impact operations at the airport of study. Also of concern is the need to alter flight paths to avoid obstructions during aircraft approaches.

GSP is in a relatively rural area between the metropolitan communities of Greenville to the west, Spartanburg to the east, and the City of Greer to the north. GSP is far enough away from other airports that airspace interest conflicts do not regularly exist. Section 2.1.1 of this report identifies multiple airports in the region, the nearest of which is over seven miles from GSP. A cursory analysis of the alignment of nearby runways and the types of approaches available to those runways indicates that Part 77 approach zone conflicts do exist between the GSP Runway 4 precision approach and the precision approach to



Source: South Carolina Aeronautics Commission, GIS map, 2017

Runway 1 at Greenville Downtown Airport (GMU), as well as with the non-precision approach available to Runway 23 at Donaldson Field Airport (GYH). The proximity of these disparate airspace surfaces is mitigated by the numerous Standard Terminal Arrivals (STARs) published for instrument flight rules (IFR) aircraft to follow when approaching GSP as well as the positive control of air traffic the GSP air traffic control tower (ATCT) maintains within GSP's Class C airspace. Overall, the airspace surrounding GSP is not overly congested by commercial, military, and/or special use airspace such that the Airport's capacity is adversely affected. The FAA VFR Atlanta Sectional Chart is depicted in **Figure 5-1**, and shows GSP's Class C airspace amongst a variety of regional Class D and Class E airspaces and well outside of Charlotte Douglas International Airport's (CLT) Class B 30 nautical mile ring.

5.1.2. Airfield Capacity Analysis

Airfield capacity refers to the ability of an airport to safely accommodate a given level of aviation activity. The following sections utilize the methodologies described in FAA AC 150/5060-5, *Airport Capacity and Delay*, to model airfield capacity at GSP.

Capacity is described through three terms: annual service volume (ASV), visual flight rules (VFR) hourly capacity, and instrument flight rules (IFR) hourly capacity. The ASV is a reasonable estimate of the annual capacity, or the maximum annual number of aircraft operations that can reasonably be accommodated. It should be noted that airports could, and often do, exceed their stated ASV. However, aircraft delays begin to increase rapidly once the ASV is exceeded.

The VFR and IFR hourly capacities are the maximum number of aircraft operations that can take place on the runway system in one hour under VFR or IFR conditions, respectively. When hourly demand approaches or exceeds the hourly capacity, delays may force traffic into the succeeding hours or cause aircraft to divert to other airports.

Factors Affecting Capacity

It is important to understand the various factors that affect the ability of an air transport system to process demand. Once these factors are identified and their effect on the processing of demand is understood, efficiencies can be evaluated. The airfield capacity analysis considers several factors that affect the ability of the Airport to process aviation demand.

These factors include:

- Meteorological Conditions
- Runway/Taxiway Use Configurations
- Runway Utilization
- Aircraft Fleet Mix
- Percent Arriving Aircraft
- Percent Touch-and-Go Operations
- Exit Taxiway Locations
- Peaking Characteristics

Figure 5-1: VFR Sectional Chart - Atlanta

Source: Atlanta Sectional Aeronautical Chart

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Meteorological Conditions

Meteorological conditions specific to the location of an airport not only influence the airfield layout but affect the use of the runway system. As weather conditions change, airfield capacity can be reduced by low ceilings and visibility. Runway usage will change as the wind speed and direction change, also impacting the capacity of the airfield.

To better understand the impact of deteriorating weather on capacity, a brief synopsis of aviation flying conditions is provided. For the purposes of capacity evaluation, these flying conditions are described as VFR conditions, IFR conditions, and poor visibility and ceiling (PVC) conditions. VFR conditions occur whenever the cloud ceiling is at least 1,000 feet above ground level (AGL) and the visibility is at least three statute miles. IFR conditions occur when the reported cloud ceiling is at least 500 feet but less than 1,000 feet AGL and/or visibility is at least one statute mile but less than three statute miles. PVC conditions exist when the cloud ceiling is less than 500 feet and/or the visibility is less than one statute mile. Decreasing cloud ceiling and visibility require an increase in aircraft spacing, as mandated by the FAA. This increase in aircraft spacing causes decreases in the frequency at which aircraft can land and depart the airfield over a specified period.

To better understand the impact that inclement weather has on GSP, climate data from the National Oceanic and Atmospheric Administration (NOAA) was obtained and analyzed to determine the ceiling and visibility characteristics at this site. Based on this data, VFR conditions occur at the Airport approximately 75.9 percent of the time and IFR conditions occur approximately 15.2 percent of the time. Finally, PVC conditions are present at the Airport approximately 8.9 percent of the time.

Wind direction and speed determine the desired alignment and configuration of the runway system. If possible, aircraft desire to take off and land into the wind. On departure into the wind, the air flowing over the wings allows the airplane to become airborne much sooner than under a no-wind or tail-wind condition. An aircraft landing into the wind will be able to slow down on approach much easier and land at a slower ground speed without any loss of aerodynamic efficiency. Runways not orientated to take the most advantage of the prevailing winds at the site will restrict capacity of an airport to varying degrees as aircraft will have greater runway occupancy times.

Runway/Taxiway Use Configurations

The configuration of the runway system refers to the number, location, and orientation of the active runways, the type and direction of operations, and the flight rules in effect at a particular time. GSP has a single bi-directional runway (Runway 4-22) supported by a full-length parallel taxiway, Taxiway L. Access to runway ends are provided by Taxiway A and Taxiway B at the Runway 4 end and Taxiway J and Taxiway K at the Runway 22 end. Taxiway C provides an entrance/exit location from Runway 4-22 just beyond the Runway 4 aiming point and four rapid-exit taxiways are located near midfield. Taxiway E and Taxiway G allow for aircraft to rapidly exit the runway after landing on Runway 4 and Taxiway F and Taxiway D serve a similar function for aircraft landing on Runway 22. Acute angle fillets are not in place for any of the rapid-exit taxiways where they intercept the runway and as such define operational use of the taxiways to a single direction.

Runway 4-22 at GSP is well equipped with exit taxiways to ensure aircraft can access and exit the runway in an efficient manner.

Runway Utilization

As identified in the meteorological conditions section, aircraft generally desire to take off and land into the wind. Since both ends of Runway 4-22 are supported by instrument approach procedures, both are available during VFR and IFR weather conditions. During times weather conditions are especially poor, aircrew and aircraft with special certification are more likely to execute an approach to Runway 4 at GSP as CAT II and CAT III ILS (instrument landing system) approaches are available. CAT II and CAT III ILS approaches allow for more precise landing and roll-out control than provided by the traditional CAT I ILS that is available to both the Runway 4 and Runway 22 ends at GSP.

Review of the annualized wind conditions obtained through the National Geophysical Data Center (NGDC) and consultation with on-site air traffic control (ATC) representatives confirmed that approximately 55 percent of the time Runway 22 is favored, and the remaining 45 percent of the time airfield operations utilize Runway 4.

Aircraft Fleet Mix

The capacity of a runway is also dependent upon type and size of aircraft that use it. As per FAA AC 150/5060-5, aircraft are placed into one of four classes (A through D) when conducting capacity analysis. These classes are based on the amount of wake vortex created when the aircraft passes through the air. They differ from the classes used in the determination of the aircraft approach category (AAC). Small aircraft departing behind larger aircraft must hold longer or provide greater separation for wake turbulence to dissipate. The greater the separation distance required, the lower the airfield's capacity.

For the purposes of capacity analysis, Class A consists of aircraft in the small wake turbulence class, single engine and a maximum takeoff weight of 12,500 pounds. Class B is made up of aircraft similar to Class A, but with multiple engines. Class C aircraft are in the large wake turbulence class with multiple engines and with takeoff weights between 12,500 pounds and 300,000 pounds. Class D aircraft are in the heavy wake turbulence class and have multiple engines and a maximum takeoff weight greater than 300,000 pounds. Typically, Class A and B aircraft are general aviation (GA) single engine and light twin engine aircraft. Class C and D consist of large jet and propeller driven aircraft generally associated with larger commuter, airline, air cargo, and military use.

The aircraft fleet mix is defined by the percentage of operations conducted by each of these four classes of aircraft at GSP. The approximate percentage of operations forecasted at GSP by each of these types of aircraft is shown in **Table 5-1**.

Table 5-1: Aircraft Fleet Mix

Aircraft Type	2016 Percent of Operations	2037 Percent of Operations
Class A	1%	1%
Class B	1%	1%
Class C	95%	90%
Class D	3%	8%

Source: McFarland Johnson Analysis, 2017.

The mix index for an airport is calculated as the percentage of Class C aircraft operations, plus three times the percentage of Class D operations (%C + 3D). At airports with only Class A and B aircraft, the separation distance required for air traffic is lower than at airports with use by aircraft in Class C or D, as small aircraft departing behind larger aircraft must hold longer for wake turbulence separation. The greater the separation distance required, the lower the airfield's capacity. The mix index used in capacity calculations is 104 presently growing to 114 by 2037.

Percent Arriving Aircraft

The capacity of the runway is also influenced by the percentage of aircraft arriving at the Airport during the peak hour. Arriving aircraft are typically given priority over departing aircraft; however, arriving aircraft generally require more time to land than departing aircraft need to take off. Therefore, the higher the percentage of aircraft arrivals during peak periods of operations, the lower the ASV. Discussions with Airport personnel indicate that operational activity at GSP is generally well balanced between arrivals and departures. Therefore, it is assumed in the capacity calculations that arrivals equal departures during the peak period.

Percent 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. A touch-and-go is counted as two operations. These operations are normally associated with training and are included in the local operations figures reported by the air traffic control tower (ATCT). Based on historical data from the Airport and the ATCT, touch-and-go operations comprise less than one percent of total operations at the Airport. This condition is not likely to change over the planning period.

Exit Taxiway Locations

A final factor in analyzing the capacity of a runway system is the ability of an aircraft to exit the runway as quickly and safely as possible. The location, design, and number of exit taxiways affect the occupancy time of an aircraft on the runway system. The longer an aircraft remains on the runway, the lower the capacity of that runway.

Existing exit taxiways for Runway 4-22 are detailed in **Table 5-2**.

Table 5-2: Exit Taxiway Distance from Threshold

Taxiway	Location
Taxiway A	Located at the Runway 4 threshold
Taxiway B	Located 365 feet from the Runway 4 threshold Located 10,635 feet from the Runway 22 threshold
Taxiway C	Located 2,080 feet from the Runway 4 threshold Located 8,920 feet from the Runway 22 threshold
Taxiway D	Inaccessible when landing Runway 4 Located 6,630 from the Runway 22 threshold
Taxiway E	Located 4,940 from Runway 4 threshold Inaccessible when landing Runway 22
Taxiway F	Inaccessible when landing Runway 4 Located 4,420 from the Runway 22 threshold
Taxiway G	Located 7,180 from Runway 4 threshold Inaccessible when landing Runway 22
Taxiway J	Located 10,635 feet from the Runway 4 threshold Located 365 feet from the Runway 22 threshold
Taxiway K	Located at the Runway 22 threshold

Source: McFarland Johnson, 2017.

FAA AC 150/5300-13A provides guidance regarding the number and location of exit taxiways as shown in **Table 5-3**.

Table 5-3: Exit Taxiway Cumulative Utilization Percentage

Distance Threshold to Exit	Wet Runways				Dry Runways				Dry Runways			
	Right and Acute Angle Exits				Right Angled Exits				Acute Angled Exits			
	A	B	C	D	A	B	C	D	A	B	C	D
2,000	60	0	0	0	84	1	0	0	90	1	0	0
2,500	84	1	0	0	99	10	0	0	99	10	0	0
3,500	99	41	0	0	100	81	2	0	100	82	9	0
4,000	100	80	1	0	100	98	8	0	100	98	26	3
4,500	100	97	4	0	100	100	24	2	100	100	51	19
5,000	100	100	12	0	100	100	49	9	100	100	76	55
5,500	100	100	27	0	100	100	75	24	100	100	92	81
6,000	100	100	48	10	100	100	92	71	100	100	98	95
6,500	100	100	71	35	100	100	98	90	100	100	100	99
7,000	100	100	88	64	100	100	100	98	100	100	100	100
8,500	100	100	100	99	100	100	100	100	100	100	100	100

Note: A – small, single engine (<12,500 pounds); B – small, twin engine (<12,500 pounds); C – large (12,500 pounds to 300,000 pounds)

Source: FAA AC 150/5300-13A (Table 4-13).

According to the AC, the percent of aircraft exiting after landing on Runway 4 are shown in **Table 5-4**.

Table 5-4: Runway 4 Exit Taxiway Usage Per Conditions

Taxiway	Disposition	Weight Class			
		A	B	C	D
Taxiway C	Wet	60	0	0	0
	Dry	84	1	0	0
Taxiway E	Wet	100	97	4	0
	Dry	100	100	51	19
Taxiway G	Wet	100	100	88	64
	Dry	100	100	100	100

Note: Taxiway D and Taxiway F are inaccessible when landing on Runway 4 because no acute angle fillet exists between that taxiway and runway to allow for exiting at these locations.

A – small, single engine (<12,500 pounds); B – small, twin engine (<12,500 pounds); C – large (12,500 pounds to 300,000 pounds)

Source: FAA AC 150/5300-13A (Table 4-13) and McFarland Johnson, 2017.

According to the AC, the percent of aircraft exiting after landing on Runway 22 are shown in **Table 5-5**.

Table 5-5: Runway 22 Exit Taxiway Usage Per Conditions

Taxiway	Disposition	Weight Class			
		A	B	C	D
Taxiway F	Wet	100	80	1	0
	Dry	100	98	26	3
Taxiway D	Wet	100	100	71	35
	Dry	100	100	100	99
Taxiway C	Wet	100	100	100	99
	Dry	100	100	100	100

Note: Taxiway E and Taxiway G are inaccessible when landing on Runway 22 because no acute angle fillet exists between that taxiway and runway to allow for exiting at these locations.

A – small, single engine (<12,500 pounds); B – small, twin engine (<12,500 pounds); C – large (12,500 pounds to 300,000 pounds)

Source: FAA AC 150/5300-13A (Table 4-13) and McFarland Johnson, 2017.

5.1.3. Capacity Calculations

FAA AC 150/5060-5 provides guidance used to calculate airfield capacity and provide planning estimates on hourly airfield capacity under both VFR and IFR conditions, which represent the theoretical maximum number of aircraft operations (takeoffs and landings) that can take place on the runway system in one hour under VFR or IFR conditions, respectively. The various capacity elements are then consolidated into a single figure, the ASV for the Airport. The ASV is the theoretical maximum number of aircraft operations that the Airport can support over the course of a year.

VFR/IFR Hourly Capacities

Because characteristics of airports vary so widely, guidance in FAA AC 150/5060-5 is provided for different types of airports, from large commercial service hubs, to small single runway facilities. According to the AC, VFR and IFR capacity calculations are based on certain assumptions such as the previously calculated mix index. These assumptions and their relevance to GSP are described below:

- The Airport is currently used by approximately two percent Class A/B aircraft, 95 percent by Class C aircraft and three percent by Class D aircraft. In the future, it is anticipated use will change to include operations by approximately two percent Class A/B aircraft, 90 percent by Class C, and eight percent by Class D aircraft. This transition will be smoothed across the planning period and applied appropriately in each forecast year for capacity calculations.
- The Airport currently has a full-length parallel taxiway with ample entrance and exit taxiways spaced at a distance away from each threshold to allow for the large majority of aircraft to effectively and efficiently exit the active runway area.
- The Airport has two runway ends equipped with an ILS approaches and necessary ATC facilities to carry out operations in a radar environment.
- Arrivals equal departures and no airspace limitations affect runway use.
- Percentage of touch-and-go operations is less than one percent.

Guidance in FAA AC 150/5060-5 was used to determine the ASV. **Table 5-6** presents a summary of the airfield capacity calculations for GSP utilizing the data and assumptions outlined above and compares that to current and forecast levels of activity.

Table 5-6: Annual Operations Forecast

Year	Demand			Calculated Capacity			Percent Peak Hour		Percent ASV
	Annual	Avg. Day Peak Month	Peak Hour	Hourly VFR	Hourly IFR	ASV[1]	VFR	IFR	
2017	44,632	137	16	55	53	176,400	29%	30%	25%
2022	46,562	143	17			175,000	31%	32%	27%
2027	49,479	152	19			176,300	35%	36%	28%
2037	55,885	171	21			172,850	38%	40%	32%

[1]*ASV was adjusted to the median between calculated ASV and the prescribed ASV for a single runway system like GSP as detailed in FAA AC 150/5060-5,* Airport Capacity and Delay.

Source: McFarland Johnson Analysis, 2017.

FAA guidelines suggest that airports should initiate planning for capacity improvements when annual aircraft operations reach 60 percent of the ASV. GSP is not anticipated to reach that target within the planning period. However, while airfield capacity enhancing projects will not be required over the 20-year planning period, this report has already identified areas for Airport improvement to better meet design standards and better meet the needs of Airport users. The subsequent sections of this chapter will identify future facility improvements for GSP that are intended to accommodate existing and proposed levels of traffic more safely, efficiently, and economically.

5.2. AIRSIDE FACILITY REQUIREMENTS

Airside facility requirements address the items that are directly related to the arrival and departure of aircraft, primarily runways and taxiways and their associated safety areas. To assure that all runway and taxiway systems are correctly designed, the FAA has established criteria for use in planning and design of airfield facilities. The selection of appropriate FAA design standards for the development of airfield facilities is based on the characteristics of the most demanding aircraft expected to use an airport or that particular facility on a regular basis (500 operations or more per year). Correctly identifying the future aircraft types that will use an airport is particularly important, because the design standards that are selected establish the physical dimensions of facilities, and the separation distances between facilities that will impact airport development for years to come. Use of appropriate standards will ensure that facilities can safely accommodate aircraft using the Airport today, as well as aircraft that are projected to use the Airport in the future.

5.2.1. Critical Design Aircraft and Runway Design Code

As identified in FAA AC 150/5300-13A, *Airport Design,* airport design standards provide basic guidelines for safe, efficient, and economic airport systems. This document provides criteria for grouping of aircraft into runway design codes (RDC) to prescribe standardized design criteria to airports of various size and utility. As described in Section 3.9 of this report, the RDC is derived from the features of the most demanding aircraft using the Airport on a regular basis coupled with the best available instrument approach minimums achievable on the airfield. Presently, the Boeing 767-300F, an RDC D-IV aircraft, is identified as the critical aircraft for GSP. In the future, however, the Boeing 747-400F and eventually the Boeing 747-8F are anticipated to replace the 767-300F as the Airport's critical aircraft requiring the Airport to meet airfield design standards for RDC D-V, and D-VI, respectively.

5.2.2. Pavement Condition

Pavement strength requirements are related to three primary factors: the weight of aircraft anticipated to use an airport, the landing gear type and geometry, and the volume of aircraft operations. Airport pavement design, however, is not predicated on a particular weight that is not to be exceeded. Design is based on the mix of aircraft that are expected to use the runway over the anticipated life of the pavement (usually 20 years). The methodology used to develop the runway pavement design considers the number of operations by both large and small aircraft and reduces this data to a number of "equivalent annual operations" by a design aircraft, which is the most demanding in terms of pavement loading expected to use an airport. This may or may not be the design aircraft for planning purposes and its selection considers the type of landing gear and tire pressure in addition to weight. The outcome of the design process is a recommended pavement section that will accommodate operations by the forecast fleet mix and withstand weather stresses without premature failure of the pavement.

As detailed in **Appendix A** of this report, a pavement management plan (PMP) was prepared as part of this study. The PMP includes the following components:

- Nondestructive testing for airside pavements
- PCN computation
- Structural evaluation
- Rehabilitation recommendations
- Evaluation report

The report contains the data gathered in the field and its analysis, rehabilitation recommendations and approximate cost estimates. During the field inspection pavement condition was assessed and specific pavement distresses and their severity level were noted. Additionally, analysis was conducted to better understand the structural capacity of the existing pavement sections and their anticipated life remaining based on the forecasted mix and volume of aircraft.

Over the period of 2019-2024 the PMP identifies the need for multiple pavement rehabilitation projects including the following:

- Mill and overlay 4" on Taxiway D and Taxiway G
- Mill and overlay 2" on Taxiway L, including L2, L3 and L4
- Full depth reconstruction of Taxiway L5 and L6
- Mill and overlay 2' Runway 4-22 asphalt, including shoulders and blast pads
- Localized PCC repairs and joint sealing (RW4-22, Taxiways A, B, C, J, K & L)
- Localized PCC repairs and joint sealing (south cargo apron, north cargo apron, GA apron)
- Reconstruct itinerant apron

Recommendation: Program, schedule, and execute PMP prescribed pavement rehabilitations and continue on-going preventative maintenance on all airfield pavements.

5.2.3. Runway Length

A wide variety of aircraft use GSP daily. These aircraft, both large and small, have different runway requirements. In some cases, smaller or older aircraft may require more runway length than larger or more efficient aircraft. A significant number of factors go into determining the runway performance of an aircraft such as airport elevation, aircraft weight, temperature, flap settings, payload, or runway condition (wet/dry), which then dictate the runway requirements that must be met for an aircraft to utilize that runway.

The FAA has published AC 150/5325-4B, *Runway Length Requirements for Airport Design*, to assist in the determination of the required runway length. Per FAA AC 150/5325-4B, both future design aircraft should be reviewed on an individual basis, as both are greater than 60,000 pounds in their maximum takeoff configuration.

Boeing 747-400F – The Boeing 747-400F has a maximum takeoff weight (MTOW) of 875,000 pounds of which a maximum of 274,100 pounds is available for payload. The 747-400F can range up to 4,300 nautical miles (nm) from GSP in a full payload configuration, and over 7,000 nm in a payload-limited configuration in optimal conditions. This range allows for operations to destinations as far as western Alaska, Great Britain, Germany, and Austria when fully loaded, and Japan, West Africa, and Saudi Arabia when optimized for a long-haul route.

However, the Boeing 747-400F aircraft performance manual (APM) indicates that the 747-400F is only capable of departing GSP while at its MTOW when conditions are at or below 55 degrees Fahrenheit and the runway is not contaminated with any water or ice. Based on hourly reporting from GSP's on-site Automated Surface Observing System (ASOS) obtained through the National Climatic Data Center (NCDC) for the previous 10-years, temperatures at the Airport are only at or below 55 degrees approximately 36 percent of the time. Thus, the 747-400F is often unable to operate fully loaded from GSP and must reduce its weight in either payload or fuel load to execute a safe departure from the Airport, depending on destination. Based on guidance made available in the 747-400F APM, departures at MTOW would be achievable on a 12,000-foot runway in temperatures as high as 86 degrees.

Presently, however, the longest stage length for cargo aircraft operating from GSP is to Frankfurt-Hahn Airport in Germany, some 4,414 nautical miles from GSP according to great circle calculations. As such, during early morning departures (as is typical for cargo operators) when the weather is cool, the 747-400F could depart in a nearly full payload configuration and still reach HHN on a non-stop route.

Boeing 747-8F – The Boeing 747-8F has a MTOW of 987,000 pounds of which a maximum of 308,000 is available for payload. The 747-8F can range up to 4,500 nm from GSP in a full payload configuration, and approximately 8,000 nm in a payload-limited configuration, assuming optimal conditions. This range allows for similar capabilities as the 747-400F when fully loaded, and destinations as far as Auckland, New Zealand and Bombay, India when optimized for a long-haul route.

Unlike the 747-400F, the 747-8F is able to depart GSP at MTOW when the temperature is at or below 82 degrees Fahrenheit which accounts for approximately 91 percent of on-site ASOS observations from the previous 10-year period.

Recommendation: No runway length improvements required. The existing 11,001-foot runway will be sufficient to support operations at GSP.

5.2.4. Runway Width

Runway 4-22 is 150 feet wide, which meets FAA standards for C/D/E-III/IV/V runways. In the future, the 747-8F, a D-VI aircraft, is anticipated to become the critical aircraft at GSP. The runway width for airplane design group (ADG) for this size of aircraft is 200 feet with 40-foot wide paved shoulders on either side. However, the Airport has already received approval for a modification of standards (MOS) to provide runway width, shoulder, and blast pads dimensions for D-V aircraft, despite the 747-8F's D-VI classification. This is permitted by FAA Engineering Brief No. 74A which speaks directly to this condition, saying "the B747-8 aircraft demonstrated during the flight certification program that it can be safely operated on runways as narrow as 150 feet wide."

Recommendation: No runway width improvements required. The existing 150-foot wide runway will be sufficient to support operations at GSP.

5.2.5. Runway Orientation

A significant factor in evaluating a runway's orientation is the direction and velocity of the prevailing winds. A runway alignment that does not allow an aircraft to go directly into the wind creates what is known as a crosswind component (i.e. winds at an angle to the runway in use), which makes it more difficult for a pilot to guide the airplane down the intended path. The commonly used measure of degree to which a runway is aligned with the prevailing wind conditions is the wind coverage percentage, which is the percent of time crosswind components are below an acceptable velocity. Essentially, this measure indicates the percentage of time aircraft within a particular design group will be able to safely use the runway.

Section 2.1.2 of this report identifies that Runway 4-22 at GSP is well positioned to maximize its ability to provide for aeronautical operations into the wind. In both the all-weather and IFR conditions, Runway 4-22 provides above 98 percent wind coverage for all categories of aircraft.

Recommendations: No change in runway orientation is required.

5.2.6. Runway Designation

A runway is identified by the whole number nearest the magnetic azimuth of the runway when oriented along the runway centerline, as if on approach to that runway end, and designated as such through painted markings. This number is then rounded off to the nearest unit of ten. Magnetic azimuth is determined by adjusting the geodetic azimuth associated with a runway to compensate for magnetic declination. Magnetic declination is defined as the difference between true north and magnetic north which varies over time and is relative to any specific location on Earth. Magnetic declination is a natural process and does periodically require the re-designation of runways.

The current magnetic declination for the Greenville-Spartanburg area was derived from the NGDC in September of 2017 and calculated to be 06°47'00" West changing by 4.0' West per year. Using the information provided through the aeronautical survey conducted for this study effort the true bearing of each runway was calculated. Using the method of *West is best – East is least*, the declination of 06°47'00" West would need to be added to the Runway's true bearing to determine its magnetic bearing. **Table 5-7** conducts this calculation and identifies that all runways are appropriately designated. Furthermore, based on the projected change in declination over time it is unlikely that the runway will required re-designation over the 20-year planning period.

Table 5-7: Runway Designation Calculation

Runway	True Bearing	Magnetic Declination	Magnetic Bearing	Required Designation
4	32°53'22"	+ 06°47'00"	39°40'22"	4
22	212°53'22"	+ 06°47'00"	219°40'22"	22

Source: McFarland Johnson, 2017.

Recommendations: No change in runway designation is required.

5.2.7. Runway Critical Areas

The following sections discuss the runway safety area, the runway object free area and the runway protection zones for GSP and the ability of those critical areas to meet design standards. **Figure 5-2** depicts these areas and will be used to inform the following discussions and recommendations.

Runway Safety Areas

Runway safety areas (RSAs) are defined by the FAA as surfaces surrounding a runway that are prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway. RSAs consist of a relatively flat graded area free of objects and vegetation that could damage aircraft. According to FAA guidance, the RSA should be capable, under dry conditions, of supporting aircraft rescue and firefighting equipment, and the occasional passage of aircraft without causing structural damage to the aircraft. The FAA design standards for RSAs surrounding runways serving D-IV, D-V, and D-VI aircraft are all identical. These category runways require an RSA width of 500 feet, a length that provides 600 feet prior to the landing threshold and extends 1,000 feet beyond the departure runway end. Additionally, transverse and longitudinal grade requirements must be met across the RSA. Transverse grades are to be between 1.5 and three percent downward from the edge of pavement and longitudinal grades are permitted between zero and three percent for the first 200 feet beyond a pavement end and up to five percent downward slope for the remainder of the RSA length.

As detailed in Figure 5-2, the Runway 4-22 RSA at GSP meets the dimensional requirements established through FAA AC 5300-13A, *Airport Design*, for RDC D-IV, D-V, and D-VI aircraft, as no incompatible uses or equipment exists within the limits of the RSA. Topographically, however, the RSA fails to maintain full compliance with longitudinal and/or transverse grades across its length and width, in some areas exceeding 50 percent of the maximum slope. Grading projects should be incorporated into future pavement projects to bring the RSA into full compliance with standards.

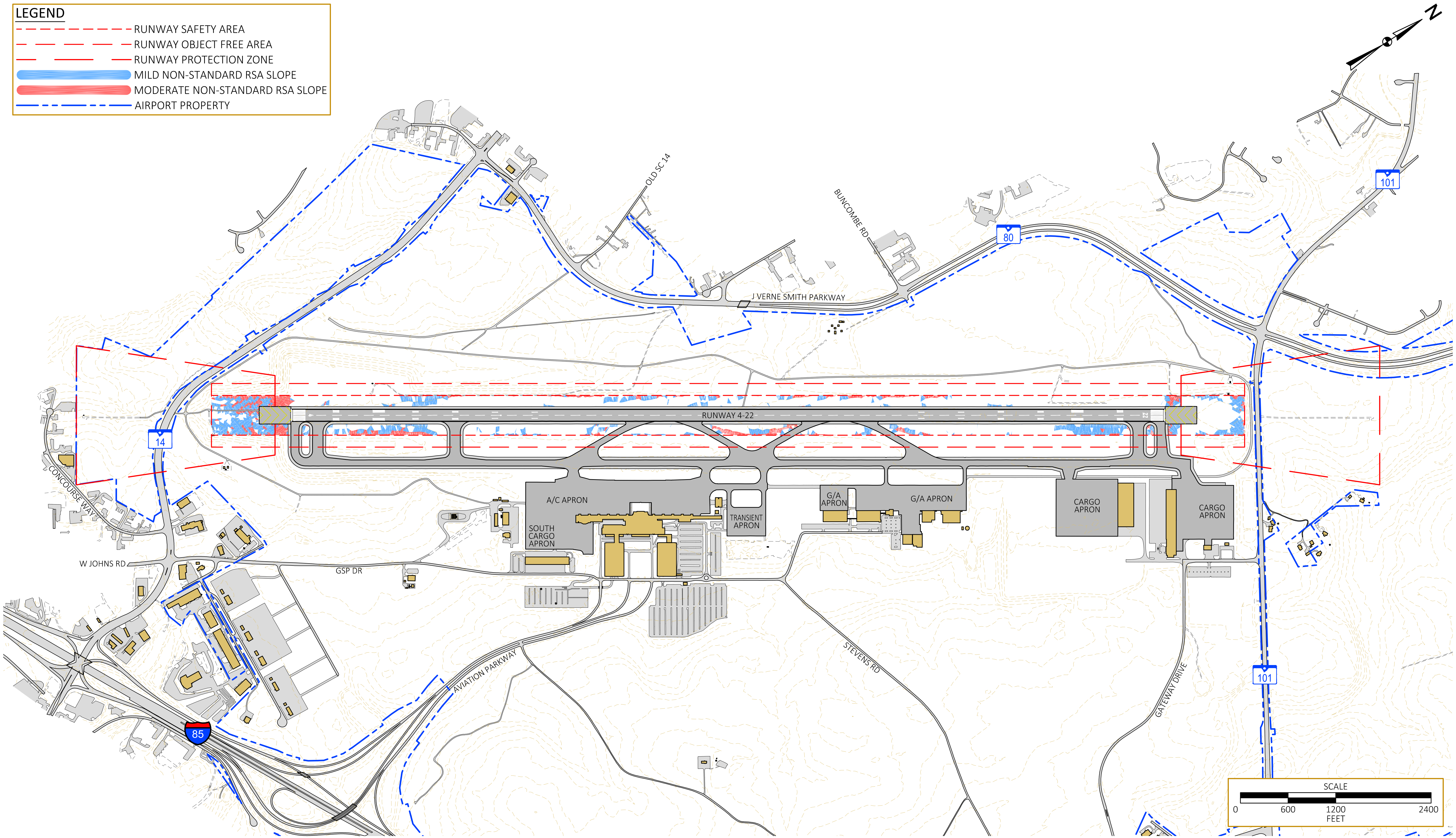
Recommendation: Develop a grading program to address grade compliance issues within the RSA. The focus should first be on the areas beyond the departure end of Runway 22 and Runway 4 before addressing transverse grade requirements along the sides of the runway.

Runway Object Free Areas

In addition to the RSA, a runway object free area (ROFA) is also defined around runways to enhance the safety of aircraft operations. The FAA defines ROFA as an area cleared of all objects except those that are related to navigational aids and aircraft ground maneuvering. However, unlike the RSA, there is no physical component to the ROFA. Thus, there is no requirement to support an aircraft or emergency response vehicles.

Similar to the FAA design standards for RSA, the standards for ROFAs surrounding runways serving RDC D-IV, D-V, and D-VI aircraft are identical. Such runways are required to maintain a ROFA width of 800 feet, a length that extends 600 feet prior to the landing threshold, and a length that extends 1,000 feet beyond the departure runway end.

Figure 5-2: Airfield Critical Areas, Topography and Slope Analysis



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The ROFA surrounding Runway 4-22 at GSP is unencumbered with incompatible uses or activities and has no physical obstructions within its limits which protrude above the plane of the RSA (or runway elevation).

Recommendation: No improvements or modifications to the ROFA are identified.

Object Free Zones

The object free zone (OFZ) clearing standard precludes aircraft and other object penetrations, except for frangible NAVAIDs that need to be located in the OFZ because of their function.

Runway Object Free Zone

The ROFZ is a defined volume of airspace centered on the runway centerline, above a surface whose elevation at any point is the same as the elevation of the nearest point on the runway centerline. The ROFZ at GSP is 400 feet wide and extends 200 feet past each end of Runway 4-22 and has no object penetrations.

Inner-Approach OFZ

The inner-approach OFZ is a defined volume of airspace centered on the approach area. At GSP, both Runway 4 and Runways 22 must consider the requirements of the inner-approach OFZ as both have approach lighting systems. This OFZ begins 200 feet from the runway threshold, is as wide as the standard OFZ, and extends 200 feet past the last light in the approach lighting system while rising at a 50:1 slope.

The Runway 4 and Runway 22 inner-approach OFZ at GSP are both cleared and unencumbered.

Inner-Transitional OFZ

The inner-transitional OFZ is a defined volume of airspace along the sides of the ROFZ and inner-approach OFZ. At GSP, both Runway 4 and Runway 22 must consider the requirements of the inner-transitional OFZ as both have approaches with visibility minima below ¾ statute mile.

The Runway 4-22 inner-transitional OFZ at GSP are cleared and unencumbered.

Precision OFZ

The precision OFZ is a defined volume of airspace above an area beginning at the threshold elevation and centered on the extended runway centerline – 200 feet long and 800 feet wide. This OFZ is in effect when an aircraft is on approach to a vertically guided runway during poor weather conditions and requires aircraft and non-critical vehicles over 10 feet in height remain clean of the area.

The Runway 4 and Runway 22 precision OFZ at GSP are both cleared and unencumbered.

Runway Protection Zones

RPZs are large trapezoidal areas on the ground off each runway end that are within aircraft approach and departure paths. The RPZ begins 200 feet beyond the end of the area usable for takeoff and landing for all runways.

The RPZ is intended to enhance the protection of people and property on the ground. Many land uses (i.e. residential, places of public assembly, fuel storage) are prohibited by FAA guidelines within these areas. However, these limitations are only enforceable if the RPZ is owned or controlled by the airport sponsor. Airport control of these areas is strongly recommended and is primarily achieved through Airport property acquisition but can also occur through easements or zoning to control development and land use activities.

The dimensions of the RPZ for each runway end are a function of the type of aircraft and the approach visibility minimums associated with operations on that runway. The existing approach visibility minimums are shown in **Table 5-8**.

Table 5-8: RPZ Dimensions Per Runway End

Runway	Length	Inner Width	Outer Width	Acreage
Runway 4	2,500’	1,000’	1,750’	78.914
Runway 22	2,500’	1,000’	1,750’	78.914

Source: FAA AC 150/5300-13A

As detailed in Table 5-8, both the Runway 4 and Runway 22 RPZs remain predominately on property. The Runway 4 RPZ is bifurcated by SC Highway 14 for which a right of way easement is provided, and the Runway 22 RPZ is similarly bifurcated by SC Highway 101 for which a right of way easement is provided. Additionally, a small portion of the northern extent of the Runway 22 RPZ crosses SC Highway 80 for which right of way easement is provide.

Recommendation: No action with respect to RPZ property is required.

5.2.8. Runway Pavement Markings

Both ends of Runway 4-22 have precision instrument approach runway markings. There are no plans for the establishment of any new precision instrument approach, nor modification of any current approach which would require remarking of the existing runway markings. Consequently, the runway markings at the Airport are appropriate for their current and future approach requirements respectively.

Recommendation: No improvements to the existing runway pavement markings are required.

5.2.9. Taxiway and Taxilane System

Planning standards for taxiways include taxiway width, taxiway safety areas, taxiway object free areas, taxiway shoulders, taxiway gradient, and for parallel taxiways, the distance between the runway and taxiway centerlines. Taxiways are designed for “cockpit over centerline” taxiing with pavement being sufficiently wide to allow a certain amount of deviation. The allowance for deviation is provided by the Taxiway Edge Safety Margin (TESM), which is measured from the outside of the landing gear to the taxiway edge. Adequate pavement fillets should be provided on turns to ensure the prescribed TESM is maintained when the pilot guides the aircraft around turns while the cockpit follows the centerline.

The dimensions of each standard vary based on the identified ADG and taxiway design group (TDG) for each taxiway. The ADG is based on the wingspan and tail height of an aircraft, while the TDG is based on the distance between an aircraft's cockpit to main gear, as well as the width of the main gear. There are six ADG groups, and seven TDG groups. Details regarding the various dimensions follow in **Table 5-9**, **Table 5-10**, and **Figure 5-3**.

Table 5-9: Taxiway Requirements – Airplane Design Group

Design Standard	ADG I	ADG II	ADG III	ADG IV	ADG V	ADG VI
Taxiway Safety Area	49	79	118	171	214	262
Taxiway Object Free Area	89	131	186	259	320	386
Runway/Taxiway Separation	225 – 400*	240 – 400*	400	400	400	500*

*Note: * Runway/taxiway separation vary based on approach visibility minimums*

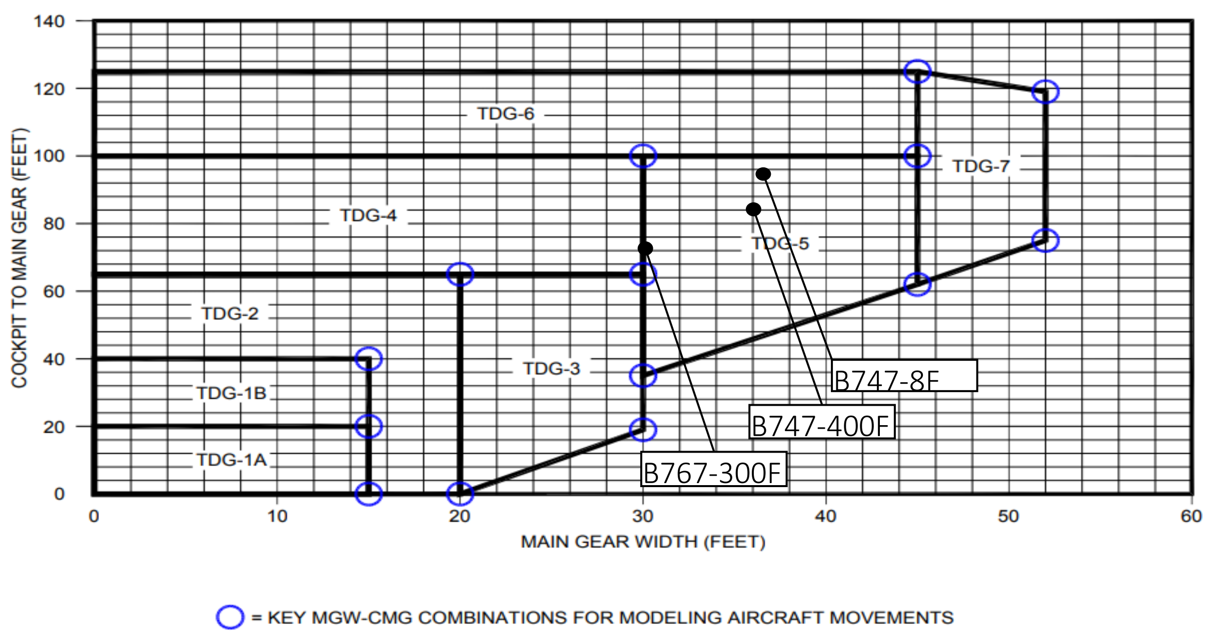
Source: FAA AC 150/5300-13A.

Table 5-10: Taxiway Requirements – Taxiway Design Group

Design Standard	TDG-1	TDG-2	TDG-3	TDG-4	TDG-5	TDG-6	TDG-7
Taxiway Width	25	35	50	50	75	75	82
Taxiway Shoulder Width	10	10	20	20	25	35	40

Source: FAA AC 150/5300-13A.

Figure 5-3: Taxiway Design Groups



Source: FAA AC 150/5300-13A Airport Design.

As taxiways are constructed or rehabilitated, design should carefully consider the recently updated guidance for taxiway design as published in FAA AC 150/5300-13A. The new requirements include the design of taxiways for cockpit over centerline taxiing as opposed to judgmental oversteering. This change particularly impacts curves and intersections, which will require changes to accommodate the cockpit over centerline taxiing. The dimensions of intersection fillets and taxiway curves are based on the associated TDG for each taxiway.

The future design aircraft (B747-400F and B747-8F) for GSP are categorized as D-V and D-VI, respectively, and both are TDG-5 aircraft. As such, GSP taxiways expected to serve all categories of aircraft must meet safety/object free area and other geometric requirements established for ADG V and eventually ADG VI aircraft. Additionally, those taxiways must also meet taxiway width, shoulder and fillet geometry based on TDG-5 standards. Taxiways not intended to be utilized by all categories of aircraft need not be developed to ADG V or VI or TDG-5 standards, and instead can be developed to the standard in place for the most demanding aircraft making regular use of that pavement section.

Existing taxiways and taxilanes are described in Section 2.2.2. All taxiways at GSP with exception of L5, L6, and the two taxilanes accessing the transient apron are intended to be utilized by TDG-5 and potentially TDG-6 aircraft. The remaining taxiways should meet the requirements for TDG 3 aircraft to best serve the predominate GA and commercial fleet which most utilize those pavements. Presently all taxiways meet width, shoulder, edge safety margin, safety area and object free area design requirements. Some operational limitations will be realized when operating group VI traffic at GSP, such as the non-standard Group VI separation between Taxiways A and B and also Taxiways J and K which will prevent the simultaneous use of those pavements by wide body aircraft. Additionally, taxiway separations from parallel centerlines and fixed/moveable objects all meet or exceed design requirements for TDG-5, with exception of the distance between Taxiway L and the parallel commercial apron taxilane. This non-standard separation is justified through FAA Engineering Brief (EB) 78 which shows through calculation that the existing 257-foot separation is acceptable over the standard 267-foot separation. Lastly, not all taxiway intersection fillet dimensions meet TDG-5 requirements as fillets are often designed considering the largest aircraft making a particular turning movement. The ability of GSP taxiway intersections to support movements, in all directions, of TDG-5/6 aircraft are explored in a subsequent section.

Recommendation: Taxiways and taxilanes should be capable of meeting design standards for the most demanding aircraft making regular use of the particular taxiway/lane segment. Further, the taxiway system should minimize adverse geometry conditions which may create hotspots or chokepoints and fillets should be expanded where necessary to permit movement of large wide-body aircraft.

Potential Hot Spots and Geometry Requirements

A hot spot is defined as “a location on an airport movement area with a history of potential risk of collision or runway incursion, and where heightened attention by pilots and drivers is necessary.”[1] There are no published hot spots at the Airport however, certain areas of the airfield meet the FAA’s definition and require further review.

Since 1983 31 incidents have occurred at the airport.[2] Of these 31 incidents only five occurred during the taxiing phase with only minor damage occurring in three of the cases. None of the cases resulted in a runway incursion. Detailed review of these incidents does not reveal any taxiway pavement geometry issues or points of confusion to pilots.

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[1] *Runway Safety – Hot Spot List, accessed Oct. 12, 2017 <http://www.faa.gov/airports/runway_safety/hotspots/hotspots_list/>.*

[2] *FAA Runway Incursion Database, accessed Oct. 12, 2017 <http://www.asias.faa.gov/pls/apex/f?p=100:28:0::NO:28::>.*

Geometry Requirements

FAA AC 150/5300-13A has multiple criteria in the design of taxiways. These geometry criteria are as follows:

- **Three Node Concept:** The three-node concept means that any taxiway intersection has no more than three choices – ideally left, straight, and right. Any more decision points make it potentially confusing to a pilot and does not allow for the proper placement of airfield markings, signage, and lighting. The three-node concept helps pilots maintain situational awareness.
- **Taxiway Intersection Angles:** Taxiway intersections are preferred to be 90-degrees whenever possible. Standard angles including 30, 45, 60, 90, 120, 135, and 150 degrees are preferred over other, non-standard, angles.
- **Wide Expanse of Pavement:** Wide pavements require placement of signs far from the pilot's eye which can be missed during low visibility conditions and should be avoided. This is especially critical at runway entrance points.
- **Limit Runway Crossings:** Limiting runway crossings reduces the opportunity for human error and reduces air traffic controller workload.
- **Avoid "High Energy" Intersections:** These intersections are located in the middle third of runways. This portion is where the pilot can least maneuver to avoid a collision.
- **Runway Intersection Angles/Increase Visibility:** Right (perpendicular) intersection angles between taxiways and taxiways, and taxiways and runways provide the best visibility to the left and right for a pilot. A right angle at the end of a parallel taxiway is a clear indication of approaching a runway. Acute-angle runway exits (rapid-exit taxiways) provide for greater efficiency in runway usage but should not be used as a runway entrance or crossover point. At GSP, this includes Taxiways D, E, F, and G.
- **Avoid "Dual Purpose" Pavement:** Runways used as taxiways and taxiways used as runways can lead to confusion. A runway should always be clearly identified as a runway and only a runway.
- **Direct Access:** Taxiways leading directly from an apron to a runway without requiring a turn can lead to confusion when a pilot typically expects to encounter a parallel taxiway but instead accidentally enters a runway.
- **Multiple Taxiway Crossings Near Runway:** A taxiway crossing a high-speed taxiway or multiple taxiways crossing each other between the hold line and the runway could cause confusion, additional time on the runway, and wrong turns/loss of pilot situational awareness.
- **Taxiway Intersecting Multiple Runways:** Taxiways must never coincide with the intersection of two runways. This creates a large expanse of pavement making it difficult to provide proper signage, marking, and lighting. These could lead to pilot loss of situation awareness and potential wrong runway use.
- **Aligned/Inline Taxiway:** An aligned taxiway is one whose centerline coincides with a runway centerline. This leads taxiing aircraft into direct line with aircraft landing or taking off therefore closing the runway for other traffic and potentially causing loss of situational awareness. Existing aligned taxiways should be removed as soon as practicable.

- **"Y" Shaped Taxiway Crossing a Runway:** Any runway crossing, or runway exit that requires a pilot to make a decision prior to exiting the runway may cause a delay in the aircraft existing the runway and loss of situational awareness.
- **Multiple Runway Thresholds in Close Proximity to One Another:** If possible, safety areas of runway ends should not overlap, since work in the overlapping area would affect both runways. Configurations where runway thresholds are closer together should be avoided, as they can be confusing to pilots, resulting in wrong-runway takeoffs. The angle between extended runway centerlines should not be less than 30 degrees to minimize confusion.
- **Short Taxi Distance:** A short distance between the terminal and the runway requires flight crews to complete the same number of checklist items in a shorter timeframe and requires more heads-down time during taxi. Many of the event reports mentioned that the flight crew members were rushing to complete their checklists or to expedite their departures.
- **Taxiway Stubs:** Short taxiway stubs including overlapping holdlines or holdlines too close together to accommodate the length of an aircraft can create confusion and may cause runway incursions or accidents.
- **Unexpected Holdlines:** Holdlines located on a parallel taxiway or other unexpected location are more likely to be overlooked and cause a runway incursion or accident and should be avoided.
- **Intersection Departures:** Airports with a single runway layout were not immune to airplanes taking off on the wrong runway, especially when intersection departures were made. In these events, the flight crew taxied onto the runway and turned in the wrong direction, taking off 180 degrees from the intended direction.

The following elements or contributing factors are historically associated with wrong runway uses and should have the highest priority in resolving: [3,4]

- Multiple runway thresholds located in close proximity to one another.
- A short distance between the airport terminal and the runway.
- A complex airport design.
- The use of a runway as a taxiway.
- A single runway that uses intersection departures.
- A single taxiway leading to multiple runways.
- More than two taxiways intersecting in one area.
- A short runway (less than 5,000 feet).
- Joint use of a runway as a taxiway.

Table 5-11 shows potential geometry issues at GSP by geometry requirement.

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[3] *Wrong Runway Departures, Aviation Safety Information Analysis and Sharing, July 2007.*
[4] *Wrong Runway Departures, FAA Runway Safety, September 2009, accessed Feb. 3, 2016 <https://www.faa.gov/airports/runway_safety/publications/media/wrong%20runway%20FINAL%20draft%20sept09.pdf>.*

Table 5-11: Geometry Issues at GSP

Geometry Requirement	Taxiway/Taxiway Int.	Runway/Taxiway Int.
Three node concept	None	None
Taxiway intersection angle	None	None
Wide expanse of pavement	Taxiway E/F/L4	None
Runway crossings	None	None
High energy intersections	None	None
Increase visibility	None	None
Dual purpose pavement	None	None
Direct access	L2-D, L4-F	None
Multiple taxiways crossing	None	None
Taxiway intersecting multiple runways	None	None
Aligned taxiway	None	None
Y-Shaped Runway Crossing	None	None
Multiple Runway Thresholds in Close Proximity	None	None
Short Taxi Distance	None	None
Taxiway Stubs	None	None
Unexpected Holdline	None	None
Intersection Departure	None	None

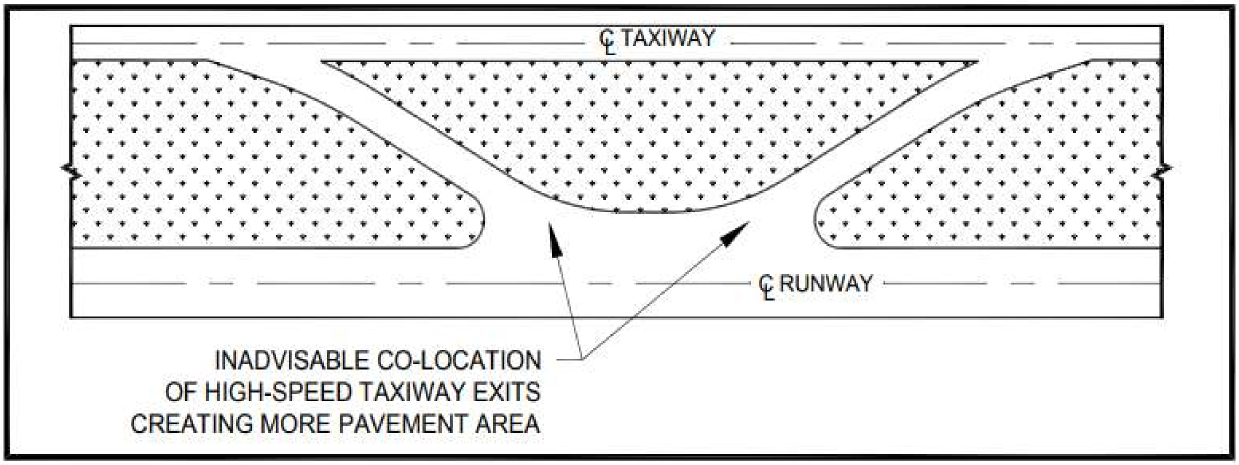
Source: McFarland Johnson Analysis, 2017.

Recommendations: Decouple the terminus of Taxiway E and Taxiway F on Taxiway L as well as remove the potential for direct apron to runway access provided by the Taxiway L-4/F connection.

Rapid-Exit Taxiway Design

Rapid-exit taxiways (also called high-speed exit taxiways and acute-angled taxiways) are designed to allow an aircraft to exit a runway without having to decelerate to typical taxi speeds. This enables aircraft to reduce runway occupancy time, thereby increasing the capacity of the runway, as well as reduce fuel consumption during taxi. FAA design guidance suggest the optimal centerline alignment for a rapid-exit taxiway is 30 degrees off the runway centerline alignment and that multiple intersecting taxiways with acute angles can create pilot confusion and lead to improper positioning of taxiway signage, as shown in **Figure 5-4**. While all rapid-exit taxiways at GSP (Taxiways D, E, F, and G) are 30-degrees from runway centerline, two (Taxiways E and F) terminate on Taxiway L at a common point. This condition creates a wide expanse of pavement on Taxiway L which is exacerbated by the Taxiway L and L4 intersection in the same area. There is also the potential for direct apron to runway access between the transient apron, Taxiway L4, and Taxiway F.

Figure 5-4: Inadvisable Rapid-Exit Taxiway Design



Source: FAA AC 150/2300-13A, Airport Design, Figure 4-20

Recommendations: Decouple the terminus of Taxiways E and F on Taxiway L to better adhere to FAA design standards.

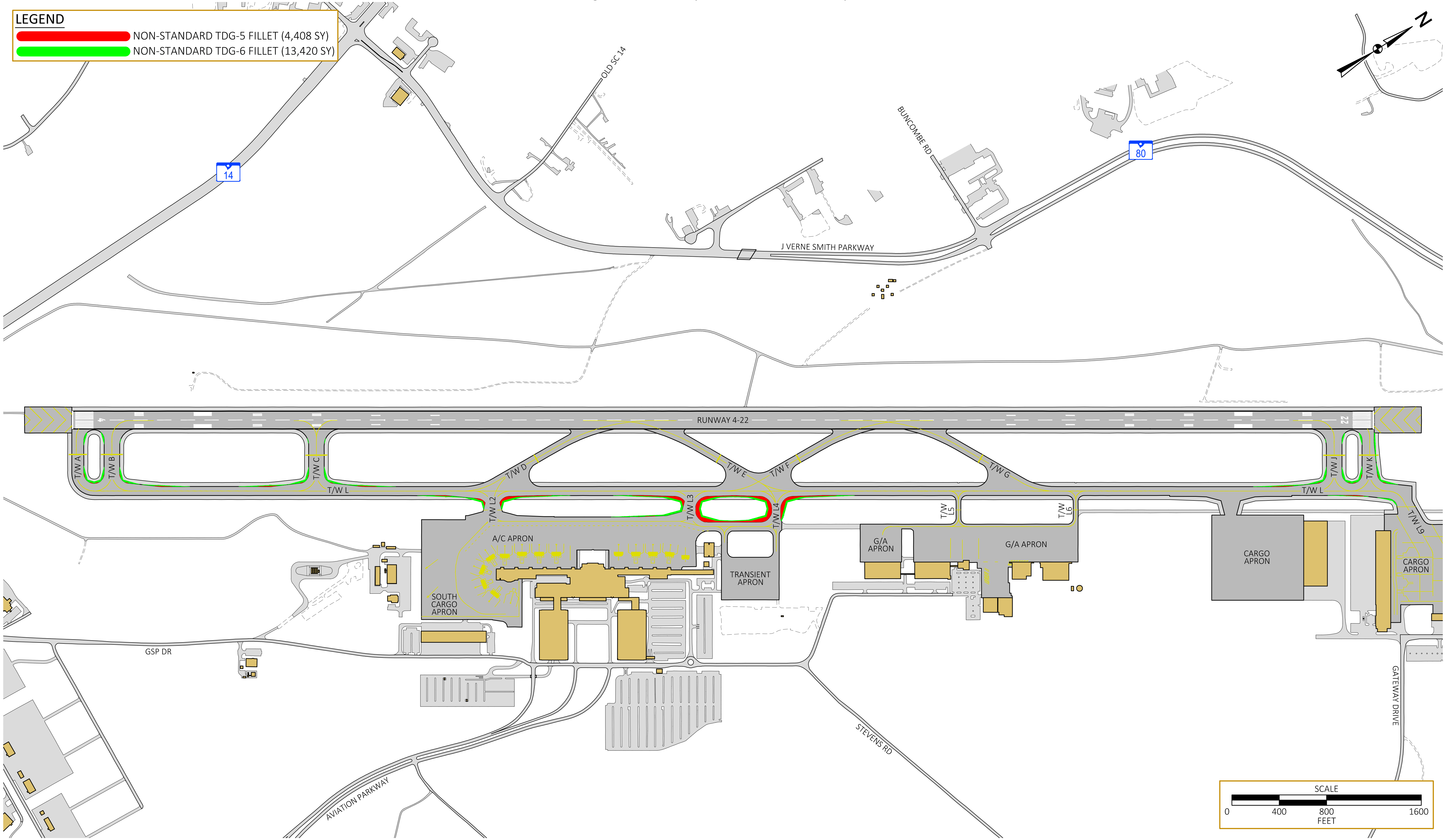
Intersection Fillet Requirements

Taxiway intersection fillets are required on the inside of a taxiway curve to permit the turning of aircraft while still maintaining the TESM. Taxiway fillets are designed in relation to the centerline of the curve, and therefore, the location of the centerline marking. Like other taxiway design standards, taxiway intersection fillet dimensions are based upon the most demanding taxiway design group anticipated to utilize a particular intersection. Based on guidance available from the FAA Advisory Circular AC 150/5300-13A, Change 1, **Figure 5-5** explores the ability of the existing taxiway infrastructure to meet the fillet design standards for existing and future critical aircraft.

Runway accessible Taxiways A, B, C, D, E, F, G, J, and K all meet TDG-5 fillet design requirements, though pavement additions would be required to facilitate TDG-6 movements on Taxiway A, B, C, J, and K. Taxiway L2, L3, and L4 would all need additional pavement to support TDG-5 movements, though only L2 is likely to be utilized by aircraft of TDG-5 size. In the future, only TDG-3 sized aircraft are anticipated on the mid to north portions of the air carrier apron, with possible larger aircraft activity utilizing the south portion of the apron. Cargo aircraft are expected to relocate to a new cargo facility on the north side of the airfield. Taxiways L5 and L6 are not expected to ever facilitate movements by TDG-5/6 aircraft and are well designed to support the variety of GA traffic accessing the GA aprons.

Recommendations: Maintain TDG-5 capable taxiway routes and improve fillet connections where necessary to support 747-8F aircraft operations. Maintain TDG-5 compliant taxiway fillets at all other intersections except for those intended for use solely by smaller aircraft.

Figure 5-5: Taxiway Intersection Fillet Analysis



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5.2.10. Airfield Lighting and Signage

Approach Lighting

The existing precision approach to Runway 4 is equipped with a 2,400-foot high intensity approach lighting system with centerline sequenced flashing lights (ALSF-2) and Runway 22 is equipped with 2,400-foot medium intensity approach lighting systems with runway alignment indicator lights (MALSRs).

The current approach lighting systems on Runways 4 and 22 meet the standards for ILS category (CAT) I approaches and meet existing needs at the Airport. Runway 4 also has a CAT II/III ILS approach. Should a CAT II/III ILS approach be sought for Runway 22 in the future an upgrade from the existing 2,400-foot MALSR system to a 2,400-foot ALSF-1 or ALSF-2, similar to that supplementing the Runway 4 approach, would be recommended.

Recommendations: Upgrade the existing Runway 22 MALSR to ALSF-2 to support lower approach minima to Runway 22.

Runway and Taxiway Lighting

High intensity runway edge lights (HIRLs) are provided on Runway 4-22 and all lighted taxiways are currently equipped with high intensity taxiway edge lights (HITLs). Airfield lighting is controlled by the on-site Airport electric vault with ample capacity and backup power for operational reliability. These systems are sufficient to adequately support Airport operations through the planning period.

Recommendation: No improvements required to runway and taxiway lighting systems.

Airfield Signage

The existing taxiway signage at the Airport does not match the preference for taxiway designations reflected in Figure 1a of FAA Engineering Brief No. 89, *Taxiway Nomenclature Convention*. Reconfiguration of taxiway signage may be appropriate and should be review with other compatible projects, like runway or taxiway rehabilitation projects.

Recommendation: A review of existing taxiway signage, considering all applicable FAA guidance, should be completed as part of future airfield pavement projects.

5.2.11. Visual Approach Aids

Both Runway 4 and Runway 22 are equipped with a 4-light precision instrument approach path indicator (PAPI) with a standard three-degree glide path. The PAPI is located to the left of Runway 4 and to the right of Runway 22. These systems provide visual glide slope guidance to pilots on approach to the runway ends.

Recommendation: No improvements required to visual approach aids at GSP.

5.2.12. Airfield Facility Requirements Summary

Several requirements for airside facilities have been discussed throughout this section. A summary of the key requirements identified can be found in **Table 5-12**. Geometry issues are identified in Table 5-11.

Table 5-12: Summary of Airside Facility Requirements

Item/Facility	Existing Facility or Capacity	Ultimate Requirement	Deficit
Pavement Management	Unable to provide structurally sound pavement for forecasted aircraft mix throughout the 20-year horizon.	Provide structurally sound pavement fore forecasted aircraft mix throughout the 20-year horizon.	Taxiway L Rehabilitation Runway 4-22 Asphalt Rehabilitation Reconstruct Itinerant Apron Localized PCC Repairs and Joint Sealing
Runway Length	11,001 FT	11,001 FT	None
Runway Width	150 FT	150 FT	None
Runway Orientation	Meets 95% wind coverage in all conditions	Meet 95% wind coverage in all conditions	None
Runway Designation	4-22	4-22	None
Runway Safety Areas	Runway 4-22 500 FT wide 1,000 FT past RW ends Limited ability to meet grade requirements	Runway 4-22 500 FT wide 1,000 FT past RW ends Full ability to meet grade requirements	Meet grade requirements
Runway Object Free Area	Runway 4-22 800 FT wide 1,000 FT past RW ends Meets clearance requirements	Runway 4-22 800 FT wide 1,000 FT past RW ends Meets clearance requirements	None
Runway Protection Zone	Runways 4 & 22 1,000 FT Inner Width 2,500 FT Length 1,750 FT Outer Width Airport ownership/ Right-of-way/ Easement	Runways 4 & 22 1,000 FT Inner Width 2,500 FT Length 1,750 FT Outer Width Airport Ownership/ Right-of-Way/ Easement	None

Item/Facility	Existing Facility or Capacity	Ultimate Requirement	Deficit
Runway Pavement Markings	Precision Instrument Markings	Precision Instrument Markings	None
Taxiways[1]	Full Length Parallel Ample Entry/Exits Meets TDG-5/6 Meet ADG VI standards Unable to fully provide TDG-5/6 Fillets Does not meet geometry	Full Length Parallel Ample Entry/Exits Meets TDG-5/6 Meet ADG VI standards Provide TDG-5/6 Fillets Meets geometry	Improve Intersection Fillets Correct Geometry
Approach Lighting	Runway 4 2,400 FT ALSF-2 Runway 22 2,400 FT MALSR	Runway 4 2,400 FT ALSF-2 Runway 22 2,400 FT ALSF-2	Runway 22 2,400 FT ALSF-2
Airfield Lighting	Runway 4-22 – HIRLs	Runway 4-22 – HIRLs	None
Airfield Signage	Meets Standards	Meet Standards	None
Runway Visual Aids	Runway 4 – PAPI Runway 22 – PAPI	Runway 4 – PAPI Runway 22 – PAPI	None
Instrument Approaches	Runway 4 – ILS/LOC (CAT I, II, and III) Runway 4 –GPS - LPV Runway 22 – ILS/LOC (CAT I) Runway 22 –GPS - LPV	Runway 4 – ILS/LOC (CAT I, II, and III) Runway 4 –GPS - LPV Runway 22 – ILS/LOC (CAT II and III) Runway 22 –GPS - LPV	CAT II/III approach to Runway 22

Note: 1/ Taxiways A/B and J/K do not provide adequate separation for dual use of ADG VI aircraft.
Source: McFarland-Johnson Analysis, 2017

5.3. PASSENGER TERMINAL FACILITY REQUIREMENTS

This section addresses the methodology, assumptions, and general planning-level factors used to analyze facility requirements for key functional areas of the GSP passenger terminal. Requirements were analyzed based on a multitude of factors and compared to growth triggers identified in the Forecasts presented in Chapter 3 and the 2010 Terminal Area Study discussed in Section 1.3.2 of this report. The primary tool used to model various terminal spatial requirements was ACRP Report 25, *Airport Passenger Terminal Planning and Design, Volume 2: Spreadsheet Models and User's Guide (Model)*. Additionally, guidelines published in the following publications were included:

- International Air Transport Association's (IATA) Airport Development Reference Manual (ADRM, 10th Edition);
- FAA AC 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities*;

- FAA AC 150/5360-9, *Planning and Design of Airport Terminal Facilities at Non-Hub Locations*; and
- FAA AC 150/5300-13A, *Airport Design*.

5.3.1. Existing Passenger Terminal

As discussed in Section 2.4.1 of this report, the passenger terminal recently underwent a major renovation and revitalization effort focused on increasing capacity, improving efficiency, and elevating the aesthetics of the terminal building and its surroundings. This undertaking was planned in the 2010 Terminal Area Study discussed previously and programed in the years that followed. This study is used as a reference in the following sections to compare calculated spatial requirements with prior planning analysis. Gaps identified between existing facilities and future need will be documented as recommended future facility improvements.

5.3.2. Methodology

Utilizing the ACRP Model and FAA and industry standards guidance listed above, the following passenger processing functions were examined:

- Terminal Curb Length
- Passenger Check-In and Ticketing
- Outbound Baggage Screening and Make-Up
- Passenger Security Screening Checkpoint
- Concourse Circulation/Concessions
- Passenger Lounges/Holdrooms
- Concourse Gates, Passenger Boarding Bridges and Terminal Apron
- Inbound Baggage Handling and Baggage Claim
- Other Terminal Support Functions

The terminal building analysis was performed under two primary scenarios: standard service by typical air carriers with operational and enplanement totals as outlined in Section 3.8 of this report and the plausible terminal spatial requirements should the Airport reach two million annual enplaned passengers (MAEP). The two MAEP scenario is considered for two reasons: (1) The 2010 terminal study anticipated two MAEP to be a triggering threshold for what that study considered to be Phase II of the terminal growth plan and (2) two MAEP could be achieved through this study's forecast should the forecast scenarios, as discussed in Section 3.4.6, be triggered.

Additionally, to provide some insight into plausible requirements beyond the planning horizon of this master plan, and presumable two MAEP, spatial requirements for out years 2045, 2055 and 2065 were also contemplated and are presented in the results of the analysis.

Application of the Model under these scenarios is presented in the following section.

Application of ACRP Model

The ACRP Model is designed to determine terminal requirements by functional area based on historical and forecasted annual enplanements, departures, and gates. The Model uses these inputs (along with a variety of assumptions) to identify peak hour activity. From this point, the

Model relies on peak hour activity levels to produce space requirements that can accommodate demand as it grows. In this way, the Model serves as "top down" analysis, starting with annual demand to estimate peak activity demand.

Facility requirements at GSP were determined using the assumptions shown in **Table 5-13** for peak hour departures, which corresponds to the baseline forecast assessment presented in Section 3.4.7 of this report and expresses steady growth in annual arriving and departing (A&D) passenger activity. Additionally, the two MAEP scenario is explored utilizing the assumptions inherent to the peaking characteristics presented in the forecast.

Table 5-13: Aircraft Seats and Scheduling Peak Characteristics

Departures and Passengers	2017	2022	2027	2037	2 MAEP
Peak Hour Departing Passengers	622	725	818	1,010	1,226
Daily Departing Passengers	3,109	3,624	4,088	5,050	6,128
Annual Arriving/Departing Passengers	1,014,611	1,182,700	1,333,823	1,648,052	2,000,000

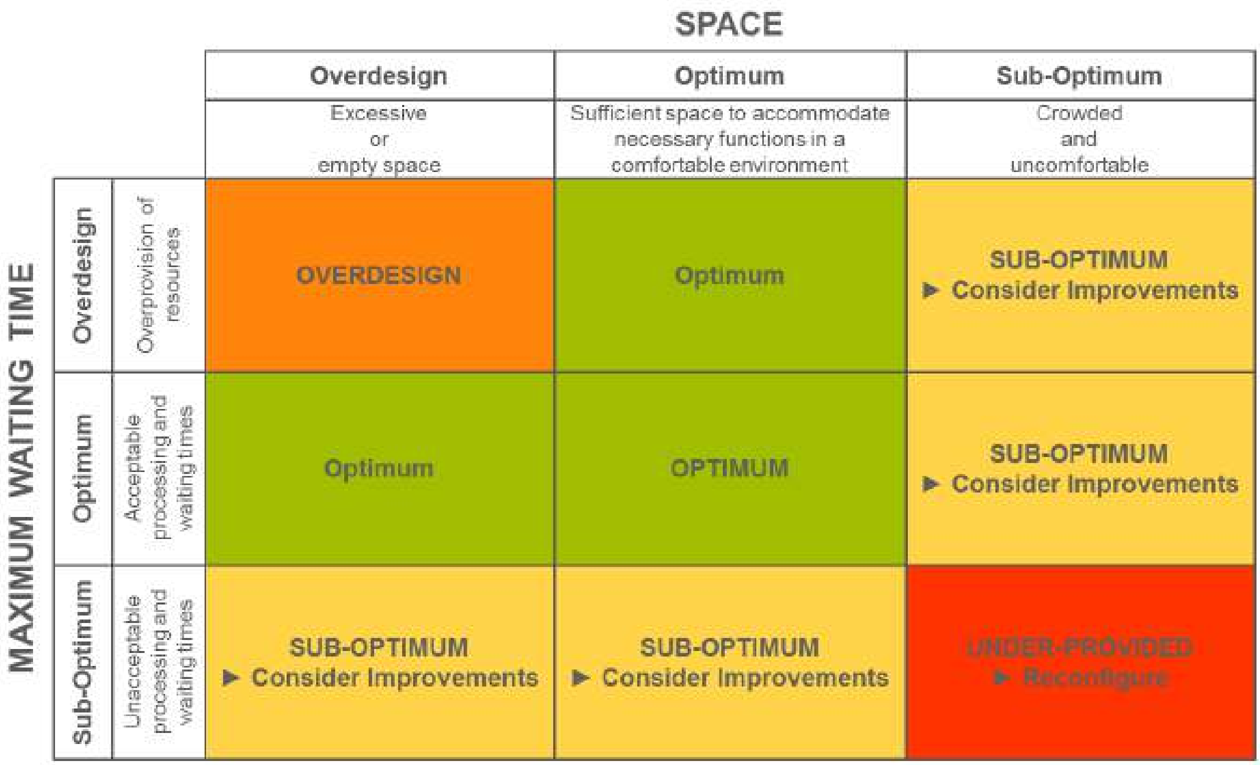
Source: McFarland Johnson, 2017.

Level of Service (LOS) Standards

The IATA has published a comprehensive guide with standards for planning various passenger processing functions for airport terminal buildings. These standards reflect the dynamic nature of terminal operations and throughput (passenger processing rate from check-in through enplanement) and have the goal of increasing infrastructure efficiency. The Airport Development Reference Manual (ADRM) sets forth two variables, which jointly dictate a Level of Service (LOS): space and maximum waiting time. This space-time concept is the LOS framework for measuring the performance of passenger processing through each functional area of an airport terminal building and corresponding waiting areas. The measurement yields an indication of existing performance within four categories: under-provided, sub-optimum, optimum, and over-design.

Figure 5-6 illustrates how the space-time concept of LOS performance in airport terminals is evaluated. The space axis defines the amount of space available per occupant, and the time axis denotes the maximum waiting time for passengers in the queue. The objective of the space-time concept in ADRM is the provision of optimum passenger facilities and the avoidance of both over- or under-providing for passengers and the airport, airline, regulatory, or tenant staff doing the work of processing arriving and departing passengers to and from aircraft.

Figure 5-6: IATA Level of Service Performance Categories



Source: IATA and ACI, 2014.

5.3.3. Assumptions

This section summarizes the assumptions utilized for the assessment of the existing Airport terminal building.

Percentage of Originated Passengers

For purposes of analyzing passenger terminal space requirements, it is assumed that 100 percent of enplaned passengers are originating at GSP. The originating passenger percentage is used to determine the number of passengers to be processed through check-in/ticketing and security screening, along with associated demands on outbound baggage functions, holdroom usage, and gate/boarding area egress.

Vehicle Demand at Terminal Curb

Vehicle demand in the Model is based on the range of vehicle types used by passengers as ground transport to an airport for departing flights. These include everything from private automobiles carrying one to three passengers to tour buses carrying large groups of passengers. For this analysis, a focus was placed on private autos, taxis/transportation network companies (TNC), limousine/executive cars, hotel shuttles, and busses. Table 5-14 illustrates the assumed breakdown of existing peak vehicle demand at the curb, dwell time assumptions, and passenger per vehicle assumptions, all of which are integral to the calculation of terminal curb requirements.

Table 5-14: Peak Hour Vehicle Assumptions

Vehicle Type	Peak Hour Vehicles	Peak 15 Min. Demand (MIN)	Dwell Time (MIN)	Total Passengers by Vehicle
Private Auto	396	158	4.5	1.5
Taxi and TNC	28	11	2	1
Limousine/Executive	12	5	3	1
Hotel Shuttle	8	3	4	2.5
Bus	5	2	3	10
Remote Parking	6	2	4	10
Total	455	181	n/a	n/a

n/a – not applicable

Source: McFarland Johnson Analysis, 2017

The number of vehicles assumes that private autos will average 1.5 passengers each, taxis/TNC will transport 1.0 passenger per vehicle, hotel shuttles will carry 2.5 passengers, buses will average 10 passengers, and parking shuttles will average 5 passengers. The Model then applies an assumption that a peak 15-minute period will require the curb to accommodate about 179 vehicles, each making one stop and dwelling from three to four and a half minutes for all vehicles except busses, which can require up to ten minutes and parking shuttles which can require up to five minutes. The Model requirements for the terminal curb are in linear feet (LF). The existing curb length is approximately 500 LF along the terminal curb front and another 500 LF along the vehicular island curb, providing approximately 1,000 LF in total. Of this, about 400 LF adjacent to the terminal ticketing lobby and 400 LF is adjacent to the baggage claim lobby, the remaining 200 LF of curb front is centrally located between both the ticketing and the baggage claim lobbies. To account for the bifurcated curb design and the operational conditions inherent to that design (a preference for the terminal-side curb over the pedestrian island curb, and limits on vehicular flow resulting from pedestrian crossings), calculated curb requirements will be elevated by 20 percent.

Passenger Check-in /Ticketing

Passenger check-in/ticketing includes the functions of full-service staffed airline counter positions, self-serve kiosks, active check-in area, passenger queue area, airline ticket office areas, circulation area, and public restrooms accessible from the ticketing lobby. Assumptions for these areas include the following:

- 60 percent of peak hour passengers could be experienced in the peak 30-minute period.
- 40 percent of passengers use check-in and ticketing facilities.
- Average passenger processing time at the counter or kiosk is three minutes.
- Existing ticket counter area roughly 5,000 square feet (SF).
- Existing ticketing kiosk area is roughly 2,700 SF.
- Existing airline ticket office area is roughly 8,600 SF.
- Existing restrooms accessible to the check-in area total roughly 2,650 SF.

- Existing circulation in and around the previously listed passenger check-in and ticketing facilities total roughly 7,300 SF.

Outbound Baggage Make-Up and Screening

Outbound baggage screening and make-up functions includes operations by Transportation Security Administration (TSA) to screen checked baggage and airline staff to collect and disperse bags to carts and the appropriate aircraft prior to departure. For outbound baggage volume the following assumptions in **5-34Table 5-15** were used.

Table 5-15: Outbound Baggage and Screening System Assumptions

Item for Analysis	Assumption
Peak Hour Passengers Checking Bags [1/]	75 Percent
Checked Bags per Passenger [2/]	1 Bag
Bag Size – Standard	95 Percent
Bag Size – Oversized	5 Percent

[1/] Number of checked bags remains constant over the period, should the trend of reduced checked baggage not continue.

[2/] It has been identified that certain legacy airlines are currently observing lower "checked bag per passenger" quantities; for planning purposes, the higher quantity has been used.

Source: McFarland Johnson Analysis, 2016.

The Model assumes between six and 13 departures per peak hour across the planning period, and that the volume of checked baggage can be accommodated utilizing 14 to 26 baggage carts. The Model suggests that each cart requires 600 square feet of space. An additional 20 percent of square footage is included for baggage train circulation and 15 percent for mechanical and support space.

In terms of Explosive Detection System (EDS), On-Screen Resolution (OSR), and Explosives Trace Detection (ETD) equipment requirements, the analysis assumed a Level 1 EDS screening rate of 220 bags per hour, with an alarm rate of 20 percent. Level 2 OSR processing ration was set at 60 bags per hour. For Level 3 ETD screening, the TSA suggests 24 bags per hour per operator.

Baggage screening space requirements contained in the Model were utilized here, and are as follows:

- Level 1 Area: 500 square feet per EDS unit
- Level 2 Area: 40 square feet per OSR station
- Level 3 Area: 100 square feet per ETD station

An additional 35 percent of space is added for circulation area, and 15 percent to allow for future equipment changes and any required reconfiguration or renovations.

Passenger Security Screening Checkpoint

This section discusses the assumptions utilized to analyze the future demand for security screening of departing passengers. The assumed processing rate for the analysis is 200 persons per hour for a two-lane screening module configuration through the 20-year planning horizon. For forecast years beyond 2040, this rate was increased to 400 passengers per hour to consider the trend toward less invasive security procedures and security protocols based on biometric identification, pre-clearance, and other developing technologies.

Although, TSA recommends 2,800 square feet of space for a two-lane screening module, GSP currently accommodates two lanes within roughly 2,000 square feet. As such, this ratio was maintained for future facility needs.

The percentage assumed for non-passenger traffic, such as employees and crew, is ten percent, which was added to the design peak hour passenger screening demand and is based on recent experience at other airports.

As with other functional areas, allowances were also included for future equipment changes (ten percent) or reconfigurations and TSA support space (12 percent).

Concourse Circulation/Concessions

In terms of area required for passenger circulation on the secure side of the terminal building, the Model considers whether the Airport operates as a hub for connecting passengers, the type of concourse design (e.g., single- versus double-loaded, with or without moving walkways), and includes assumptions for percentage of the concourse length that is usable (e.g., concourses with holdrooms at the end are not 100 percent usable). For this analysis, a single-loaded concourse with no moving walkways and no connecting flights was used, making 100 percent of the concourse usable by passengers.

Terminal concessions include both non-secure and secure area retail establishments to service departing and arriving passengers. For this assessment, it is assumed that 20 percent of peak hour passengers will utilize pre-secure concessions and 80 percent of peak hour passengers will patronize post-secure area concessions. The model makes the following assumptions to calculate spatial requirements:

- Food and beverage-based concessions require seven square feet per peak hour passenger
- Retail based concessions requires 3.5 square feet per peak hour passenger
- Service based concessions require 0.5 square feet per peak hour passenger
- A multiplier of 15 percent is used to account for support space for food and beverage concessions
- A multiplier of five percent is used to account for support space for retail concessions
- Internal circulation area allowance of 10 percent is also included for terminal building concession areas.

Passenger Lounges/Holdrooms

Holdroom space typically accounts for seating a certain percentage of passengers, with the remaining passengers either not in the holdroom area or standing. For this analysis, it was assumed that 85 percent of passengers are in the hold room area of which 80 percent of passengers are seated. The analysis assumed 15 square feet per seated passenger and ten square feet per standing passenger. The Model also includes some flexibility to account for amenities (e.g., children’s play area, telephones, work areas, charging stations, etc.), and high utilization and holdroom sharing, when the holdroom is utilized for passengers waiting for more than one flight or is shared between gates.

The model recommends approximately 230 square feet to accommodate one airline gate podium and agents, as well as 240 square feet for boarding corridor space per gate. Both are added to holdroom space requirements in the analysis.

Allowances for amenities, circulation, and restrooms are assumed to be five percent, 30 percent, and eight percent, respectively.

Inbound Baggage Handling & Baggage Claim

Inbound baggage handling includes the unloading of baggage from aircraft and transferring them to the baggage claim unit for circulation to the baggage claim hall. The model calculates baggage claim requirements assuming that a certain percentage of passengers will deplane in a peak 30-minute period. For GSP, it is assumed that 100 percent of passengers terminate at the Airport. As previously noted, it is also assumed that 75 percent of passengers will check one bag. Additionally, the following assumptions are made:

- A multiplier of 105 percent is applied to the number of passenger checking bags to account for meters and greeters
- 1.3 linear feet of claim is required for each person in the claim lobby
- Typical carousel unit frontage at GSP is 110 linear feet
- 14 square feet per person in the baggage claim lobby is required to provide for adequate queuing, bag retrieval, and circulation space
- Baggage claim area is increased by 10 percent to provide for baggage services office
- Baggage claim area is increased by 15 percent to provide for meet and greet area
- Baggage claim area is increased by 25 percent to provide for circulation space
- Baggage claim area is increased by 15 percent to provide for restroom facilities.

To account for inbound baggage handling area the following assumptions are made:

- Take off belts require 850 square feet of space each.
- Baggage train circulation requires 1,275 square feet of per take off belt.
- 255 square feet per take off belt is provided to account for conveyor belts equipment and other miscellaneous equipment.

Other Terminal Support Facilities

The final consideration of passenger terminal functional areas includes allowances for the following:

- Airline Operations: two percent of calculated departure/arrival areas
- Ground Handling Services: four percent of calculated departure/arrival areas
- Airport Operations and Maintenance: five percent of calculated departure/arrival areas
- Facilities Support and Services: 1.5 percent of calculated departure/arrival areas
- Building Structure Allowance: six percent of net departure/arrival/secure areas
- Vertical Circulation: seven percent of net departure/arrival/secure areas

- Mechanical/Electrical/Utility: 12 percent of net departure/arrival/secure areas
- Allowance for Other Tenants/Configurations: four percent of total terminal area

Concourse Gates, Passenger Board Bridges and Terminal Apron

To determine the required number of concourse gates, and subsequently passenger boarding bridges and terminal apron requirements, the model employs a departure per gate approach which assumes four daily departures per gate until 2040 after which time it slowly transitions to 4.5 average daily departures in 2065. The two million annual passengers scenario is modeled using four average daily departures per gate.

5.3.4. Results of Analysis

The results of the terminal capacity assessment are summarized in **Table 5-16**.

Table 5-16: Terminal Functional Area Requirements

Functional Area	Existing Facility	Ultimate Requirement	2 MAEP	Beyond 2040		
				2045	2055	2065
Annual Enplanements	1,182,700	1,648,052	2,000,000	2,153,123	2,745,443	3,500,708
Peak Hour Enplanements	622	1,010	1,226	1,320	1,683	2,145
Gates	13	+2 Gates	+5 Gates	+6 Gates	+10 Gates	+15 Gates
Curb Length	1,000 LF	+65 LF	+286 LF	+508 LF	+812 LF	+1,202 LF
Check-In/Ticketing						
Staffed Counter Positions	40 Positions	No Change	No Change	No Change	No Change	No Change
Check-In Ticket Area (Counter/Active/Queue)	4,998 SF	No Change	No Change	No Change	+674 SF	+2,175 SF
Kiosks Positions	19 Positions	No Change	No Change	No Change	+5 Positions	+11 Positions
Kiosk Check-In Area (Active/Queue)	2,691 SF	+206 SF	+827 SF	+1,173 SF	+2,211 SF	+3,492 SF
Airline Ticket Office Area	8,631 SF	No Change	No Change	No Change	No Change	No Change
Check-In/Ticketing Circulation Area	7,300 SF	No Change	No Change	No Change	No Change	+672 SF
Restrooms	2,654 SF	No Change	+105 SF	+313 SF	+1,137 SF	+2,129 SF
Outbound Baggage Screening and Make-Up						
Level 1 EDS Units	4	No Change	+ 1 Unit	+ 1 Unit	+3 Units	+4 Units
Level 2 OSR Stations	2	+1 Station	+2 Stations	+2 Stations	+3 Stations	+4 Stations
Level 3 ETD Stations	2	+1 Station	+1 Station	+1 Station	+2 Stations	+3 Stations
Level 1 EDS Screening Area	2,054 SF	No Change	+446 SF	+446 SF	+1,446 SF	+1,946 SF
Level 2 OSR Screening Area	100 SF	+20 SF	+60 SF	+60 SF	+100 SF	+140 SF
Level 3 ETD Screening Area	400 SF	No Change	No Change	No Change	No Change	+100 SF
Make-Up Area (Including Baggage Train Circulation & Mech. Support Spaces)	15,032 SF	No Change	No Change	No Change	+1,528 SF	+6,496 SF
Passenger Security Screening Checkpoint						
Screening Lanes	4 Lanes	+3 Lanes	+5 Lanes	+2 Lanes	+3 Lanes	+5 Lanes

Functional Area	Existing Facility	Ultimate Requirement	2 MAEP	Beyond 2040		
				2045	2055	2065
Annual Enplanements	1,182,700	1,648,052	2,000,000	2,153,123	2,745,443	3,500,708
Peak Hour Enplanements	622	1,010	1,226	1,320	1,683	2,145
Security Screening Module Area	3,850 SF	+3,150 SF	+5,150 SF	+2,150 SF	+3,150 SF	+5,150 SF
Passenger Queue Area	3,026 SF	+3,519 SF	+4,918 SF	+5,528 SF	+7,880 SF	+10,874 SF
Allowance for Future Equipment Changes	1,524 SF	No Change	+170 SF	No Change	+267 SF	+766 SF
TSA Support Space Area	1,717 SF	+71 SF	+520 SF	+204 SF	+647 SF	+1,036 SF
Passenger Lounges/Holdrooms						
Holdrooms (Seated/Standing/Ticketing/Boarding)	36,950 SF 13 Gates	+ 1,180 SF +2 Gates	+ 8,806 SF +5 Gates	+11,348 SF +6 Gates	+21,516 SF +10 Gates	+34,226 SF +15 Gates
Allowance for Amenities	1,907 SF	No Change	+ 381 SF	+ 508 SF	+ 1,106 SF	+ 1,652 SF
Holdroom Circulation Area	12,600 SF	No Change	+ 1,813 SF	+ 2,614 SF	+ 5,817 SF	+ 9,820 SF
Restrooms	2,910 SF	+140 SF	+750 SF	+ 954 SF	+ 1,767 SF	+ 2,784 SF
Inbound Baggage Handling and Claim						
Baggage Claim Frontage (LF)	321 LF	+ 270 LF	+ 396 LF	+ 451 LF	+ 664 LF	+ 934 LF
Baggage Claim Units	3 Units	+ 2 Units	+ 4 Units	+ 4 Units	+ 6 Units	+ 8 Units
Baggage Claim Unit Area	2,967 SF	+ 2,345 SF	+ 3,481 SF	+ 3,976 SF	+ 5,885 SF	+ 8,315 SF
Passenger Queue & Bag Retrieval Area	8,048 SF	No Change	+ 62 SF	+ 684 SF	+ 3,085 SF	+ 6,141 SF
Baggage Service Office	588 SF	+ 611 SF	+ 868 SF	+ 979 SF	+ 1,411 SF	+ 1,959 SF
Allowance for Meeters/Greeters	2,665 SF	No Change	No Change	No Change	+ 333 SF	+ 1,156 SF
Baggage Claim Area Circulation	4,179 SF	No Change	+ 370 SF	+ 719 SF	+ 2,066 SF	+ 3,781 SF
Restrooms	1,391 SF	+1,420 SF	+ 2,021 SF	+ 2,283 SF	+ 3,293 SF	+ 4,579 SF
Take-Off Belts	3 Unites	+ 2 Units	+ 4 Units	+ 4 Units	+ 6 Units	+ 8 Units
Take-Off Belt Area	2,300 SF	+2,266 SF	+3,242 SF	+ 3,667 SF	+ 5,308 SF	+ 7,396 SF
Allowance for Baggage Train Circulation	5,160 SF	+1,688 SF	+3,153 SF	+ 3,791 SF	+ 6,252 SF	+ 9,385 SF

Functional Area	Existing Facility	Ultimate Requirement	2 MAEP	Beyond 2040		
				2045	2055	2065
Annual Enplanements	1,182,700	1,648,052	2,000,000	2,153,123	2,745,443	3,500,708
Peak Hour Enplanements	622	1,010	1,226	1,320	1,683	2,145
Allowance for Conveyor Belt & Equip.	500	+870 SF	+1,163 SF	+ 1,290 SF	+ 1,782 SF	+2,409 SF
Concourse Circulation/Concessions						
Pre-Secure Concession Area (Service/Support)	4,800	No Change	+240 SF	+ 626 SF	+ 2,119 SF	+ 4,022 SF
Post-Secure Concession Area (Service/Support)	19,200	No Change	+960 SF	+2,503 SF	+8,474 SF	+16,087 SF
Total Terminal Building Area Requirement	N/A	+ 17,756 SF	+ 38,414 SF	+ 46,267 SF	+ 89,918 SF	+149,622 SF

Source: McFarland-Johnson Analysis, 2017.

5.4. ROADWAY ACCESS AND PARKING FACILITY REQUIREMENTS

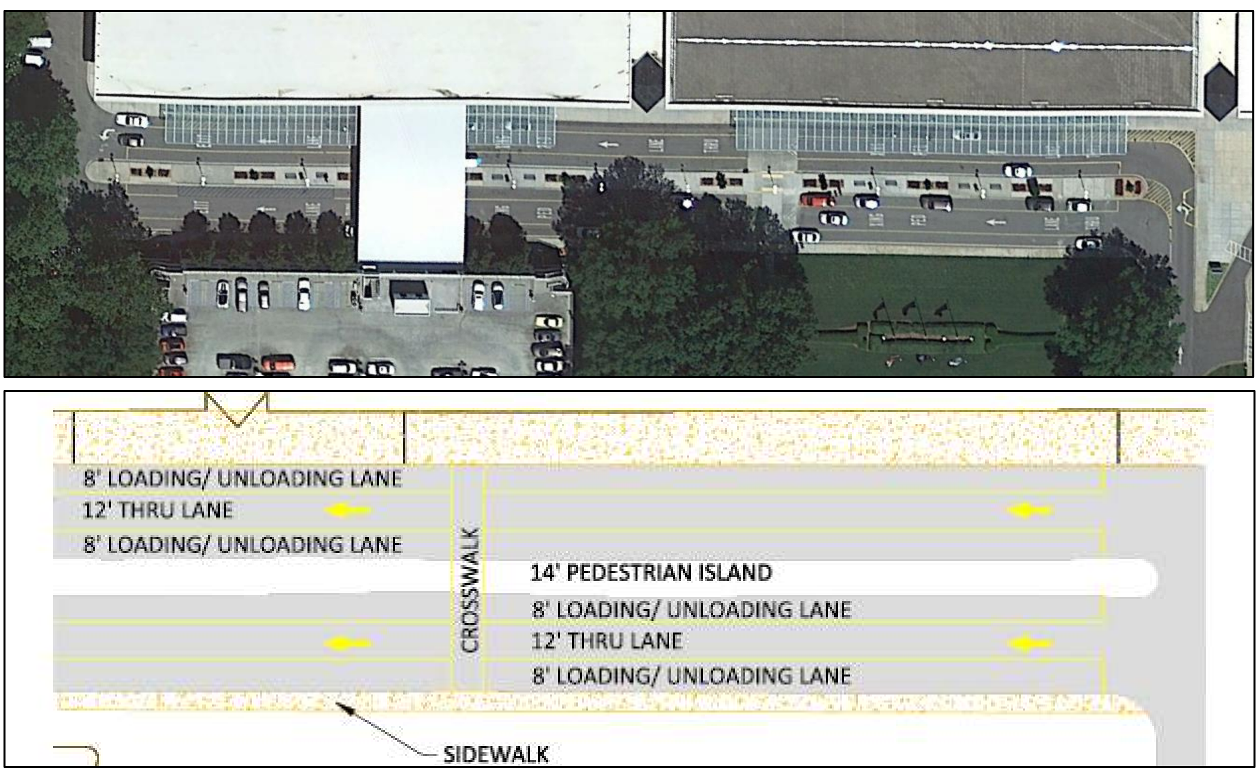
To determine future roadway access and parking facility requirements at GSP, the performance of existing facilities was assessed through detailed review of peak activity vehicular movements about the GSP campus along with daily activity records for each parking lot over a three-year period. This information enables the understanding of traffic profiles during various peak activity periods across an average day as well as typical demands on parking facilities and their peaking characteristics.

5.4.1. Airport Roadway and Circulation Assessment

Existing Airport Entrance Road and Terminal Curb Circulation

The primary Airport entrance road, Aviation Parkway, is comprised of two ingress lanes and two egress lanes divided by a landscaped median. Each lane has a width of 12 feet. At the terminal curb, the two-lane ingress roadway bifurcates and widens to provide a total of six lanes, three on each side of a raised central median. The center lane of each set of lanes are dedicated movement lanes and the outer lanes are for passenger loading/unloading. This provides up to four lanes for passenger unloading/loading all of which provide roughly 500 linear feet when not considering crosswalk spaces. The Airport and its terminal curb circulation roadway can also be access via GSP Drive which connects State Route 41 and Highway 101 through Airport property via Stevens Road and State Road S-42-12. **Figure 2-2** of this report identifies the airport roadway network while **Figure 5-7** depicts the terminal curb layout.

Figure 5-7: Existing Terminal Curb



Source: Google Earth, 2018; McFarland Johnson, 2018.

Traffic Analysis Study Area

The traffic analysis completed as part of this master plan included a study area that incorporated all access routes to the Airport via GSP Drive, Aviation Parkway, and Stevens Road. The I-85 interchange 57 with Aviation Parkway was not included in the study area. Traffic data was collected at the following existing intersections within the study area:

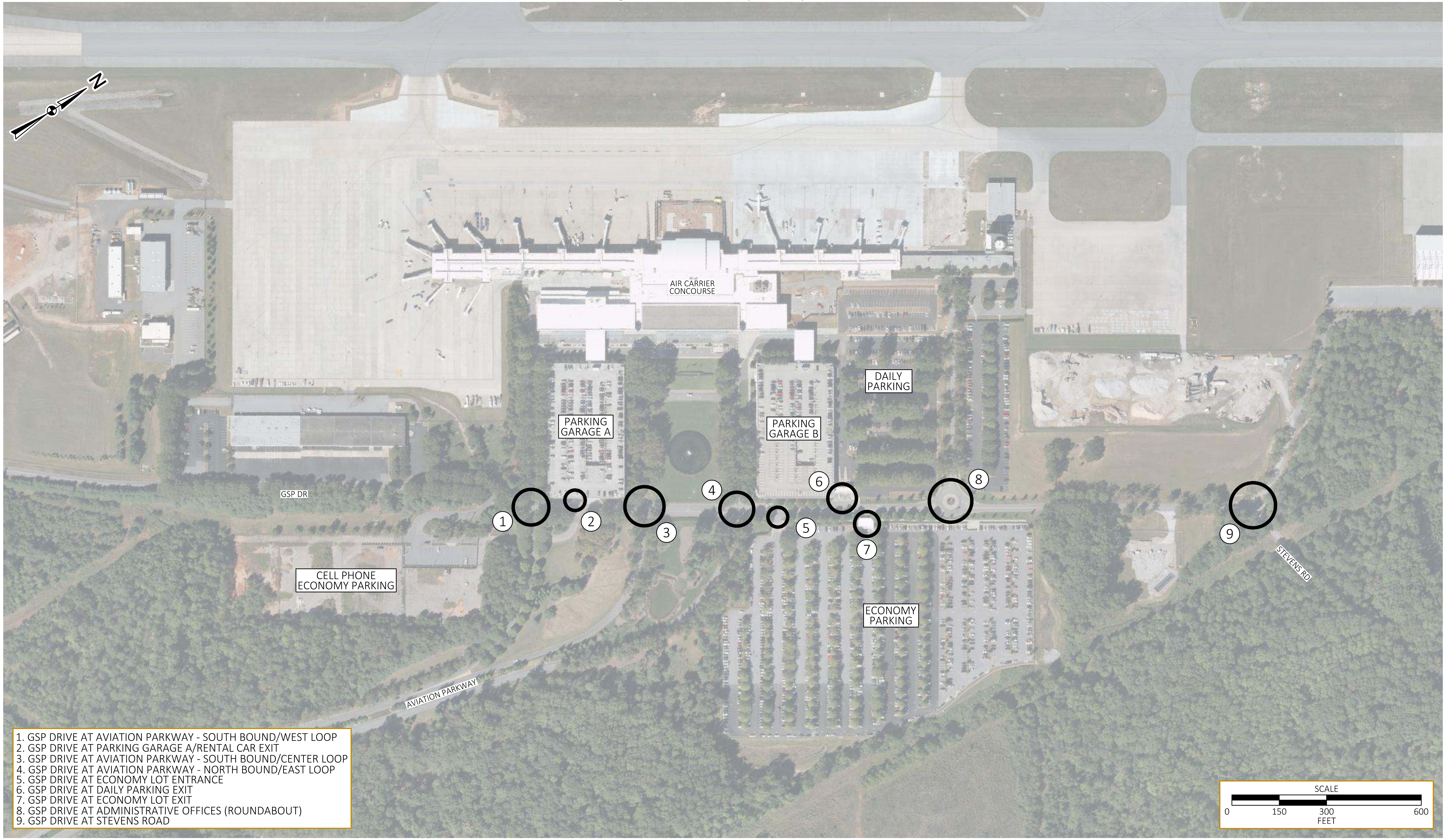
- GSP Drive at Aviation Parkway – South Bound/West Loop *(Un-Signalized)*
- GSP Drive at Parking Garage A/Rental Car Exit *(Un-signalized)*
- GSP Drive at Aviation Parkway – South Bound/Center Loop *(Un-Signalized)*
- GSP Drive at Aviation Parkway – North Bound/East Loop (*Un-Signalized*)
- GSP Drive at Economy Lot Entrance (*Un-Signalized*)
- GSP Drive at Daily Parking Exit (*Un-Signalized*)
- GSP Drive at Economy Lot Exit (*Un-Signalized*)
- GSP Drive at Administrative Offices (*Roundabout*)
- GSP Drive at Stevens Road (*Un-Signalized*)

Figure 5-8 depicts the location of the intersection locations evaluated

Traffic Data Collection

Existing traffic data was collected within the study area including traffic volumes and directional movement, vehicle classifications, airport parking lot volumes, intersection geometry, existing signage and pavement striping. Traffic volumes along the study area roadways were recorded for 24-hours on Tuesday, November 14, 2017 from directional automatic counters in both 15-minute and hourly intervals to determine peak hour timeframes as well as daily traffic volumes on GSP Drive and Aviation Parkway. Manual turning movement counts (TMC) were performed for the study area intersections and recorded 15-minute data intervals during the identified peak timeframes determined from the hourly machine counts. The TMC were video recorded from 6:45 to 9:45 AM and 3:15 to 6:15 PM on Tuesday, November 14, 2017. The TMC data shows that the weekday peak hour traffic in the study area is between 7:30 - 8:30 AM and 8:45 - 9:45 AM in the morning and 4:30 - 5:30 PM in the evening. Existing parking data obtained from the Airport included hourly entering and exiting traffic volumes for each parking lot/garage for the years 2014 through 2017. Traffic volume data collection summary sheets are included in Appendix B.

Figure 5-8: Traffic Analysis Study Area



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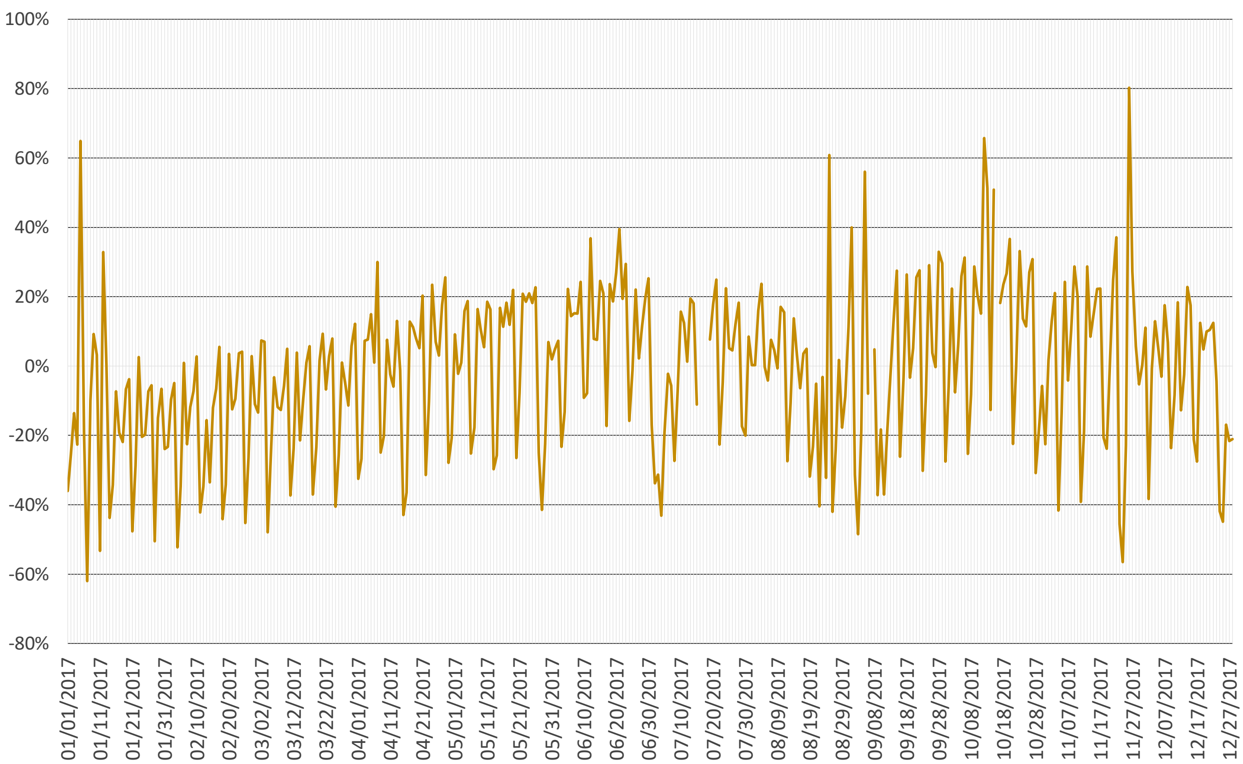
Existing Traffic Volumes

The traffic data collected was used to create traffic volume flow diagrams for the entire study area. Each diagram shows the directional turning movement of traffic by volume at each intersection of study. Utilizing the parking data available, it was determined that the November 14, 2017 traffic activity at the Airport represented a 67th percentile amount of traffic. This indicates an above average, but not overly busy day for traffic at the Airport. **Figure 5-9** shows the daily variation of traffic from the average throughout 2017 based on the parking lot activity. As shown in the graph, the traffic fluctuates daily from 40 percent less than average to 60 percent more than average. After coordination with the Airport, the design team determined that the 90th percentile traffic should be used as the design standard for the roadway assessment and is similar to the design standards applied in typical roadway design projects by municipal departments of transportation. The 90th percentile peak hour traffic volume flow diagrams are included as **Figure 5-10** through **Figure 5-12**.

Figure 5-9: 2017 Daily Traffic Variation



Source: McFarland-Johnson Analysis, 2017.

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Figure 5-10: 90th Percentile Weekday AM Peak Volumes 7:30 to 8:30

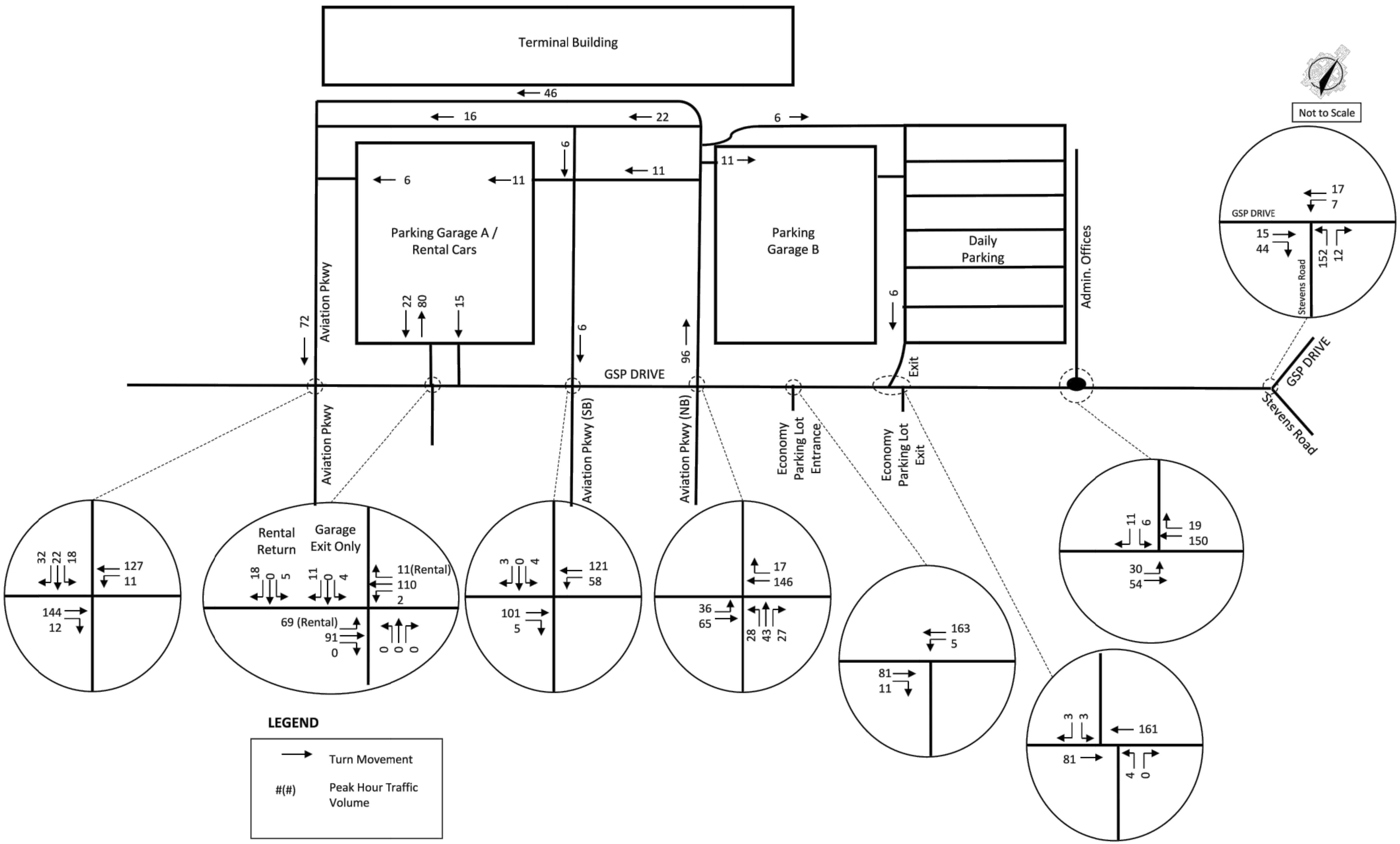

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Figure 5-11: 90th Percentile Weekday AM Peak Volumes 8:45 to 9:45

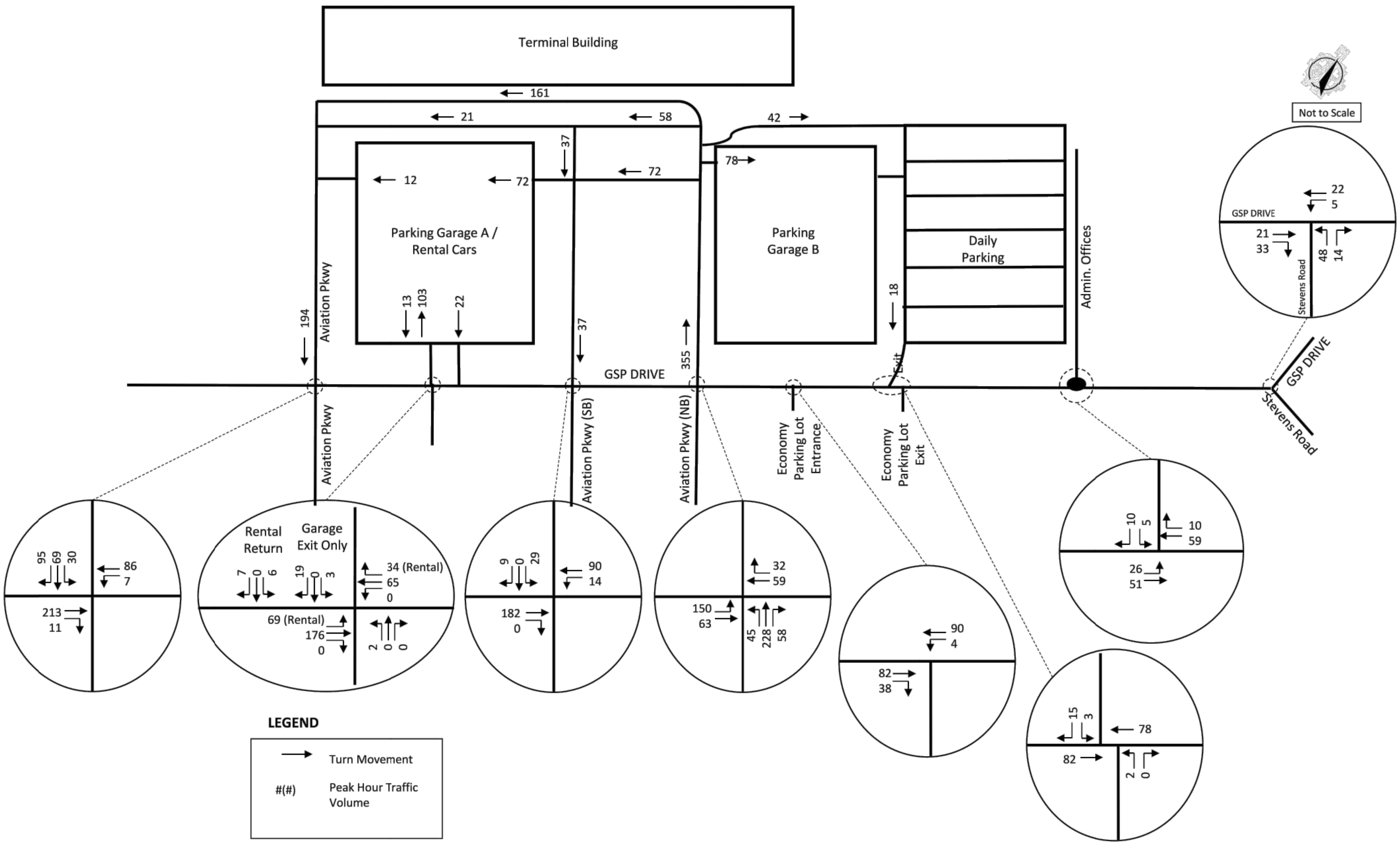

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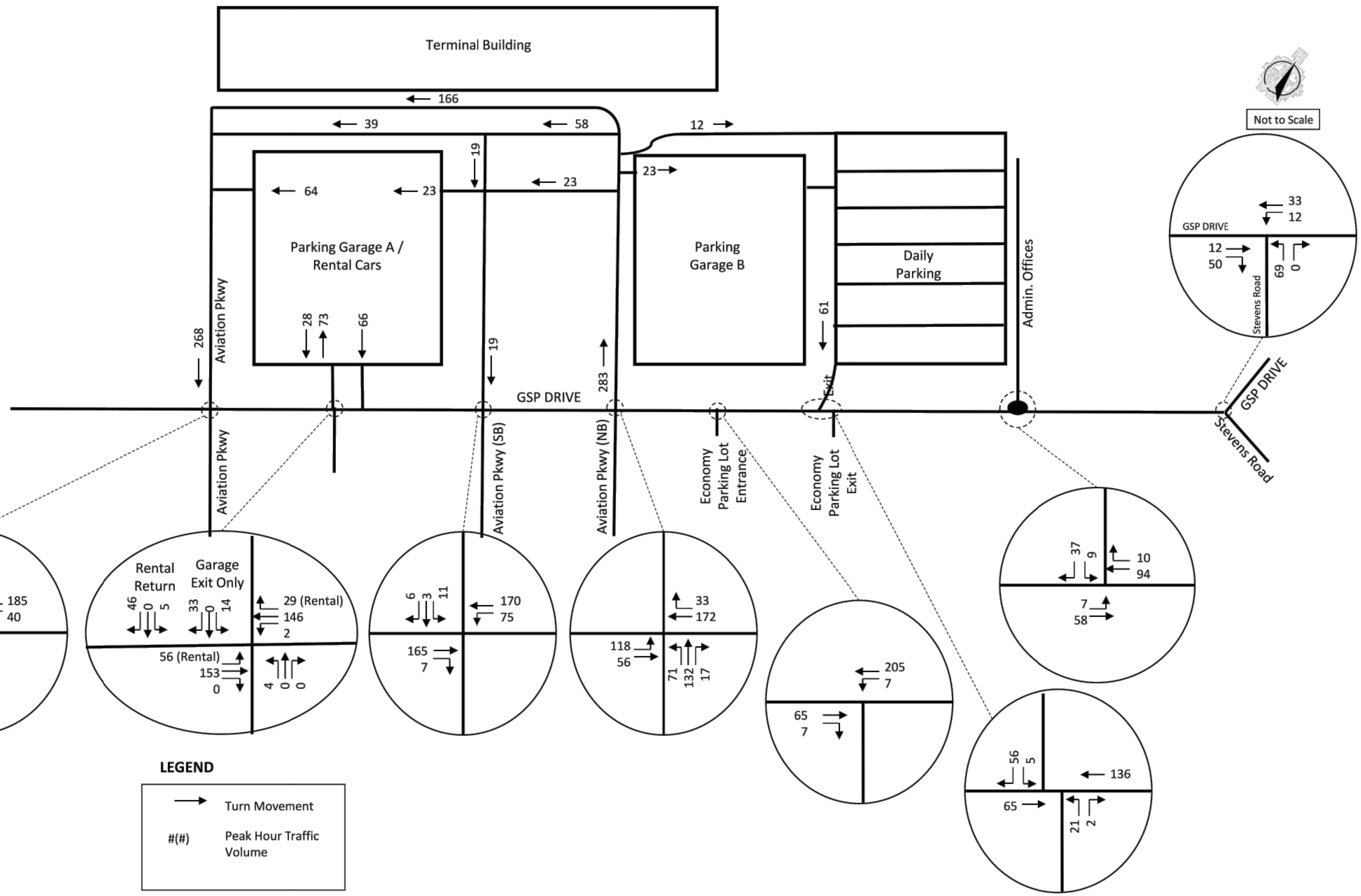
Figure 5-12: 90th Percentile Weekday PM Peak Volumes 4:30 to 5:30



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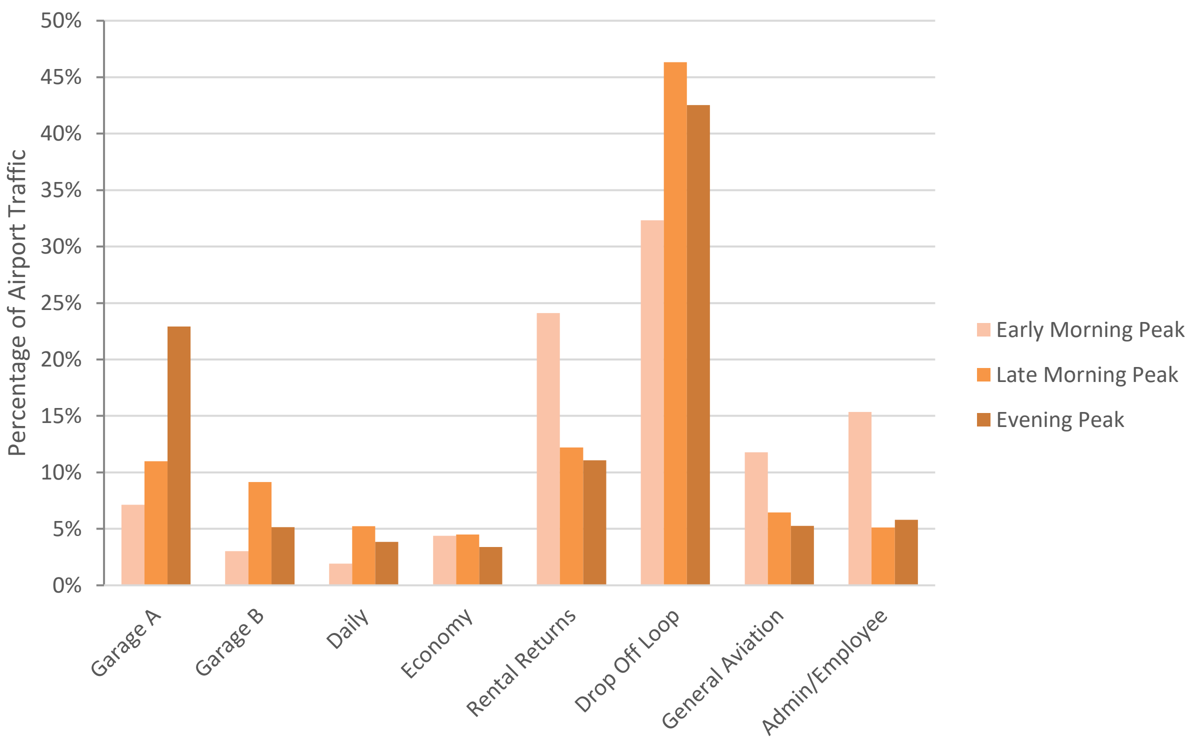
Existing Traffic Patterns

The traffic data collected was used to determine the existing traffic patterns for the area and the distribution of traffic within the study area. It was identified that there is a significant amount of cut through traffic during the commuter peak hours (7:30-8:30AM and 4:30-5:30PM) that range from 20 to 50 percent of the traffic on GSP Drive. The cut through traffic generally represents vehicles that are neither originating from, or destined to, the airport or facilities on the airport. Rather this traffic is effectively using GSP Drive as a shortcut alternative route to Interstate 85 and increasing congestion and road maintenance requirements at the Airport.

Figure 5-13 shows the distribution of airport-related traffic for each of the observed peak hours.

Figure 5-13: Airport-Related Traffic by Destination



Source: McFarland-Johnson Analysis, 2017.

As shown in Figure 5-12, the existing primary traffic destination is the terminal drop off area for all peak timeframes. Garage A has the most parking activity as the rental returns are also currently located within Garage A. This distribution was used to project future traffic volumes with adjustments to available destinations that includes Garage C and additional future surface parking lots.

Existing Traffic Operations

The existing roadway operations were analyzed utilizing Synchro and SimTraffic traffic modeling software. This software requires the input of the roadway conditions (number of lanes, lane widths, traffic controls, speed limits, etc.) as well as the existing traffic data (turn movement volumes, vehicle classification, etc.) to develop a model that simulates the traffic operations and provides level of service (LOS) results. LOS is a term used to characterize the operational conditions of a traffic facility at a particular point in time. Numerous factors contribute to a facility's LOS including travel delay and speed, congestion, driver discomfort, convenience, and safety based on a comparison of the facility's capacity to the facility's demand. Alphabetic designations A through F define the six levels of service. LOS A represents very good traffic operating conditions with minimal delays while LOS F depicts poor traffic operating conditions with excessive delays and queues. Based on the operational conditions, primarily the amount of vehicle delays and queues, operating levels of service are calculated using the procedures defined in the 2010 Highway Capacity Manual, published by the Transportation Research Board. **Table 5-17** provides the LOS results from the analysis of the existing traffic conditions which shows that the existing roadway network has adequate capacity for the current traffic demand of the airport. Synchro existing conditions traffic model result printouts are provided in **Appendix B**.

Table 5-17: Roadway Existing Conditions Level of Service Table

Study Intersection	Approach and Movement		7:30 AM - 8:30 AM LOS	8:45 AM - 9:45 AM LOS	4:30 PM - 5:30 PM LOS
GSP Drive at Aviation Parkway (SB)/West Loop (Un-Signalized)	Eastbound	T-L	A	A	B
	Westbound	T-R	A	A	B
	Southbound	L	A	A	A
		T-R	A	A	B
	Overall		**A**	**A**	**B**
GSP Drive at Parking Garage A/Rental Car Exit (Un-Signalized)	Eastbound	L	A	A	A
	Southbound	L	B	A	B
		R	A	A	A
	Overall		**A**	**A**	**A**
GSP Drive at Aviation Parkway(SB)/Center Loop (Un-Signalized)	Eastbound	T-R	A	A	A
	Westbound	T	A	A	A
		L	A	A	A
	Southbound	T-R	A	A	A
		L	A	A	A
	Overall		**A**	**A**	**A**
GSP Drive at Aviation Parkway(NB)/East Loop Entrance (Un-Signalized)	Northbound	L	A	B	B
		T-R	A	B	A
	Eastbound	L	A	B	B
	Westbound	T	A	A	A
		R	A	A	A
	Overall		**A**	**B**	**A**
GSP Drive at Economy Lot Entrance (Un-Signalized)	Westbound	T	A	A	A
	Overall		**A**	**A**	**A**
	Southbound	L	A	A	A

Study Intersection	Approach and Movement		7:30 AM - 8:30 AM LOS	8:45 AM - 9:45 AM LOS	4:30 PM - 5:30 PM LOS
GSP Drive at Daily Parking Exit (Un-Signalized)	**Overall**		**A**	**A**	**A**
GSP Drive at Economy Lot Exit (Un-Signalized)	Northbound	L	B	A	A
		R	A	A	A
	Overall		**A**	**A**	**A**
GSP Drive at Admin. Offices (Roundabout)	Northbound	L	A	A	A
	Eastbound	L	A	A	A
	Westbound	T	A	A	A
	Overall		**A**	**A**	**A**
GSP Drive at Stevens Road (Un-Signalized)	Northbound	L	A	A	A
	Westbound	L	A	A	A
	Overall		**A**	**A**	**A**

Source: McFarland-Johnson Analysis, 2017.

Future Traffic Volumes

The future traffic volumes analyzed for the study area were based on the Airport's annual enplanement forecast. The future traffic volumes were established based on a linear rate of growth from the current roughly 1.1 million annual enplanements in 2017, from which the existing traffic counts were taken, to a projected 3.5 million annual enplanements in the future. The projected future peak hour traffic volume flow diagrams are included as **Figure 5-14** to **Figure 5-16**.

Future Traffic Operations

Future traffic volumes were determined with the non-airport cut through traffic removed, without considering roadway improvements, using Synchro and SimTraffic traffic modeling software packages and incorporating projected future traffic volumes. The existing traffic patterns were adjusted for future parking facilities and conditions. The results are shown in the **Table 5-18**.

Table 5-18: Roadway Future Conditions Level Of Service

Study Intersection	Approach and Movement		7:30 AM - 8:30 AM LOS	8:45 AM - 9:45 AM LOS	4:30 PM - 5:30 PM LOS
GSP Drive at Aviation Parkway (SB)/West Loop (Un-Signalized)	Eastbound	T-L	B	F	F
	Westbound	T-R	B	C	F
	Southbound	L	B	B	C
		T-R	A	C	F
	Overall		**B**	**E**	**F**
GSP Drive at Parking Garage A/Rental Car Exit (Un-Signalized)	Eastbound	L	A	A	A
	Southbound	L	C	D	E
		R	A	B	B
	Overall		**A**	**A**	**A**
GSP Drive at Aviation Parkway(SB)/Center Loop (Un-Signalized)	Eastbound	T-R	B	D	C
	Westbound	T	A	A	B
		L	A	B	C
	Southbound	T-R	A	B	B
		L	A	A	A
	Overall		**A**	**C**	**C**
GSP Drive at Aviation Parkway(NB)/East Loop Entrance (Un-Signalized)	Northbound	L	B	F	E
		T-R	A	F	C
	Eastbound	L	B	F	F
	Westbound	T	B	B	C
		R	A	B	C
	Overall		**B**	**F**	**E**
GSP Drive at Economy Lot Entrance (Un-Signalized)	Westbound	T	A	A	A
	Overall		**A**	**A**	**A**
GSP Drive at Daily Parking Exit (Un-Signalized)	Southbound	L	B	B	B
	Overall		**A**	**A**	**A**
GSP Drive at Economy Lot Exit (Un-Signalized)	Northbound	L	B	A	B
		R	A	A	A
	Overall		**A**	**A**	**A**
GSP Drive at Admin. Offices (Roundabout)	Northbound	L	A	A	A
	Eastbound	L	A	A	A
	Westbound	T	A	A	A
	Overall		**A**	**A**	**A**
GSP Drive at Stevens Road (Un-Signalized)	Northbound	L	B	B	B
	Westbound	L	A	A	A
	Overall		**A**	**A**	**A**

Source: McFarland-Johnson Analysis, 2017.

Figure 5-14: 3 Million Enplanements AM Peak Volumes 7:30 to 8:30

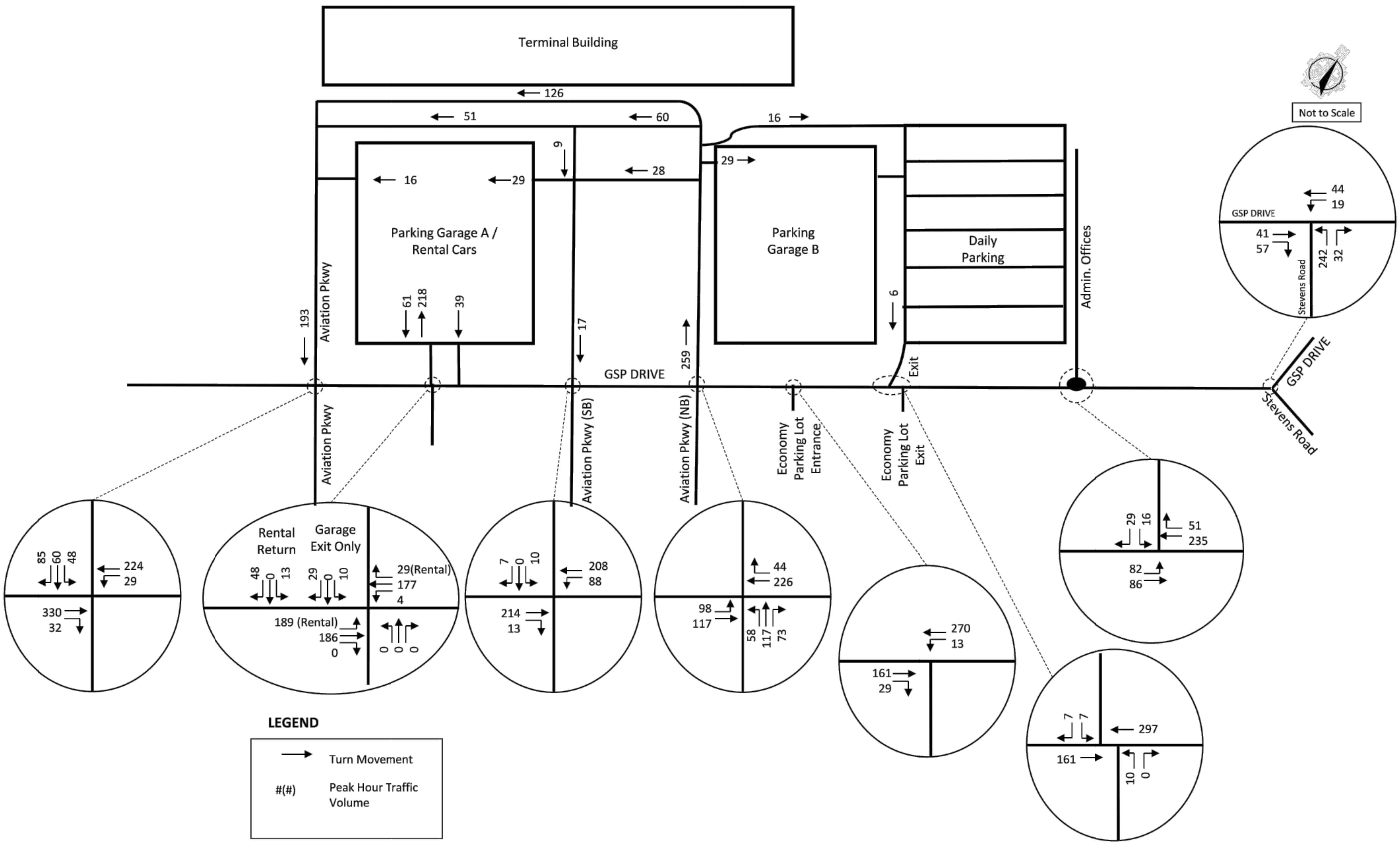


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Figure 5-15: 3 Million Enplanements AM Peak Volumes 8:45 to 9:45

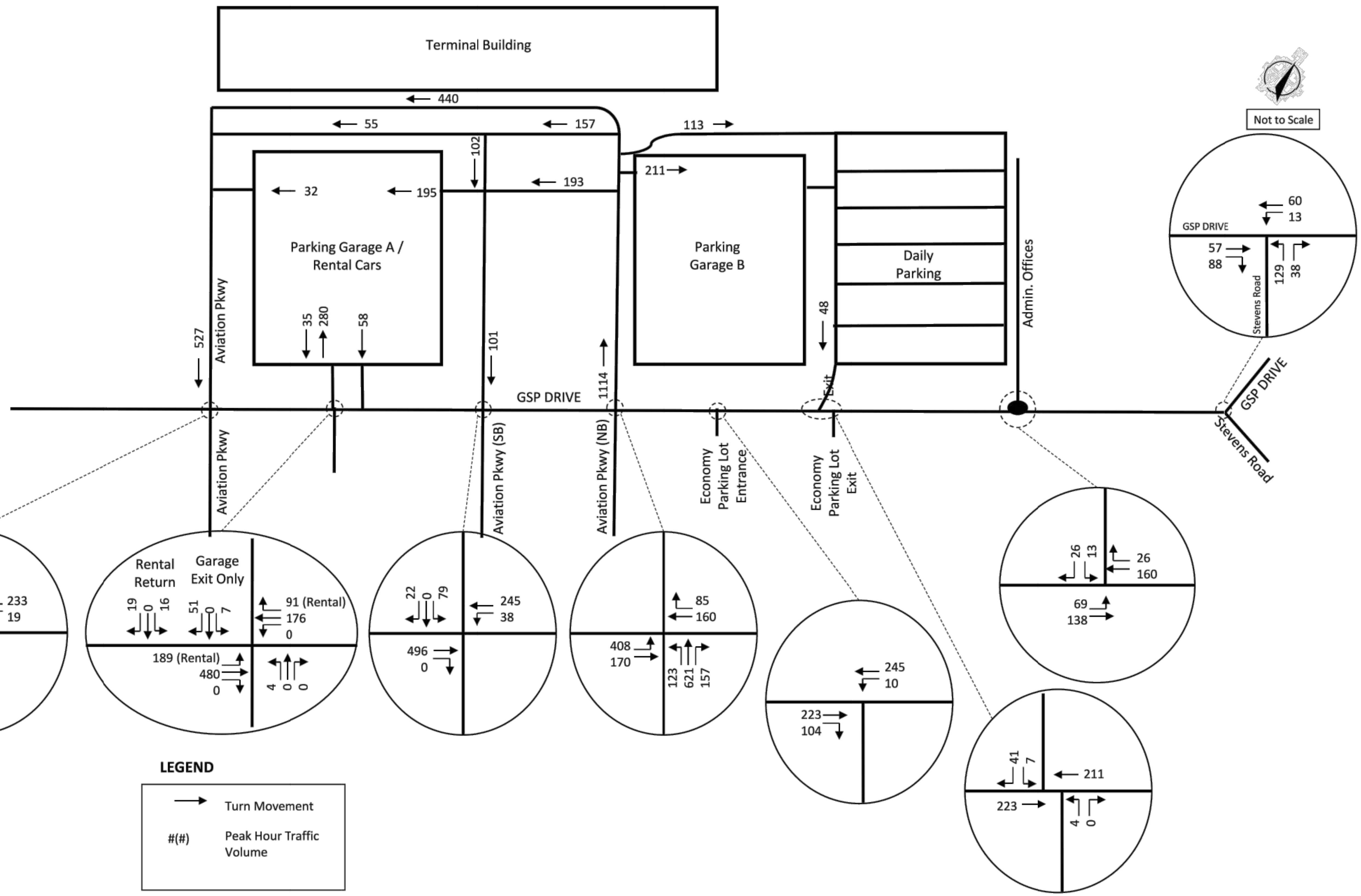

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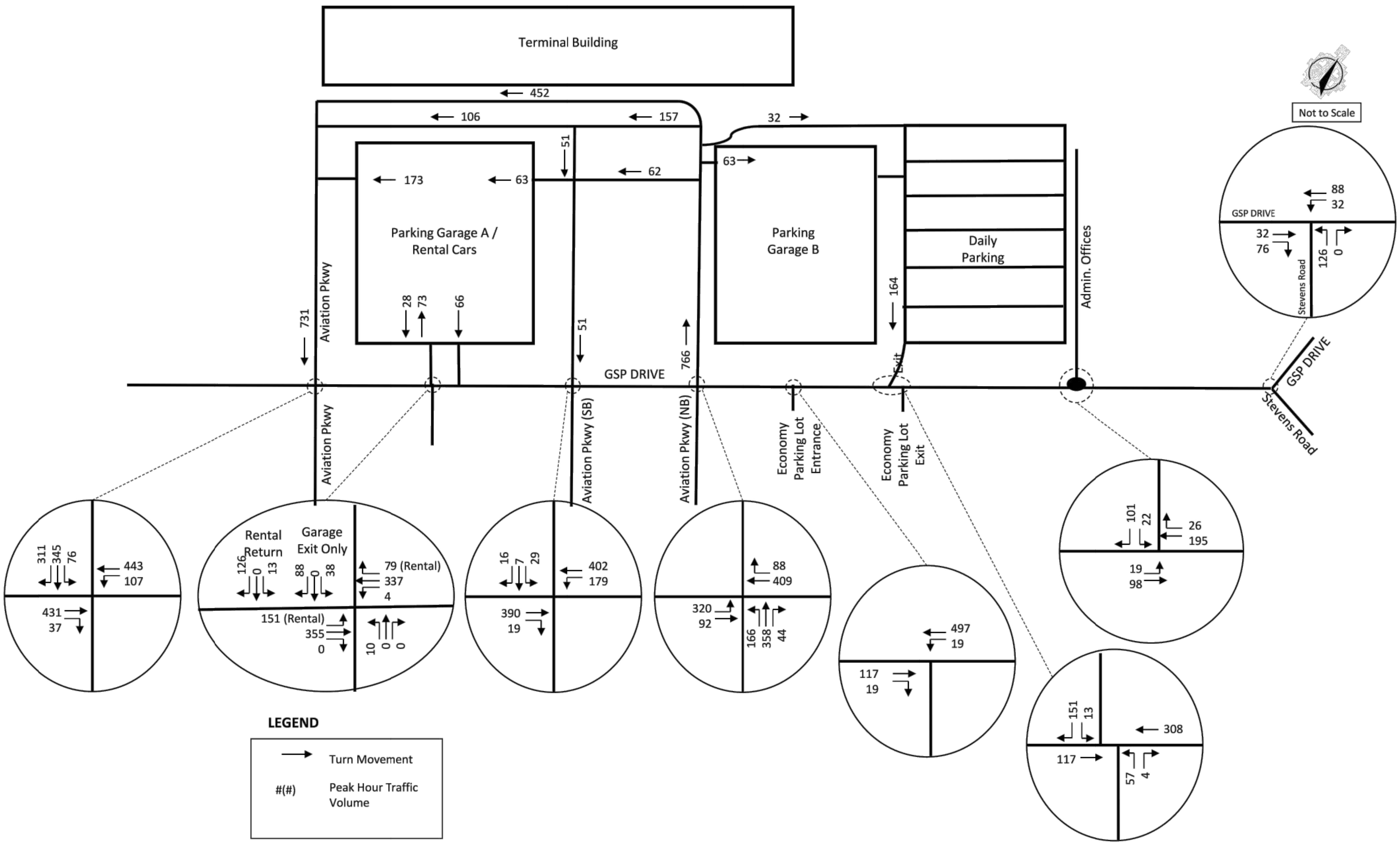
Figure 5-16: 3 Million Enplanements PM Peak Volumes 4:30 to 5:30



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The traffic model analysis results show that the existing roadway network does not have adequate capacity to accommodate the projected future traffic volumes. Significant degradation in LOS is anticipated with failing operations of an LOS E or F and congested operations of an LOS of D are projected during the airport and commuter peak hours throughout the day. Synchro future conditions traffic model result printouts are provided in **Appendix B**. Roadway improvements are assessed in Chapter 6 of this report to review various alternatives and their ability to mitigate the effects of the projected increase in traffic volume and improve accessibility to the airport. **Table 5-19** presents key findings relative to GSP's existing access roadway performance.

Table 5-19: Roadway Access Performance Key Findings

Facility	Performance Key Findings
Airport Entrance/Circulatory Roadway	
Traffic Levels, Congestion, and Level of Service	The existing roadway network does not have adequate capacity to accommodate the projected future traffic associated with airport growth to 3.5 million annual enplanements.
Operating Speeds	The existing operating speeds provide for efficient movement of vehicles within the study area. As the airport grows and additional parking lots are constructed, speeds should be further assessed if pedestrian crosswalks are maintained and/or proposed in new locations.
Geometric Issues	The existing roadways have adequate alignments for the design speeds; however, the un-signalized intersections do not have adequate capacity to accommodate the projected future traffic volumes. The terminal curb drop-off area is the primary vehicle destination within the airport. GSP Drive traffic is currently hindering this access and unrestricted/free flow access for the terminal loop is recommended as the airport traffic volumes grow.
Operational Efficiency	All entering traffic from both Aviation Parkway and GSP Drive are required to utilize Aviation Parkway when accessing the Terminal Drop Off, Rental Cars Drop off, Garage A, Garage B and the Daily Lot/Garage C. This combination of destinations to a single point is not sustainable as the airport continues to grow.
Access Control Issues	Stevens Road creates opportunity for cut through traffic and does not serve the commercial air traveler or GA user.
Other Facilities	
Pedestrian Accommodation	Pedestrian crosswalks are provided to the parking garages from the terminal and in a couple locations along GSP drive to access the economy lot. As the airport grows, pedestrian facilities to access new/expanded parking facilities should be incorporated.
Sign and Wayfinding	Existing patrons access the terminal, rental cars and parking garages through the Aviation Parkway leg into the Airport. As traffic volumes grow, segregation of these destinations as patron enter the airport with separate entrances and signage will be beneficial for customer wayfinding as well as traffic congestion.

Source: McFarland-Johnson Analysis, 2017.

5.4.2. On-Site Parking and Facility Assessment

Identified in Section 2.4.6 of this report, GSP maintains two parking garages, Garage A and B, and multiple surface lots organized for daily parking, economy parking, overflow parking, cell phone waiting, and employee parking. Rental car ready/return areas are currently located in Garage A but will be relocated to the new Garage C, once constructed. Existing parking lot capacities are summarized in **Table 5-20** below.

Table 5-20: Parking Facilities Overview

Parking Facility	Parking Spaces	Notes
Garage A	356 Covered Public Spaces 324 Uncovered Public Spaces 386 Covered Rental Spaces	All rental spaces to be converted to publicly accessible spaces once Garage C is operational.
Garage B	1,182 Covered Public Spaces 323 Uncovered Public Spaces	
Garage C	Currently in Design	Anticipated to be opened Summer of 2020
Daily Lot	367 Uncovered Public Spaces 117 Uncovered Valet Spaces	Spaces to be sacrificed for Garage C
Economy Lot	1,522 Uncovered Public Spaces	
Overflow Lot	500 Uncovered Public Spaces	Operational
Cell Phone Lot	40 Uncovered Public Spaces	
Employee Parking Lot	214 Employee Uncovered	Identified to be presently operating at capacity

Source: Greenville Spartanburg International Airport District, 2018.

The condition of Airport parking garages are in good condition and capable, if maintained, to support airport activity throughout the planning period. The condition of surface parking facilities in the terminal area is fair to good condition, with sections exhibiting longitudinal, transverse, and alligator cracking in the surface lots. Pavement drainage is good, with some localized ponding of water in parking lots most likely due to pavement overlays and crack sealing creating small low points. The overflow lot was recently constructed and is now opened to accommodate increase traffic from new air carrier entrant. This pavement is in excellent condition.

Parking Facilities Performance Key Findings

Parking demand was segregated into public parking and employee parking. The total existing demand for public parking is based on the estimated number of parked cars in a typical month based on data provided by the Airport parking operator quantifying movements into and out of Airport parking facilities, as well as on-site observation and discussion with Airport management staff. The demand for on-Airport public parking facilities was identified to be 80 percent or higher of available spaces in all GSP parking garages and lots. The practical capacity for a parking facility is generally assumed to be 85 percent to 90 percent of the available spaces because, at those occupancy levels, parking patrons have trouble in finding available spaces and chose to park at alternative locations or choose other access modes. As a result, on-airport parking facilities are recognized to be constrained currently and effectively operating at capacity during peak periods.

Table 5-21 summarizes the key findings made via field observations of Airport parking performance.

Table 5-21: Parking and Facilities Performance Key Findings

Facility	Performance Key Findings
Terminal Area Parking	
Parking Lot Utilization	Garage A – 85 percent utilized Garage B – 80 percent utilized Garage C – Zero percent utilized (under design) Daily Lot – 85 percent utilized Economy Lot – 80 percent utilized Overflow Lot – Utilization Varies Cell Phone Lot – Utilization Varies Employee Lot – 95 percent utilized
Peaking Characteristics	GSP Garages and surface parking lots have generally consistent demand across the year with peaks experienced in the summer months through the early fall. An analysis of activity levels by day of the week indicated that activity in the garages peak on Monday and Tuesday, while activity in the economy lot peaks on Friday and Saturday.
Other Facilities	
Location, Effectiveness, and Pedestrian Accommodation	Garages A and B are located near the terminal area. Garage A and B are connected to the terminal via covered concrete sidewalks equipped with striped crosswalks at each of two roadway crossings leading to terminal. Garage C is currently under design and anticipated to be connected to terminal via covered walkway upon completion through either a new connection or connection to the existing Garage B sidewalk. The Daily Lot will be removed to allow for Garage C. The Economy Lot is located east of GSP drive requiring an approximately 700-foot uncovered walk to the terminal from the lot's nearest corner. The Overflow Lot is located east of GSP drive and south of Aviation Parkway and not in near proximity to the terminal. This lot requires a transit connection to the terminal.
Sign and Wayfinding	Parking facilities are identified though conspicuous, concise, comprehensible, legible and well-located signage along aviation parkway and GSP drive. Parking garages are also equipped with a parking guidance to indicate available spaces to drivers.
Security Issues	Vehicles allowed to dwell at terminal curb for an extended period of time, parking in some cases.

Source: McFarland-Johnson Analysis, 2017.

Forecast of Peak Period Passenger Parking Demand

Forecast of peak period passenger parking demand is based on projections on peak month enplanement projections identified in Chapter 3, *Aviation Forecasts*, and average month parking garage/lot records. **Table 5-22** presents passenger demand factors utilized in the analysis while **Table 5-23** applies those factors to computationally explore future parking spaces anticipated per garage/lot. The total future number of parking spaces calculated was adjusted to compensate for the loss of 484 Daily Lot spaces with the construction of Garage C in 2019/2020. Additionally, a 25 percent utility/planning factor was applied to ensure a high level of service in all parking facilities throughout the planning period.

Table 5-22: Passenger Demand Factors

Factor	Demand	
Passenger Parking Facility	Vehicles Parked	
Average Month – Garage A		11,979
Average Month – Garage A Sky Lot		1,827
Average Month – Garage B+ Daily Lot		16,823
Average Month – Garage B Sky Lot		1,211
Average Month – Economy		9,020
Average Month – TOTAL		40,860
Enplanements	2017	2036
Average Month	84,551	137,338
Peak Month	95,373	154,917
Average Day/Peak Month	3,077	4,997

Source: ABM Parking Services, 2018; and McFarland-Johnson Analysis, 2017

Table 5-23: Peak Passenger Parking Demand

Garage	2017 Spaces	2017 Avg. Monthly Parking	Parking per Space	2037 Avg. Monthly Parking Demand	2037 Spaces Required	Surplus / (Deficit)	+25 Percent Utility/ Planning Factor
Garage A	356	11,979	33.65	19,458	578	(222)	(278)
Garage A Sky	324	2,968	5.64	2,968	526	(202)	(253)
Garage B + Daily	1,666	27,326	10.10	27,326	2,706	(1,040)	(1,300)
Garage B Sky	323	1,967	3.75	1,967	525	(202)	(253)
Economy Lot	1,522	14,651	5.93	14,651	2,472	(950)	(1,188)
						TOTAL:	(3,270)
						+ Daily Lot Loss for Garage C:	(3,754)

Source: McFarland-Johnson Analysis, 2017

Plans for the development of Garage C should consider the need for approximately 1,500 to 1,800 premium parking spaces in the future. The proposed relocation of rental car ready/return facilities from Garage A to the new Garage C will go a long way to better balancing publicly accessible garage parking facilities across the GSP terminal area. Future roadway developments around Garage C should consider segregated access points for private and rental cars.

Parking Demand Considerations

A number of factors that affect parking demand at airports should be monitored as scheduled passenger service offerings change at GSP and passenger behavior evolves around emerging technologies. These factors include:

- Originating Passengers: The ratio of originating to terminating passengers is a key metric for auto parking because only originating passengers have the ability to park at the airport. The inverse of this ratio, which represents terminating passengers is helpful in planning for rental car facilities and ground transportation. For this analysis, it is assumed that all passengers enplaned at GSP are originating passengers, since the Airport does not function as a hub for connecting flights. If service changes and the volume of originating passengers at GSP increases significantly, parking demand could increase.

- Impacts of ULCC Service: The average number of passengers per vehicle could increase if service by a ULCC is added at GSP, as leisure markets typically experience higher travel party size compared to business markets. ULCC service will also likely increase the duration of parked vehicles at GSP, and ULCC flights that operate once per day could limit space turnover since passengers departing on the one daily flight will arrive to the airport before arriving passengers on the inbound flight can vacate parking spaces. In the event that significant increases to weekly available seats to leisure markets are added at GSP, parking duration should be closely monitored to ensure that peak demand can be accommodated.

- Impacts to passenger's mobility options and transportation preferences over the next twenty plus years could have a significant impact in future demand for parking facilities at the Airport and how they are used. The rise of transportation network companies, development of autonomous vehicle technology, and even shifting values relative to vehicle ownership and non-traditional transit options are all likely to play a role in shaping GSP parking demand in the future. While Garage C will provide a significant boost in parking capacity, the same demand ratios may not be applicable as Airport enplanement volumes grow, past this study's planning period, towards 3 million annually.

Recommendations: Over the planning period an additional 3,754 parking spaces can be reasonably anticipated based on current use patterns. This includes approximately 2,000 in a garage with the remainder located in surface lots. Future land for beyond planning period needs should be reserved and traveler parking habits monitored over time.

Employee Parking Facility Requirements

The employee parking lot at GSP regularly operates at full capacity and additional employee parking is needed. The existing 214 employee lot is undersized and will be eliminated with the construction of Garage C. Approximately 250 employee spaces are required today, and space should be planned to provide 400-500 spaces by the end of the planning period.

Recommendations: A relocated and expanded employee parking lot should be constructed to provide for 400-500 individual parking spaces. Should the future lot not be co-located with the terminal building, shuttle bus stops should be provided within the lot and the impact of employee shuttles on the terminal curb should be considered if necessary.

Parking Lot Connectivity – Bussing and PRT

As the GSP parking facility system is developed over time to support growing demand from commercial air travelers and other users, consideration should be given to the need for an internal shuttle bus or personal rapid transit (PRT) system to provide connectivity from all parking areas to the terminal in an integrated, safe, and sustainable way. The model for implementing bussing operations to shuttle travelers between parking facilities and the terminal curb is well understood and should be employed at GSP as parking lots not-contiguous with the terminal core or terminal campus begin being utilized. Over time, as driverless technologies become more developed and implementable, consideration should be given to PRT systems to more efficiently and economically provide for passenger/terminal connectivity.

5.4.3. Summary of Roadway Access and Parking Facility Requirements

The preceding sections reviewed the ability of existing airport roadway and parking facilities to support projected levels of activity across the planning period and beyond. **Table 5-24** summarizes future roadway and parking requirements.

Table 5-24: Parking and Roadway Access Facility Requirements Summary

Item/Facility	Existing Facility or Capacity	Ultimate Requirement	Deficit/Goals
Airport Entrance/ Circulatory Roadway	Unable to provide current LOS through 3.5 MAEP	Phased approach to providing high LOS at 3.5 MAEP	Increase Capacity, Limit/Remove Full-Stop Intersections, Minimize Crosswalks, Decouple Terminal Curb and Parking Traffic, Balance Garage Utilization
Airport Parking	Most lots approaching capacity on peak days.	Support parking needs through 2 MAEP	Provide for an additional 2,000 garage spaces and 1,800 surface lot spaces.

Source: McFarland-Johnson Analysis, 2017

5.5. AIR CARGO FACILITY REQUIREMENTS

The following sections explore how growth in air cargo demand at GSP will drive development of dedicated air cargo facilities at the Airport. Section 3.5 of this report identifies strong growth in air cargo at GSP for both integrated carriers, such as FedEx and UPS, and all cargo carriers such as Senator International Freight Logistics, LLC (Senator). With compound annual growth rates forecasted between 3.2 percent and 6.1 percent, GSP can expect to facilitate the movement of anywhere from 103,000,000 pounds to 250,000,000 pounds by 2037, and upwards of 826,000,000 pounds by 2065 should trends continue. Existing cargo facilities and equipment, as discussed in Section 2.4.3 of this report, will be unable to support the variety and quantity of air cargo anticipated in the future. In fact, new cargo facilities are already under construction as of July 2018.

5.5.1. Near-Term Cargo Facility Developments

To better support the growing operations of Senator International a new 63,500 square yard cargo apron and 100,000 square foot air cargo building with 10,000 square feet of attached office space has been designed and is anticipated to be operational within year 1 of the planning period (2019). This new apron and building will allow Senator's current level of activity on the South Cargo Apron to relocate to the new north apron and provide additional space for the growing operation.

5.5.2. Methodology

Report 143 of the Transportations Research Board's (TRBs) Airport Cooperative Research Program (ACRP), entitled *Guidebook for Air Cargo Facility Planning and Development*, was published in 2015 and serves as the primary guidance to inform air cargo facility considerations at GSP. This report provides effective strategies and tools for identifying and responding to changing conditions affecting air cargo demand

The primary cargo-related facilities requiring analysis include:

- Cargo Building Space
- Aircraft Ramp Area
- Paved GSE Storage
- Truck and Auto Parking
- Landside/Airside Truck Doors

5.5.3. Assumptions

Air Cargo Building/Warehouse Space

Air cargo building facility requirements are based on the overall amount of cargo moving through the building and the throughput capacity of the portion of the building dedicated to air cargo processing/warehousing. Based on the survey data collected as part of ACRP Report 143, air cargo buildings for integrated express carriers at domestic airports average 29,100 square feet and at international gateway airports average 81,200 square feet. The report also indicates that when multiple integrated express carriers operate at an airport, one commonly has a larger sortation facility on airport, and another maintains a much smaller cargo building and trucks air cargo off airport to a regional sortation facility. In these situations, the throughput ratio of the buildings are substantially different. This is the case with Fed Ex and UPS on the north cargo apron. Fed-ex operates from a 100,000 square foot cargo building/warehouse, while UPS operates from a much smaller 5,000 square foot building used solely to facilitate parcels moving from plane to truck. UPS maintains a very high throughput ratio with its building, while Fed-Ex is much lower on account of the building also being utilized as a sorting/warehousing facility.

Presently no dedicated cargo building/warehouse is available for all cargo freight carriers. The south apron is currently used to accommodate both airline belly cargo and all cargo freight operations. A new 100,000 square foot cargo building is under construction and will open to accommodate scheduled cargo services currently provided by Senator and relocated from the south apron.

Table 5-25 presents the default tonnage per square foot cargo building ratios used for this analysis. While these values are slightly below the ratios presented in ACRP Report 143, they are more in line with actual operations at GSP.

Table 5-25: Air Cargo Building/Warehouse Ratio Inputs

Integrated Express	All Cargo
0.20 Tons/SF	0.30 Tons/SF

Source: ACRP Report 143, McFarland-Johnson Analysis, 2017

Aircraft Apron Area

The role of the air cargo apron is to provide aircraft parking adjacent to the air cargo terminal building, provide sufficient space for ground handling operations for the loading and unloading of cargo aircraft as well as to service the aircraft, and provide sufficient space for the storage of ground service equipment, cargo containers, pallets, etc. Air cargo aprons are sized to accommodate the anticipated maximum amount of simultaneously parked aircraft and the size of those aircraft. **Table 5-26** presents the air cargo parking requirement assumptions based on forecasted levels of air cargo and fleet mix.

Table 5-26: Air Cargo Apron Parking Requirements

Integrated Express	Existing	Short-Term	Mid-Term	Ultimate
Integrated Express PH Demand	D-IV (3)	D-IV (4) D-V (1)	D-IV (3) D-V (3)	D-IV (2) D-V (4)
All Cargo PH Demand	D-V (3)	D-IV (2) D-V (4) D-VI (0)	D-IV (0) D-V (6) D-VI (0)	D-IV (2) D-V (5) D-VI (1)

Source: McFarland-Johnson Analysis, 2017

Paved GSE Storage

Paved storage area for ground service equipment (GSE) is an essential component of the air cargo apron. This area is generally located in between the aircraft and the air cargo building or adjacent to the aircraft and used to stage the wide variety of equipment utilized to efficiently load and unload aircraft.

Based on guidance from ACRP Report 143 and review of GSP operational practices, **Table 5-27** presents the tonnage per square foot GSE storage apron ratios used for this analysis.

Table 5-27: Air Cargo Building/Warehouse Ratio Inputs

Integrated Express	All Cargo
0.57 Tons/SF	1.11 Tons/SF

Source: ACRP Report 143, McFarland-Johnson Analysis, 2017

Truck Docks and Parking Areas

For the purpose of this analysis a ratio of one truck dock for every 2,400 square feet of cargo building will be utilized. Additionally, 75 percent of these docks will be assumed to be on the landside of the building while the remaining 25 percent are located on the airside. These assumptions are consistent with ACRP Report 143, typical air cargo developments, and the existing development on the north cargo apron at GSP.

To plan for appropriate space for truck and automobile parking the standard planning metric of 1.7 times the cargo building area was used. This metric is recommended for typical air cargo developments by ACRP Report 143 and is consistent with existing air cargo development at GSP.

5.5.4. Results of Analysis

Table 5-28 presents the results of the air cargo facility requirements based on the assumptions outlined in the preceding sections.

Table 5-28: Air Cargo Facility Requirements Summary

Item/Facility	Existing Facility or Capacity (2019)	Short-Term	Mid-Term	Ultimate
Aircraft Parking Positions	6	12	12	14
Air Cargo Building	100,000 SF	+110,581 SF	+156,614 SF	+262,487 SF
Aircraft Apron Area	30,000 SY	+ 16,911 SY	+ 20,800 SY	+ 39,267 SY
Paved Cargo Handling Ground Equipment Storage	9,500 SY	+ 1,529 SY	+ 3,330 SY	+ 8,624 SY
Total Apron	39,500 SY	+ 18,440 SY	+ 24,130 SY	+ 47,891 SY
Truck and Auto Parking	27,750 SY	None	+ 6,074 SY	+ 20,028 SY
Number of Landside Truck Docks/Doors	38 Doors	+ 17 Doors	+ 29 Doors	+56 Doors
Number of Airside Truck Doors	10 Doors	+ 9 Door	+ 13 Doors	+ 22 Doors

Source: McFarland-Johnson Analysis, 2017

Recommendations: Air cargo operations at GSP continue to grow rapidly and have expanded significantly during development of this Master Plan. Based on this growing and forecast demand, GSP should seek to meet the projected demand by developing additional air cargo facilities to meet the building, apron and parking requirements outlined above. Additional future cargo facilities beyond the current facility under construction (as of 2018) should be planned to meet forecast demand. Additional capacity beyond forecast numbers should also be considered should actual demand outpace forecast activity.

5.6. GENERAL AVIATION FACILITY REQUIREMENTS

This section discusses the requirements for each of the general aviation (GA) elements. Requirements for GA facilities at GSP were calculated based on data collected during the inventory, forecasts of aviation demand, consultation with Airport staff, as well as FAA standards. The following facilities were examined:

- Aircraft Hangars
- Aircraft Aprons
- General Aviation Terminal and FBO Facilities
- General Aviation Access and Auto Parking

5.6.1. Aircraft Hangars

General aviation hangars at an airport are planned for both based and itinerant aircraft. Requirements are calculated based on the size and quantity of aircraft based at the Airport. While each aircraft will vary in size, the following planning factors were used to calculate the approximate hangar space requirements for aircraft based at GSP:

- 1,200 square feet for single engine and rotor aircraft
- 1,600 square feet for multi engine aircraft
- 3,200 square feet for jet aircraft

The current hangar provisions for GA aircraft are shown in **Table 5-29**.

Table 5-29: Existing Hangar Facilities

Designation	Location	Lessee (Use)	Space in SF (Based Aircraft Storage in SF)
Hangar 1	2100 GSP Drive	PSA Airlines (Maintenance)	N/A
Hangar 2	2102 GSP Drive	Cerulean Aviation	29,700 (24,000)
Hangar 3	2106 GSP Drive	SAI Flight Service (Storage)	13,200 (All)
Hangar 4	2108 GSP Drive	Milliken (Storage/Office)	16,200 (13,200)
Hangar 5	2110 GSP Drive	Michelin (Storage/Office)	21,200 (17,800)
Hangar 6	2112 GSP Drive	Venture Air (Bulk Storage)	33,790 (All)

Source: Greenville-Spartanburg International Airport, 2017

Based Aircraft

As of 2017, 100 percent the based jet and multi-engine aircraft are housed within the conventional hangar space provided. It is anticipated that any additional jet and multi-engine aircraft will require additional conventional hangar space.

Ideally, 100 percent of aircraft are stored in hangars. For planning purposes, it is assumed that 75 percent of single-engine aircraft will be stored in conventional hangars and 25 percent will require apron space to tie-down. Additionally, 75 percent of multi-engine aircraft will be stored in conventional hangars and 25 percent will require apron parking space. All jet and rotor aircraft will be stored in conventional hangars.

Dependent on the aviation forecast outline in Chapter 3, *Forecast*, based aircraft hangar space demand was calculated as displayed in Table 5-30. This analysis shows based aircraft will not necessitate additional hangar capacity at GSP within the 20-year planning period. However, as GSP grows alongside its regional economy there is great potential for the Airport to benefit from unforeseen opportunities and outpace this study's conservative forecast for based GA aircraft. Further, opportunities to attract new based aircraft from regional sources has been identified by GSP. As such, it is prudent to plan for future facility expansion to accommodate such potential.

Itinerant Aircraft

As the owner and operator of the airfield's FBO, GSP currently offers a variety of high-level services to transient aircraft. As this operation grows, temporary aircraft storage for itinerant aircraft will elevate the FBO's capability to serve its client base. Aircraft storage demand for itinerant aircraft was calculated under the following assumptions:

- Peak day operations reflect the largest potential demand for itinerant aircraft
- Jet aircraft requiring hangar space account for 25 percent of itinerant GA operations
- Multi-engine aircraft requiring hangar space account for 25 percent of itinerant GA operations
- Single-engine itinerant aircraft do not require hangar space
- Only peak day arriving aircraft will require space (50 percent of total itinerant operations)
- Of peak day arriving aircraft, 75 percent will require hangar space at the same time.

Itinerant aircraft hangar space demand is displayed in Table 5-30, revealing only limited additional need within the current planning horizon, but substantial improvements beyond. It should be noted here that this model only explores requirements based on the forecast need which does not take into account the ability of the Airport to outperform its historical growth or market share by actively marketing new itinerant activity. As the regional economy grows, the Airport will only become more attractive to parties interested in locating their aeronautical assets and/or operations at the Airport.

Table 5-30: Aircraft Hangar Demand

Functional Area	Existing Facility	Short-Term	Mid-Term	Ultimate	Beyond 2040		
					2045	2055	2065
Based Aircraft Demand*	101,990 SF	None	None	None	None	+17,410 SF	+41,464 SF
Itinerant Aircraft Demand	0 SF	None	+12,000 SF	+12,000 SF	+14,400 SF	+28,800 SF	+28,800 SF
Total	101,990 SF	None	+12,000 SF	+12,000 SF	+14,400 SF	+39,010 SF	+79,864 SF

*Note: * = Subject to new based aircraft relocations.*
Source: McFarland Johnson Analysis, 2017

Recommendations: While based aircraft are forecast to drive limited demand for additional hangar capacity, the aeronautical forecasts do suggest that additional hangar capacity will be required to support growth in itinerant GA activities throughout the planning period. Additionally, it is important the Airport remain available to respond to current and unforeseen opportunities which could significantly impact GA facility needs. Planning for new facilities and additional long term GA development in the vicinity of the existing GA facilities is recommended.

5.6.2. Aircraft Aprons

The two general aviation apron areas are identified and discussed in Section 2.2.3 of this report and comprise an area of approximately 63,615 square yards of pavement. This area is utilized for a variety of purposes including:

- Based aircraft parking
- Itinerant aircraft parking (transient apron)
- Aircraft fueling apron/ fuel truck storage
- Staging and maneuvering areas

The sum of these components determines the total area of apron required to meet the forecasted level of general aviation activity at the Airport.

Based and itinerant Aircraft Parking

Parking demand for based aircraft was determined under the following assumptions:

- 25 percent of based single-engine aircraft require apron parking space
- 25 percent of based multi-engine aircraft require apron parking space
- Non-turbine-based aircraft require 300 square yards (SY) of parking space each.

Parking demand for itinerant aircraft was determined under the following assumptions:

- Calculate the total design day operations for all itinerant GA operations
- Calculate itinerant arrivals on the design day if half of the operations are arrivals.
- Assume that approximately 50 percent of these aircraft will require transient parking space during the course of the day. Of these, 25 percent are considered turbine aircraft with the remaining 25 percent a mix of single-and multi-engine propeller aircraft.

- Assume that up to 75 percent of these transient aircraft will be on the apron at the same time during peak events.
- Allow an area of 360 SY per transient propeller aircraft and 800 SY for turbine aircraft, due to the need for taxiing space and the consideration of aircraft of different sizes.

Existing apron area dedicated to the purpose of based and itinerant aircraft parking was calculated based on the following assumptions:

- The southern portion of the GA Apron is reserved for exclusive use and therefore not counted for based and itinerant aircraft tie-down needs
- Of the 53,000 square yards of pavement available on the North GA Apron:
    - 13,000 square yards is used as a taxilane
    - 30,000 square yards is reserved for hangar staging and maneuvering for apron fronting hangars
    - An additional 5,000 square yards is reserved for apron maneuverability
    - 1,500 square yards is reserved for parking of fuel trucks

Apron space requirements for based and itinerant GA aircraft parking at GSP are shown in **Table 5-31**.

Table 5-31: Apron Parking Demand

Functional Area	Existing Facility	Short-Term	Mid-Term	Ultimate	Beyond 2040		
					2045	2055	2065
Based Aircraft Demand*	1,200 SY	None	None	None	None	None	None
Itinerant Aircraft Demand	2,300 SY	+1,450 SY	+1,450 SY	+1,450 SY	+1,450 SY	+3,950 SY	+5,200 SY
Total	3,500 SY	+1,450 SY	+1,450 SY	+1,450 SY	+1,450 SY	+3,950 SY	+5,200 SY

Source: McFarland Johnson Analysis, 2017

Recommendations: As based and itinerant aircraft grow over the forecast period, increased apron space to accommodate aircraft parking is recommended. By the end of the planning period 1,450 additional square yards will be needed to meet this demand. Additionally, as the size of GA aircraft operating at GSP continues to increase, consideration should be given to the required load bearing capacity of existing GA aprons and the potential need to improve these pavements to meet the increased aircraft weights.

Staging and Maneuvering Areas

Adequate space for the safe maneuvering of aircraft to and from aprons, hangars, and taxiways must also be included in any forecast of apron requirements. Staging and maneuvering is most closely associated with the provision of space in front of conventional hangars. Space reserved for such use is generally equal to, or slightly higher than, the size of the adjacent hangar. Presently, adequate staging and maneuverability space is available on the GA aprons to support existing hangars. In the future, as additional hangars are built, a commensurate level of apron should be provided. Based on Table 5-30, this would account for an additional 1,500 square yards of GA apron in the future.

Recommendations: Provide additional staging and maneuvering apron with the addition of any aircraft hangar for an area equal to or exceeding the size of the adjacent hangar.

5.6.3. General Aviation Terminal and FBO Facilities

A general aviation terminal provides space for offices, waiting area, flight planning, concessions, storage, and other amenities for pilots and passengers. General aviation terminals also provide the first and last impression of the airport and local area that GA pilots and passengers experience. As identified in Section 2.4.2 of this study, the existing FBO terminal facility is approximately 6,700 square feet in size. However, the existing space is not well organized, and the quality of overall user experience is of concern. The Airport recognizes the need to remodel and expand this space in the future.

The following analysis was conducted to estimate what amount of space should be considered to accommodate the pilots/passengers expected during the planning period. For this, an estimate of the peak hour pilots/passengers is necessary to determine the number of people that would use the general aviation terminal facilities during a one-hour period. To estimate the peak hour pilots/passengers and terminal spatial requirements, the following methodology was applied with the results shown in **Table 5-32**.

- The number of GA operations conducted during the peak hour of the average day during the peak month was calculated using data from the forecast chapter. It was assumed GA activity represents 25 percent of total airport activity. It was further assumed that arriving and departing general aviation pilots/passengers could use the terminal at the same time. Likewise, both local and itinerant operations would require terminal space at the Airport.
- The adjusted peak hour operations (arriving or departing) were estimated to have an average of five people on board (pilots and passengers).
- An area of 200 SF was used for each peak hour pilot/passenger to determine the terminal space requirements. This value accommodates all functions of a full-service general aviation terminal building including FBO counter space, waiting area, snack room, office space, pilot's lounge, restrooms, training area, circulation space, etc.

Table 5-32: GA Terminal Gross Area Analysis

	Existing Facility	Short-Term	Mid-Term	Ultimate	Beyond 2040		
					2045	2055	2065
GA Peak Hour Operations	4	4	4	5	6	6	7
Number of People	24	30	30	36	42	48	54
Total Terminal Space Required	4,800	6,000	6,000	7,200	8,400	9,600	10,800
Additional Need	None	None	None	500 SF	1,700 SF	2,900 SF	4,100 SF

Source: McFarland-Johnson Analysis, 2017

Recommendations: In the short-term the Airport should focus on a remodeling and rejuvenation effort for the GA Terminal building. In the mid- to long-term the Airport should plan to expand the facility up to 4,100 square feet. It may be necessary to complete such an expansion sooner in the planning period to meet unforeseen demand and/or elevate the customer experience.

5.6.4. General Aviation Access and Auto Parking

All general aviation facilities at the Airport are accessible via GSP drive north of the passenger terminal complex. To access the GA facilities, most customers utilize Aviation Parkway from I-85 or come in on GSP Drive from SC Route 14. Stevens Road provides an alternative means of access from SC Route 101 via State Rd. S 42-12, though is utilized less often. Ideally, access to GA facilities at the Airport would be provided by a dedicated route separated from commercial terminal traffic. Any future roadway improvements at GSP should consider an alternative and segregated route to the GA development area.

There are several corporate hangar areas on-Airport which individually provide vehicular parking for their users. With these being privately owned/operated facilities, the Airport does not provide any vehicle parking for the private use facilities. However, approximately 115 parking spaces are located adjacent to the FBO terminal building and available for use by the public. **Table 5-33** displays FBO vehicle parking requirements.

General aviation auto parking demand is identified based on the following assumptions:

- Peak hour operations can often compound over multiple days.
- Vehicles in the FBO parking lot can often remain for multiple days
- Five vehicle parking spaces per 1,000 square feet of FBO terminal is the lower bound parking demand ratio
- Ten vehicle parking spaces per 1,000 square feet of FBO terminal is the upper bound parking demand ratio

Table 5-33: GA FBO Auto Parking

	Existing Facility	Short-Term	Mid-Term	Ultimate	Beyond 2040		
					2045	2055	2065
Terminal Space Required	4,800	6,000	6,000	7,200	8,400	9,600	10,800
5 Spaces per 1,000 SF	24	30	30	40	45	50	55
10 Spaces per 1,000 SF	48	60	60	80	90	100	110
Additional Need	None	None	None	None	None	None	None

Source: McFarland-Johnson Analysis, 2017

Recommendations: Limited improvements to the GA parking lot should be considered with any future expansion of the FBO and GA terminal building.

5.6.5. General Aviation Facility Requirements Summary

The preceding sections reviewed a variety of general aviation facilities at GSP, **Table 5-34** summarizes their future requirements.

Table 5-34: General Aviation Facility Requirements Summary

	Existing Facility	Short-Term	Mid-Term	Ultimate	Beyond 2040		
					2045	2055	2065
Total Hangar Need	101,990 SF	None	None	+12,000 SF	+14,400 SF	+39,010 SF	+70,264 SF
Total Apron Need	2,867 SY	None	None	+733 SY	+1,213 SY	+2,653 SY	+4,093 SY
Total Terminal Need	None	None	None	500 SF	1,700 SF	2,900 SF	4,100 SF
FBO Auto Parking Need	None	None	None	None	None	None	None

Source: McFarland-Johnson Analysis, 2017

5.7. AIRPORT SUPPORT FACILITY REQUIREMENTS

5.7.1. Air Traffic Control Tower (ATCT)

The existing air traffic control tower (ATCT) is discussed in detail in Section 2.3.1 of this report. GSP's ATCT is currently located on the north end of the terminal building on the commercial terminal apron. In this location, the ATCT would limit the ability to expand concourse B and a new site near the GA area is currently being studied by the FAA. This future site is anticipated to be the location for a replacement tower to be built by the FAA sometime in the future. This site is being studied to ensure the future tower has unrestricted visibility of all aircraft movement areas on the future airfield as identified in this report.

Recommendation: No upgrades are required for the ATCT. However, future development should consider its impact to ATCT line-of-sight of airfield movement areas and glare.

5.7.2. Aircraft Rescue and Fire Fighting (ARFF)

As discussed in Section 2.4.4 of this report, the existing GSP ARFF facility is located on the north end of the passenger service apron next to the ATCT where it has immediate access to Runway 4-22 and ARFF personnel are able to quickly respond to any passenger emergencies in the terminal building. This Index C ARFF Facility is currently equipped with three ARFF trucks, one quick response ARFF truck, one custom pumper, one heavy rescue service truck, and one brush truck.

ARFF index requirements are defined by two factors: 1) the length of air carrier aircraft, and 2) the average daily departures of air carrier aircraft. Air carrier aircraft are grouped by length to determine an airport's ARFF index as detailed below:

- Index A includes aircraft less than 90 feet in length
- Index B includes aircraft at least 90 feet but less than 126 feet in length
- Index C includes aircraft at least 126 feet but less than 159 feet in length
- Index D includes aircraft at least 159 feet but less than 200 feet in length
- Index E includes aircraft at least 200 feet in length

Based on the current and future anticipated fleet mix for air carrier aircraft at GSP, the existing level of equipment meeting Index C requirements is sufficient throughout the planning period.

Furthermore, the existing ARFF building is sufficient to house all ARFF equipment and provides ample support/operational space for ARFF personnel. The location of the existing ARFF facility, which also houses the airfield electrical vault, limits the future development of Concourse B and, being an aging facility, is slated for demolition and replacement in the future. Design has already been procured for a replacement ARFF facility just south of the GA apron area.

Recommendation: No facility improvements or additional ARFF equipment is required over the planning period.

5.7.3. Airfield Maintenance Facility and Equipment

The Airport operations staff performs the day-to-day responsibilities of maintaining and inspecting the airfield facilities, including the removal of snow, as needed, during winter months.

As noted in Section 2.4.4 of this report, the Airport has wide variety of vehicles and equipment for airfield and grounds maintenance and snow removal stored in one of four maintenance facility buildings developed on an approximately 9-acre area of the airfield located off the south edge of the commercial terminal apron and south cargo apron.

In recent years the Airport developed its maintenance area significantly through the construction of two new maintenance buildings, expansion of the maintenance employee parking lot, and development of fuel and liquid chemical storage facilities.

Based on discussion with Airport maintenance staff the following notes were made relative to future facility and equipment planning:

- The Airport maintenance facilities operate at capacity today.
- The Airport plans to acquire an additional snow machine in the short-term.
- Future buildout of terminal concourse and anticipated growth in cargo facilities are likely to require additional maintenance facilities in equipment beyond what is presently available at GSP, to include:
    - An additional two to three service bays on existing maintenance building
    - Additional diesel and gasoline storage
    - A doubling of capacity to store de-ice material/liquid
- A new building or addition to existing maintenance building for fuel truck service to support current operations and future growth. Currently fuel trucks are serviced on the apron outside of the maintenance building.
- An additional storage building is required in the short-term to house miscellaneous maintenance equipment for currently not stored under cover.

Recommendation: It is recommended that the Airport plan for growth in both maintenance facilities and equipment within the confines of the existing airfield maintenance area. Space should be provided for expansion of the existing maintenance building to provide two to three additional equipment bays, a new equipment storage building, and an expanded fuel and chemical storage area.

5.7.4. Aviation Fuel Storage and Distribution

The Airport's existing fuel facilities are discussed in Section 2.4.4 which identifies five aviation fuel tanks having a total Jet-A capacity of 150,000-gallons and 12,000-gallon capacity for avgas. Fuel flowage information for calendar year 2017 was provided by the Airport-owned FBO, Cerulean Aviation, the sole purveyor of fuel at the airfield, and was used to project fuel demand over the planning period. Although the Airport currently receives fuel deliveries nearly daily, it should not be dependent on such frequency. Storage capacity capable of facilitating a 5-day or 7-day demand would increase the operational reliability to the Airport during times of fuel shortage or unforeseen logistical issues related to the delivery of fuel.

Based on fuel flowage projections it is estimated that over 16.5 million gallons of Jet-A and over 45,000 gallons of AvGas will be sold at GSP annually by 2037. These calculations are developed by calculating the 2017 gallons per operation value and applying it to forecast annual activity levels. The results of this analysis are depicted in **Table 5-35** and **Table 5-36.**

Table 5-35: Airport Fuel Sale Projection – Jet-A

Year	Annual Operations	Gallons/ Operation	Annual Fuel Demand	Peak Day Operations	Storage Requirement (Gal.)	
					5-Day	7-Day
2017	44,632	297.43	13,274,742	137	203,737	285,232
2022	46,562	297.43	13,848,775	143	212,660	297,724
2027	49,497	297.43	14,721,722	152	226,044	316,462
2037	55,885	297.43	16,621,683	171	254,300	356,020

Source: McFarland Johnson, 2017.

Table 5-36: Airport Fuel Sale Projection – AvGas

Year	Annual Operations	Gallons/ Operation	Annual Fuel Demand	Peak Day Operations	Storage Requirement (Gal.)	
					5-Day	7-Day
2017	44,632	0.78	34,904	137	536	750
2022	46,562	0.78	36,413	143	559	783
2027	49,497	0.78	38,709	152	594	832
2037	55,885	0.78	43,704	171	669	936

Source: McFarland Johnson, 2017.

Recommendation: Jet-A storage capacity should be doubled by 2022 to provide for a minimum five-day storage capacity throughout the planning period. Additionally, based on data received from Airport staff, fuel trucks currently often operate at capacity, and an additional fuel truck should be planned for in the short-term. As new Jet-A storage capacity comes on-line in the future, consideration should be given to a separate fuel farm to support air cargo operations.

5.7.5. Support Facility Requirements Summary

The preceding sections reviewed a variety of support facilities at GSP, **Table 5-37** summarizes their future requirements.

Table 5-37: Support Facility Requirements Summary

Item/Facility	Existing Facility or Capacity	Ultimate Requirement
Air Traffic Control Tower	Fully Visible Airport Operations Area	New ATCT development on new site
Aircraft Firefighting/Rescue	Meets Index C Requirements	New ARFF development on new site
Airfield Maintenance	Four Buildings 9.18 Acre Site	+2-3 Service Bays Expanded diesel/gas storage Expanded chemical storage New building for fuel truck maintenance New building for miscellaneous equipment
Fuel Storage and Distribution	150,000-Gallon Jet-A 12,000-Gallon AvGas	300,000-Gallon Jet-A 12,000-Gallon AvGas

Source: McFarland-Johnson Analysis, 2017

5.8. FORECAST SCENARIO FACILITY REQUIREMENTS

The following sections discuss the forecast scenarios identified for this study and their impacts on airport facilities, especially the passenger terminal complex as its facilities predominately impacted by shifts in peak hour activity and therefore more sensitive to shifts in demand patterns than other airfield facilities. It should be noted that these scenarios are not mutually exclusive and should multiple occur the prospective operational impacts would be additive.

5.8.1. New Ultra Low-Cost Carrier (ULCC) Service

Compared to network airlines or even low-cost carriers (LCCs), the ULCC model favors less than daily service and varying schedules. This scenario considers the introduction of a new ULCC providing an average of 10-weekly frequencies to multiple destinations on aircraft in the 150 to 175 seat range.

The introduction of a new ULCC could increase total enplanements by the end of the planning period by approximately 217,152 over the baseline forecast to a total of 1,865,204. While this would represent a 13 percent increase in annual enplanements, introduction of new ULCC activity is not likely to cause a 13 percent increase in peak hour. In focusing more on the leisure traveler, the ULCC model is less focused on early morning and late afternoon flights and is more likely to utilize airport spaces in off-peak times. As such, to forecast facility requirements along this scenario, a five percent increase to peak hour demand is anticipated.

5.8.2. New LCC Service

Unlike the various schedules of the ULCC model, the LCC model tends to favor large focus cities as opposed to point-to-point or hub-and-spoke models. This scenario considers the introduction of new LCC service to one or two large focus cities with an average of three daily departures on aircraft in the 100 to 120 seat range.

The introduction of a new LCC could increase total enplanements by the end of the planning period by approximately 115,684 over the baseline forecast to a total of 1,763,736, representing seven percent increase in annual enplanements. Unlike the ULCC scenario, it is plausible to assume that an LCC service would seek to compete for demand to the paired focus city and desire to operate in peak times. For this reason, a seven percent increase to peak hour activity is considered resulting in needs below those associated with the two million annual enplaned passenger scenario.

5.8.3. New International Service

Many medium sized airports such as Buffalo, Columbus, and Providence have seen the introduction of international service over the past several years and there is potentially opportunity for this trend to continue for small-hub airport such as GSP. This scenario will consider the demand and facility impacts associated with the introduction of twice weekly service to markets such as Cancun on aircraft in the 150-175 seat range.

The introduction of a new international service could increase total enplanements by the end of the planning period by approximately 22,464 over the baseline forecast to a total of 1,670,516. Despite this scenario being small in relation to annual activity, representing only a 1.4 percent increase over forecasted enplanements, the nature of international traffic could have significant impacts to terminal requirements. However, with the existence of 15 U.S. Customs and Board Protection (CBP) air preclearance stations around the world and the expansion of that program, these impacts can be hard to predict. Presently 15 airports in six countries: Dublin and Shannon in Ireland; Aruba; Freeport and Nassau in the Bahamas; Bermuda; Abu Dhabi, United Arab Emirates; and Calgary, Toronto, Edmonton, Halifax, Montreal, Ottawa, Vancouver, and Winnipeg in Canada, are equipped with CBP preclearance operations. Stockholm, Sweden and Punta Cana, Dominican Republic are also anticipated to be equipped soon, and the program continues to grow.

Should CBP facilities be required at GSP to process new international service under this scenario which is not precleared out of country, a Federal Inspection Station (FIS) would need to be constructed within the terminal building and a sterile corridor provided connecting deplaning international passengers with the station.

5.8.4. Market Interruption

While long term growth is anticipated for GSP, there is a potential for a temporary market interruption due to factors unrelated to the local GSP passenger market. Examples of a market interruption include airline network changes (loss of service or bankruptcy), enhanced low-fare competition at Charlotte Douglas International Airport (CLT), or a 9/11-like national event.

This scenario includes a ten percent drop in passenger demand/traffic with a 5-year recovery period (two percent annually). Such an operational interruption will not significantly impact growth management at the Airport but will likely require the reassessment of project phasing and capital improvement prioritization.

5.8.5. Enhanced Aircraft Up-gauging

Enhanced up-gauging of aircraft could result in systemic terminal impacts as peak hour activity is likely to grow by 12 to 15 percent as this scenario includes a high mix of mainline aircraft (seating minimum of 150 passengers) expected to replace some frequency of multiple regional aircraft. This would place peak period demands on spaces from curb to gate, beyond what they may be currently designed for.

5.9. FACILITY REQUIREMENT SUMMARY

The facility requirements recommended for GSP are expressed in the preceding sections and **Table 5-38**. highlights the key improvements that are recommended for future development at GSP.

Table 5-38: Facility Requirements Total Summary

Airfield Facility Requirements

Item/Facility	Existing Facility or Capacity	Ultimate Requirement	Deficit
Pavement Management	Unable to provide structurally sound pavement for forecasted aircraft mix throughout the 20-year horizon.	Provide structurally sound pavement fore forecasted aircraft mix throughout the 20-year horizon.	Taxiway L Rehabilitation Runway 4-22 Asphalt Rehabilitation Reconstruct Itinerant Apron Localized PCC Repairs and Joint Sealing
Runway Length	11,001 FT	11,001 FT	None
Runway Width	150 FT	150 FT	None
Runway Orientation	Meets 95% wind coverage in all conditions	Meet 95% wind coverage in all conditions	None
Runway Designation	4-22	4-22	None
Runway Safety Areas	Runway 4-22 500 FT wide 1,000 FT past RW ends Limited ability to meet grade requirements	Runway 4-22 500 FT wide 1,000 FT past RW ends Full ability to meet grade requirements	Meet grade requirements
Runway Object Free Area	Runway 4-22 800 FT wide 1,000 FT past RW ends	Runway 4-22 800 FT wide 1,000 FT past RW ends	None

Item/Facility	Existing Facility or Capacity	Ultimate Requirement	Deficit
	Meets clearance requirements	Meets clearance requirements	
Runway Protection Zone	Runways 4 & 22 1,000 FT Inner Width 2,500 FT Length 1,750 FT Outer Width Airport ownership/ Right-of-way/ Easement	Runways 4 & 22 1,000 FT Inner Width 2,500 FT Length 1,750 FT Outer Width Airport Ownership/ Right-of-Way/ Easement	None
Runway Pavement Markings	Precision Instrument Markings	Precision Instrument Markings	None
Taxiways[1]	Full Length Parallel Ample Entry/Exits Meets TDG-5/6 Meet ADG VI standards Unable to fully provide TDG-5/6 Fillets Does not meet geometry	Full Length Parallel Ample Entry/Exits Meets TDG-5/6 Meet ADG VI standards Provide TDG-5/6 Fillets Meets geometry	Improve Intersection Fillets Correct Geometry
Approach Lighting	Runway 4 2,400 FT ALSF-2 Runway 22 2,400 FT MALSR	Runway 4 2,400 FT ALSF-2 Runway 22 2,400 FT ALSF-2	Runway 22 2,400 FT ALSF-2
Airfield Lighting	Runway 4-22 – HIRLs	Runway 4-22 – HIRLs	None
Airfield Signage	Meets Standards	Meet Standards	None
Runway Visual Aids	Runway 4 – PAPI Runway 22 – PAPI	Runway 4 – PAPI Runway 22 – PAPI	None
Instrument Approaches	Runway 4 – ILS/LOC (CAT I, II, and III) Runway 4 –GPS - LPV Runway 22 – ILS/LOC (CAT I) Runway 22 –GPS - LPV	Runway 4 – ILS/LOC (CAT I, II, and III) Runway 4 –GPS - LPV Runway 22 – ILS/LOC (CAT II and III) Runway 22 –GPS - LPV	CAT II/III approach to Runway 22

Passenger Terminal Facility Requirements

Functional Area	Existing Facility	Ultimate Requirement	2 MAEP	Beyond 2040		
				2045	2055	2065
Annual Enplanements	1,182,700	1,648,052	2,000,000	2,153,123	2,745,443	3,500,708
Peak Hour Enplanements	622	1,010	1,226	1,320	1,683	2,145
Gates	13	+2 Gates	+5 Gates	+6 Gates	+10 Gates	+15 Gates
Curb Length	1,000 LF	+65 LF	+286 LF	+508 LF	+812 LF	+1,202 LF
Check-In/Ticketing						
Staffed Counter Positions	40 Positions	No Change	No Change	No Change	No Change	No Change
Check-In Ticket Area (Counter/Active/Queue)	4,998 SF	No Change	No Change	No Change	+674 SF	+2,175 SF
Kiosks Positions	19 Positions	No Change	No Change	No Change	+5 Positions	+11 Positions
Kiosk Check-In Area (Active/Queue)	2,691 SF	+206 SF	+827 SF	+1,173 SF	+2,211 SF	+3,492 SF
Airline Ticket Office Area	8,631 SF	No Change	No Change	No Change	No Change	No Change
Check-In/Ticketing Circulation Area	7,300 SF	No Change	No Change	No Change	No Change	+672 SF
Restrooms	2,654 SF	No Change	+105 SF	+313 SF	+1,137 SF	+2,129 SF
Outbound Baggage Screening and Make-Up						
Level 1 EDS Units	4	No Change	+ 1 Unit	+ 1 Unit	+3 Units	+4 Units
Level 2 OSR Stations	2	+1 Station	+2 Stations	+2 Stations	+3 Stations	+4 Stations
Level 3 ETD Stations	2	+1 Station	+1 Station	+1 Station	+2 Stations	+3 Stations
Level 1 EDS Screening Area	2,054 SF	No Change	+446 SF	+446 SF	+1,446 SF	+1,946 SF
Level 2 OSR Screening Area	100 SF	+20 SF	+60 SF	+60 SF	+100 SF	+140 SF
Level 3 ETD Screening Area	400 SF	No Change	No Change	No Change	No Change	+100 SF
Make-Up Area (Including Baggage Train Circulation & Mech. Support Spaces)	15,032 SF	No Change	No Change	No Change	+1,528 SF	+6,496 SF
Passenger Security Screening Checkpoint						
Screening Lanes	4 Lanes	+3 Lanes	+5 Lanes	+2 Lanes	+3 Lanes	+5 Lanes

Functional Area	Existing Facility	Ultimate Requirement	2 MAEP	Beyond 2040		
				2045	2055	2065
Annual Enplanements	1,182,700	1,648,052	2,000,000	2,153,123	2,745,443	3,500,708
Peak Hour Enplanements	622	1,010	1,226	1,320	1,683	2,145
Security Screening Module Area	3,850 SF	+3,150 SF	+5,150 SF	+2,150 SF	+3,150 SF	+5,150 SF
Passenger Queue Area	3,026 SF	+3,519 SF	+4,918 SF	+5,528 SF	+7,880 SF	+10,874 SF
Allowance for Future Equipment Changes	1,524 SF	No Change	+170 SF	No Change	+267 SF	+766 SF
TSA Support Space Area	1,717 SF	+71 SF	+520 SF	+204 SF	+647 SF	+1,036 SF
Passenger Lounges/Holdrooms						
Holdrooms (Seated/Standing/Ticketing/Boarding)	36,950 SF 13 Gates	+ 1,180 SF +2 Gates	+ 8,806 SF +5 Gates	+11,348 SF +6 Gates	+21,516 SF +10 Gates	+34,226 SF +15 Gates
Allowance for Amenities	1,907 SF	No Change	+ 381 SF	+ 508 SF	+ 1,106 SF	+ 1,652 SF
Holdroom Circulation Area	12,600 SF	No Change	+ 1,813 SF	+ 2,614 SF	+ 5,817 SF	+ 9,820 SF
Restrooms	2,910 SF	+140 SF	+750 SF	+ 954 SF	+ 1,767 SF	+ 2,784 SF
Inbound Baggage Handling and Claim						
Baggage Claim Frontage (LF)	321 LF	+ 270 LF	+ 396 LF	+ 451 LF	+ 664 LF	+ 934 LF
Baggage Claim Units	3 Units	+ 2 Units	+ 4 Units	+ 4 Units	+ 6 Units	+ 8 Units
Baggage Claim Unit Area	2,967 SF	+ 2,345 SF	+ 3,481 SF	+ 3,976 SF	+ 5,885 SF	+ 8,315 SF
Passenger Queue & Bag Retrieval Area	8,048 SF	No Change	+ 62 SF	+ 684 SF	+ 3,085 SF	+ 6,141 SF
Baggage Service Office	588 SF	+ 611 SF	+ 868 SF	+ 979 SF	+ 1,411 SF	+ 1,959 SF
Allowance for Meeters/Greeters	2,665 SF	No Change	No Change	No Change	+ 333 SF	+ 1,156 SF
Baggage Claim Area Circulation	4,179 SF	No Change	+ 370 SF	+ 719 SF	+ 2,066 SF	+ 3,781 SF
Restrooms	1,391 SF	+1,420 SF	+ 2,021 SF	+ 2,283 SF	+ 3,293 SF	+ 4,579 SF
Take-Off Belts	3 Unites	+ 2 Units	+ 4 Units	+ 4 Units	+ 6 Units	+ 8 Units
Take-Off Belt Area	2,300 SF	+2,266 SF	+3,242 SF	+ 3,667 SF	+ 5,308 SF	+ 7,396 SF
Allowance for Baggage Train Circulation	5,160 SF	+1,688 SF	+3,153 SF	+ 3,791 SF	+ 6,252 SF	+ 9,385 SF

Functional Area	Existing Facility	Ultimate Requirement	2 MAEP	Beyond 2040		
				2045	2055	2065
Annual Enplanements	1,182,700	1,648,052	2,000,000	2,153,123	2,745,443	3,500,708
Peak Hour Enplanements	622	1,010	1,226	1,320	1,683	2,145
Allowance for Conveyor Belt & Equip.	500	+870 SF	+1,163 SF	+ 1,290 SF	+ 1,782 SF	+2,409 SF
Concourse Circulation/Concessions						
Pre-Secure Concession Area (Service/Support)	4,800	No Change	+240 SF	+ 626 SF	+ 2,119 SF	+ 4,022 SF
Post-Secure Concession Area (Service/Support)	19,200	No Change	+960 SF	+2,503 SF	+8,474 SF	+16,087 SF
Total Terminal Building Area Requirement	N/A	+ 17,756 SF	+ 38,414 SF	+ 46,267 SF	+ 89,918 SF	+149,622 SF

Source: McFarland-Johnson Analysis, 2017.

Roadway Access and Parking Facility Requirements

Item/Facility	Existing Facility or Capacity	Ultimate Requirement	Deficit/Goals
Airport Entrance/ Circulatory Roadway	Unable to provide current LOS through 3.5 MAEP	Phased approach to providing high LOS at 3.5 MAEP	Increase Capacity, Limit/Remove Full-Stop Intersections, Minimize Crosswalks, Decouple Terminal Curb and Parking Traffic, Balance Garage Utilization
Airport Parking	Most lots approaching capacity on peak days.	Support parking needs through 2 MAEP	Provide for an additional 2,000 garage spaces and 1,800 surface lot spaces.

Air Cargo Facility Requirements

Item/Facility	Existing Facility or Capacity (2019)	Short-Term	Mid-Term	Ultimate
Aircraft Parking Positions				
Air Cargo Building	100,000 SF	+110,581 SF	+156,614 SF	+262,487 SF
Aircraft Apron Area	30,000 SY	+ 16,911 SY	+ 20,800 SY	+ 39,267 SY
Paved Cargo Handling Ground Equipment Storage	9,500 SY	+ 1,529 SY	+ 3,330 SY	+ 8,624 SY
Total Apron	39,500 SY	+ 18,440 SY	+ 24,130 SY	+ 47,891 SY
Truck and Auto Parking	27,750 SY	None	+ 6,074 SY	+ 20,028 SY
Number of Landside Truck Docks/Doors	38 Doors	+ 17 Doors	+ 29 Doors	+56 Doors
Number of Airside Truck Doors	10 Doors	+ 9 Door	+ 13 Doors	+ 22 Doors

General Aviation Facility Requirements

	Existing Facility	Short-Term	Mid-Term	Ultimate	Beyond 2040		
					2045	2055	2065
Total Hangar Need	101,990 SF	None	None	+12,000 SF	+14,400 SF	+39,010 SF	+70,264 SF
Total Apron Need	2,867 SY	None	None	+733 SY	+1,213 SY	+2,653 SY	+4,093 SY
Total Terminal Need	None	None	None	500 SF	1,700 SF	2,900 SF	4,100 SF

FBO Auto Parking Need	None	None	None	None	None	None	None

Support Facility Requirements

Item/Facility	Existing Facility or Capacity	Ultimate Requirement
Air Traffic Control Tower	Fully Visible Airport Operations Area	New ATCT development on new site
Aircraft Firefighting/Rescue	Meets Index C Requirements	New ARFF development on new site
Airfield Maintenance	Four Buildings 9.18 Acre Site	+2-3 Service Bays Expanded diesel/gas storage Expanded chemical storage New building for fuel truck maintenance New building for miscellaneous equipment
Fuel Storage and Distribution	150,000-Gallon Jet-A 12,000-Gallon AvGas	300,000-Gallon Jet-A 12,000-Gallon AvGas

Source: McFarland-Johnson Analysis, 2017